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AIR FORCE MATERIALS LAB WRIGHT-PATTERSON AFB OHIO  
ABSTRACTS OF AF MATERIALS LABORATORY REPORTS JANUARY 1976 - DEC--ETC(U)  
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**ABSTRACTS OF AF MATERIALS LABORATORY REPORTS  
JANUARY 1976 - DECEMBER 1976**

AIR FORCE MATERIALS LABORATORY

MARCH 1977

TECHNICAL REPORT AFML-TR-77-57

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AIR FORCE MATERIALS LABORATORY  
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES  
AIR FORCE SYSTEMS COMMAND  
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

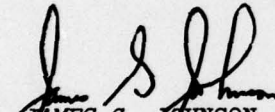
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This report was prepared by the Scientific and Technical Information Office (STINFO), Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio, under job order number 73810328. Mr. James G. Johnson (AFAL/TSR) was the project engineer.

This report has been reviewed by the Information Office (IO) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

  
JAMES G. JOHNSON  
Project Engineer

FOR THE COMMANDER

  
WARREN P. JOHNSON  
Chief, Operations Office

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A number of indices are included in the report: subject (KWOC), AD accession number, AFML report number, contract number, contractor, author, AFML project monitor and title. A listing of project and task numbers is also included.

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FOREWORD

Technical reports published by the Air Force Materials Laboratory during the period 1 January 1976 - 31 December 1976 are abstracted herein. Reports on research conducted by Air Force Materials Laboratory personnel as well as that conducted on contract are included. The abstracts are separated into sections corresponding to the divisions of the laboratory with nine indices provided. The accession number cited with each abstract provides access to the document itself in the Air Force Materials Laboratory's document collection.

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ABSTRACTS OF TECHNICAL REPORTS

OPERATIONS OFFICE (AFML/DO)

REPORT NO: AFML-TR-75-206  
ACCESS NO: 204,311 December 1975  
TITLE: AN ANALYSIS OF THE USE OF AVAILABLE ON-LINE TECHNICAL LITERATURE DATA BASES FOR MATERIALS RESEARCH  
AUTHOR(S): J.F. March and F.L. Scheffler  
CONTRACT NO: F33615-75-C-5005  
CONTRACTOR: University of Dayton Research Institute  
PROJECT MONITOR: D. Wisnosky (AFML/DO)  
PROJECT NO: 7381  
TASK NO: 738103  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: To provide some understanding of how on-line services are being used, the organization and missions of the Air Force Materials Lab are described. As expected, the more research and development-oriented groups were heavy users. Statistics on data base use showed that Government Reports available through NTIS represented the most frequently used data base. The role of the information specialist in interacting with the end user is very important. As a result of increased literature searching activity and the subsequent demand for original items, the MDC has established a small technical library with some key periodicals, reference books, and special technical bulletins, etc., to serve better the needs of the AFML personnel.

REPORT NO: AFML-TR-76-66 AD A032 506  
ACCESS NO: 204,586 September 1976  
TITLE: ABSTRACTS OF ACTIVE CONTRACTS-AIR FORCE MATERIALS LABORATORY  
AUTHOR(S): T.G. Purnhagen  
CONTRACT NO: Internal  
CONTRACTOR: AFML/DO  
PROJECT MONITOR: T.G. Purnhagen (AFML/DOC)  
PROJECT NO: 7381  
TASK NO: 738103  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Abstracts of Air Force Materials Laboratory Contracts that were active on 05 February 1976 are reported. The abstracts are indexed by contractor, contract number, and project task number. Each abstract entry provides the title of the contract, contractor, duration, AFML project engineer, objective and progress or approach in the case of new contracts where there is no progress to report yet.

ADVANCED DEVELOPMENT DIVISION (AFML/LC)

REPORT NO: AFML-TR-75-92 AD A021 688  
ACCESS NO: 204,171 June 1975  
TITLE: EVALUATION OF HYBRID COMPOSITE MATERIALS  
AUTHOR(S): S.V. Kulkarni, B.W. Rosen and H.C. Boehm  
CONTRACT NO: F33615-74-C-5174  
CONTRACTOR: Materials Sciences Corporation  
PROJECT MONITOR: B.A. Kosmal (AFML/LC)  
PROJECT NO: 69CW01  
TASK: N/A  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A methodology is presented to obtain minimum cost and weight configurations for simple structural configurations which are representative of "real world" structures, over practical range of loadings. Aluminum and hybrid and single-fiber laminates are the candidate materials. Materials costs, manufacturing costs, and premiums are all treated as variables in this design study. The results can be applied to a broad range of problems of interest for the dual purposes of (1) establishing cost-performance ranking of a particular hybrid system in a preliminary design fashion for a specific structural application and loading and (2) providing guidance for developing additional improved material systems and hybrid laminate configurations.

REPORT NO: AFML-TR-75-112 AD B010 170  
ACCESS NO: 201,883 September 1975  
TITLE: MANUFACTURING METHODS FOR LOW COST TOOLING FOR  
ADVANCED COMPOSITE SHELL TYPE STRUCTURES  
AUTHOR(S): E.H. Swazey  
CONTRACT NO: F33615-73-C-5119  
CONTRACTOR: General Dynamics  
PROJECT MONITOR: S. Litvak (AFML/LC)  
PROJECT NO: 474-3  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This report contains results of resin/hardener characterization and the investigative methods used, the fabrication of two subcomponent molds made directly on a conventional template/gypsum master-form. The fabrication and verification of a full-scale graphite-epoxy sandwich-type tool is summarized. The report also includes the evaluation of two full-scale components and a production analysis for a complete fuselage including the numbers and types of tools required in quantity production. There is also a summary of accomplishments which is a detailed description of the applications of the established process to other AFML contracts.

AFML/LC

REPORT NO: AFML-TR-75-181 AD B014 689  
ACCESS NO: 204,558 November 1975  
TITLE: DEVELOPMENT OF IMPROVED ENVIRONMENTAL RESISTANT  
ORGANIC-REINFORCED MATERIALS SYSTEMS  
AUTHOR(S): M.G. Maximovich  
CONTRACT NO: F33615-74-C-5142  
CONTRACTOR: Aerotherm Division  
PROJECT MONITOR: G.D. Hollingsworth (AFML/LC)  
PROJECT NO: 69CW01  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Commercially available matrix resins were identified and a list of resin criteria along with target goals for properties and performance was established. A screening program consisting of dimensional change measurements, water pickup determinations, and TMA curves before and after 24-hour boil was run on a series of castings and/or moldings prepared from the various candidate resins. Several systems emerged which exhibited moisture resistance superior to that of commercially available epoxy systems. Process and cure studies were carried out on glass reinforced laminates which also exhibited excellent moisture resistance. Prepreg parameter and compatibility studies along with tape and laminate fabrication and testing were carried out on the most promising candidate systems. Severe difficulties were finally encountered in achieving both high quality laminates and adequate performance at elevated temperature. The difficulties were identified and alternate means of overcoming these problems were suggested.

REPORT NO: AFML-TR-75-192 AD B015 408  
ACCESS NO: 204,630 June 1976  
TITLE: ADVANCED DEVELOPMENT OF CONCEPTUAL HARDWARE -  
FUSELAGE  
AUTHOR(S): R.L. Carri  
CONTRACT NO: F33615-73-C-5173  
CONTRACTOR: Grumman Aerospace  
PROJECT MONITOR: W.J. Schulz (AFML/LC)  
PROJECT NO: 2105  
TASK NO: 210501  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The objective of the program was to validate the feasibility of using metal matrix composites for fuselage components of the B-1 aircraft. The B/Al and Be/Ti coupon and element tests showed that the materials were of structural grade with the repeatability needed for strength critical structures. The subcomponent testing proved that the B/Al skin has satisfactory post-buckling strength and that the overall design easily satisfies the fatigue resistance needed for the intended application. The final component failed at 109% of design limit load under combined shear and pressure loading. The failure analysis indicated the

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failure resulted from both a material deficiency and a lower than anticipated buckling load. Premature buckling occurred due to the inability of local pads to simulate a uniform pressure distribution.

REPORT NO: AFML-TR-76-53 AD B014 957L  
ACCESS NO: 204,624 May 1976  
TITLE: EVALUATION OF HYBRID COMPOSITES  
AUTHOR(S): J.T. Hoggatt and A.L. Dobyms  
CONTRACT NO: F33615-74-C-5074  
CONTRACTOR: Boeing  
PROJECT MONITOR: G.D. Hollingsworth (AFML/LC)  
PROJECT NO: 69CW01  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This was a two-phased program aimed at deriving useful engineering and design data on hybrid composite systems which were optimized for both cost and particular engineering property. 16 different hybrid composite systems were analytically derived for evaluation. Each system was then evaluated in three different laminate configurations to provide a basis for assessing the accuracy and validity of the available laminate analysis techniques. The 48 laminates were assessed for cost and mechanical properties (tension, compression, and shear). Select systems were evaluated for fatigue properties, thermal expansion, thermal shock, moisture stability, and crack propagation. This program demonstrated that hybridizing high modulus reinforcing fibers with lower cost reinforcements was a viable approach to low cost composite structures.

METALS AND CERAMICS DIVISION (AFML/LL)

REPORT NO: AFML-TR-74-149 AD A026 870  
 ACCESS NO: 204,359 February 1975  
 TITLE: THE RETARDATION OF CRACK PROPAGATION FOR HIGH STRENGTH,  
 LOW ALLOY STEELS IN AQUEOUS MEDIA BY ADDITION OF  
 OXIDIZING INHIBITORS

AUTHOR(S): P.A. Parrish  
 CONTRACT NO: Internal  
 CONTRACTOR: AFML/LLN  
 PROJECT MONITOR: P.A. Parrish (AFML/LLN)  
 PROJECT NO: 7351  
 TASK NO: 735106

DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: Oxidizing inhibitors can be utilized to retard crack growth in high strength, low alloy martensitic steels in aqueous solution. Artificial crevice cell and crack tip pH measurements have shown that conditions favorable for hydrogen embrittlement of the steel exist in propagating cracks. Hydrazine was effective in reducing the crack growth rate by one order of magnitude for D6 AC in aqueous solution. Sodium dichromate was also effective in reducing crack growth rates in aqueous solution.

REPORT NO: AFML-TR-74-191 AD A031 774  
 ACCESS NO: 204,525 July 1976  
 TITLE: DAMPING IN PORCELAIN ENAMEL COATINGS

AUTHOR(S): P.I. Sridharan  
 CONTRACT NO: F33615-72-C-1315  
 CONTRACTOR: University of Minnesota  
 PROJECT MONITOR: J.P. Henderson (AFML/LLN)  
 PROJECT NO: 7351  
 TASK NO: 735106

DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: Equipment was developed and tested which was used for measuring the complex elastic moduli of thin porcelain enamel coatings at temperatures where they became very soft. Previous work has been done in glasses, almost exclusively at relatively low temperatures, to measure the effects of ionic diffusion or other chemical activation changes or at high temperatures where one is dealing with a melt. Measurements from  $10^2$  to  $10^{12}$  poise have been conducted mainly for production control and have relied on standard tests. The present work shows how the storage and loss portions of the shear and Young's modulus can be measured directly as functions of temperature and frequency and proposes a general relation which depends only on the room temperature modulus, the activation energy, the critical temperature, and one other parameter which gives the relaxation spectrum bandwidth.

REPORT NO: AFML-TR-74-264 AD A033 215  
 ACCESS NO: 204,636 September 1976  
 TITLE: FILLED BILLET OXIDE DISPERSION STRENGTHENED HOLLOW  
 AIRFOIL EXTRUSIONS

AUTHOR(S): G. Friedman  
 CONTRACT NO: F33615-73-C-5037  
 CONTRACTOR: Nuclear Metals

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PROJECT MONITOR: W. O'Hara (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735108  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: An yttria-strengthened, mechanically attributed nickel-chromium-aluminum powder, HDA 8077, (Ni-16Cr-4Al-1.5Y<sub>2</sub>O<sub>3</sub> nominal composition) was extruded with no prior consolidation into tubes and thin-wall hollow airfoils. Through metallography, physical and mechanical property determination, and elevated temperature dynamic oxidation tests, it was determined that strong, corrosion-resistant, net airfoil shapes could be made directly from powder by the filled billet extrusion technique. Process scale-up recommendations for larger airfoils are included.

REPORT NO: AFML-TR-75-26 AD B011 425  
ACCESS NO: 204,350 May 1975  
TITLE: AERODYNAMIC ENHANCEMENT OF LASER DAMAGE TO TITANIUM ALLOYS  
AUTHOR(S): A. Mandl  
CONTRACT NO: F33615-73-C-5158  
CONTRACTOR: Avco Everett Research Lab  
PROJECT MONITOR: S. Lyon (AFML/LLM)  
PROJECT NO: 2387  
TASK NO: 238700  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The aerodynamic enhancement of laser damage to titanium alloys has been studied both experimentally and theoretically. Spot size, power density and aerodynamic effects of laser damage in the laminar flow regime have been studied. Weight loss measurements have shown that the major melt removal is dominated by the downstream motion of the viscous melt over the surface and not by droplet and "spray" formation into the flow. Some alloy effects have been observed and some emission spectra taken during ignition. Spatially separated thermocouple measurements were also recorded. The first quantitative and direct relationship between front surface melting and ignition has also been observed. Finally, a marked dependency of damage on Mach number and spot size was observed.

REPORT NO: AFML-TR-75-118  
ACCESS NO: 204,179 July 1975  
TITLE: EFFECT OF STEP-AGING AND THERMOMECHANICAL TREATMENT ON MECHANICAL PROPERTIES OF Ti-7 Mo-16 Al ALLOY AT ELEVATED TEMPERATURES  
AUTHOR(S): A. Gysler, M. Hida and S. Weissmann  
CONTRACT NO: F33615-72-C-1566  
CONTRACTOR: Rutgers  
PROJECT MONITOR: S. Fujishiro (AFML/LLS)  
PROJECT NO: 7353  
TASK NO: 735302  
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ABSTRACT: Step-aging programs, based on principles of particle-dislocation interactions, were developed systematically to obtain increases in the high-temperature strength and ductility properties of Ti-7 at % Mo-16 at % Al alloy. A triple-step aging program produced a yield stress of about 1,500 MN/m<sup>2</sup> at room temperature and 900 MN/m<sup>2</sup> at a deformation temperature of 600° C. Preliminary results achieved by thermomechanical treatments, consisting of deformation in the +Ti<sub>3</sub>Al phase field, show reasonable high-temperature deformation properties, but a brittle behavior at lower test temperatures.

REPORT NO: AFML-TR-75-133 AD A021 530  
ACCESS NO: 202,092 August 1975  
TITLE: RESEARCH WITH IN-SITU COMPOSITES ALIGNED WITH EUTECTOID AND EUTECTIC TRANSFORMATIONS  
AUTHOR(S): J.G. Smeggil  
CONTRACT NO: F33615-73-C-5083  
CONTRACTOR: General Electric  
PROJECT MONITOR: R.M. Dunco (AFML/LLM)  
PROJECT NO: 7353  
TASK NO: 735306  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Directionally aligned eutectoids are of potential interest for high temperature turbine applications. The Hf-HfCr<sub>2</sub> eutectoid was selected from several systems, to explore the potential of using solid-solid transformation to yield a suitable, aligned microstructure. Extensive heat treatments of this eutectoid indicated very rapid microstructural coarsening resulting from both thermal and dissolved oxygen effects and severe Cr volatilization occurring during directional alignment. Directionally solidified eutectics are being developed for high temperature turbine blades. Chemical vapor deposition (CVD) techniques were used to deposit simple and complex layers of the elements Ni, Cr, and Al required for high temperature, oxidation resistant coatings.

REPORT NO: AFML-TR-75-148 AD A021 174  
ACCESS NO: 202,944 September 1975  
TITLE: DEVELOPMENT OF A WELDABLE HIGH STRENGTH STEEL  
AUTHOR(S): C.D. Little and P.M. Machmeier  
CONTRACT NO: F33615-73-C-5093  
CONTRACTOR: General Dynamics  
PROJECT MONITOR: M.H. Horowitz (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735105  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: An existing 10Ni-8Co-1Mo steel (HY180) was modified to a higher strength level to meet the need for weldable and fracture-resistant high-strength steel alloys required in current and future airframe structural applications. The selected alloy composition (14Co-10Ni-2Cr-1Mo-0.16C) was scaled-up to a 2000 lb VIM/VAR heat with no apparent decrease in mechanical properties. Aging at 950F produced a K<sub>Ic</sub>=130Ksi√in and K<sub>Isc</sub>>100 Ksi√in at the 255Ksi ultimate strength level. Preliminary results indicate low fatigue crack growth rates both in ambient and corrosive environments, improved S/N fatigue and

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good general corrosion resistance. The 14CO-10Ni-2Cr-1Mo-0.16C steel (AF1410) was found to be quite weldable by conventional arc weld processes.

REPORT NO: AFML-TR-75-149 AD A029 235  
ACCESS NO: 204,707 November 1975  
TITLE: LASER WELDING-THE PRESENT STATE-OF-THE-ART  
AUTHOR(S): E.M. Breinan, C.M. Banas and M.A. Greenfield  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLM  
PROJECT MONITOR: M.A. Greenfield (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735102  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The evolution of laser systems is briefly reviewed from the first successful operation of the ruby laser in 1960 to the present. Laser materials processing developments are then reviewed followed by general discussions of currently available high power laser equipment, laser welding performance, laser weld characteristics, and the properties of laser welds in metals and alloys. A discussion of current industrial laser welding applications is also included. The report constitutes an effort to comprehensively review the important developments in laser welding up to the summer of 1975.

REPORT NO: AFML-TR-75-151 AD A022 346  
ACCESS NO: 204,225 October 1975  
TITLE: METHODS DEVELOPMENT FOR NON-DESTRUCTIVE MEASUREMENT OF BOND STRENGTH IN ADHESIVELY BONDED STRUCTURES  
AUTHOR(S): J.A. Seydel  
CONTRACT NO: F33615-75-C-5134  
CONTRACTOR: University of Michigan  
PROJECT MONITOR: R.M. Panos (AFML/LLP)  
PROJECT NO: 7353  
TASK NO: 735308  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: An automated ultrasonic test system was used to measure the ultrasonic reflectivity of adhesively bonded structures as a function of frequency. An attempt was made to correlate the measurements with adhesive bond strength.

REPORT NO: AFML-TR-75-163 AD A025 966  
ACCESS NO: 204,388 March 1976  
TITLE: HOT PRESSURE WELDING OF ALUMINUM ALLOYS  
AUTHOR(S): G.E. Metzger  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLM  
PROJECT MONITOR: G. Metzger (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735102  
DIST. STATEMENT: Approved for public release; distribution unlimited.

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**ABSTRACT:** The welding of butt joints in 1100, 6061, 7075 aluminum by the hot pressure welding process with a vacuum atmosphere has been studied. Solid cylinders were welded in a closed die. The tensile strength joint efficiency of 1100 aluminum welds was 100% at a welding temperature of 600°C with 24% weld deformation and also at 500°C and 44%. Alloy 7075 welded at 490°C and with 20-30% deformation exhibited a joint efficiency of 100% in the as-welded condition and 93% in the T6 condition. The tensile elongation of welds was good except for 7075 aluminum in the T6 condition. This was about 1%, which increased to about 2% after postweld diffusion treatment. Abrasion of the faying surfaces by preweld relative movement of a ring-shaped specimen on a flat sheet was of only limited effect in improving weld strength. Joint efficiencies of 100% (based on annealed strengths) were achieved with 1100 and 6061 aluminum, but not with 7075 aluminum.

REPORT NO: AFML-TR-75-177 AD A021 116  
ACCESS NO: 204,217 December 1975  
TITLE: NOTCHED BEND BEHAVIOR OF BERYLLIUM OVER A WIDE RANGE OF STRAIN RATES  
AUTHOR(S): T. Nicholas  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLN  
PROJECT MONITOR: T. Nicholas (AFML/LLN)  
PROJECT NO: 7351  
TASK NO: 735106

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Three point bend tests on U-notched Charpy specimens were conducted for six grades of beryllium over a range in loading rates from 10-6 to 10 m/sec. Load-deflection curves were obtained from tests performed on servo-controlled hydraulic testing machines at low and intermediate loading rates and with a Hopkinson pressure bar apparatus at high rates. Curves of absorbed energy, maximum load, and maximum deflection against loading velocity indicate a transition velocity for several grades of beryllium at which the ductility of the material decreases sharply.

REPORT NO: AFML-TR-75-187 AD A027 069  
ACCESS NO: 203,130 November 1975  
TITLE: EXPLORATORY DEVELOPMENT AND EVALUATION OF LOW COST BORON ALUMINUM  
AUTHOR(S): V. Krukonis, A.W. Hauze and F. Wawner  
CONTRACT NO: F33615-74-C-5082  
CONTRACTOR: Avco Systems Division  
PROJECT MONITOR: J.S. Santner (AFML/LLS)  
PROJECT NO: 7351  
TASK NO: 735102

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: One inch wide monolayer boron-aluminum cast tape was successfully fabricated by passing collimated nitrided boron through molten aluminum. The oxidizing and nitriding temperatures and rates of the nitrided boron were found to be critical in producing a nitride layer which was continuous and

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sound enough to prevent attack of the boron by the molten aluminum, but thin enough to allow sufficient reaction to provide fiber-matrix bonding. The critical balance of boron nitride to the aluminum could not be attained consistently to provide composites with both longitudinal and transverse properties equivalent to diffusion bonded boron-aluminum. The nitrided boron was found to exhibit 30% higher strength than unnitrided boron and retain its strength better when subjected to high temperature exposure.

REPORT NO: AFML-TR-75-191 AD A025 365  
ACCESS NO: 204,312 January 1976  
TITLE: FURTHER DEVELOPMENT OF RELIABILITY ANALYSIS APPLICATION  
TO STRUCTURAL FATIGUE EVALUATION  
AUTHOR(S): I.C. Whittaker and S.C. Saunders  
CONTRACT NO: F33615-74-C-5037  
CONTRACTOR: Boeing  
PROJECT MONITOR: R.C. Donat (AFML/LLN)  
PROJECT NO: 7351  
TASK NO: 735106  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Three parameter symmetric distributions have been investigated for application as a fatigue life distribution model. Maximum likelihood (ML) estimator and simulation procedures for maximum variance unbiased estimates and confidence bounds have been developed for analysis of censored data. A technique for testing the hypothesis of two censored samples having a common parent population is also presented. The effect on airplane structural reliability resulting from differing levels of fatigue performance from nominally identical structures is discussed, and a preflaw model was developed and incorporated in a reliability analysis method. Parametric studies were conducted using the reliability method to obtain qualitative information on the impact and interaction in terms of structural reliability of several variables such as preflaws, loads environment, material, structural configuration, and designed residual strength.

REPORT NO: AFML-TR-75-196 AD A025 473  
ACCESS NO: 204,322 January 1976  
TITLE: THE INFLUENCE OF HEAT TREATMENT ON THE STRUCTURE AND  
PROPERTIES OF AN ISOTHERMALLY FORGED Ti6Al-6V-2Sn NOSE  
WHEEL AND STRUCTURAL SHAPE  
AUTHOR(S): W.R. Kerr  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLS  
PROJECT MONITOR: W.R. Kerr (AFML/LLS)  
PROJECT NO: 7351  
TASK NO: 735108  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Two isothermal forgings, an F111 nose wheel and a structural shape were sectioned, heat treated and evaluated by metallography and by

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tensile and fracture toughness tests. Results indicate reasonable uniformity of structure and properties throughout the isothermal forgings, and heat treatment response similar to that of conventional forgings of the same alloy. The as-forged microstructure is largely dependent on the preform microstructure.

REPORT NO: AFML-TR-75-200 AD A023 185  
ACCESS NO: 204,230 January 1976  
TITLE: MEASUREMENT OF STRESS CORROSION CRACKS IN ALUMINUM ALLOY  
DCB SPECIMENS USING AN ULTRASONIC PULSE-ECHO TECHNIQUE  
AUTHOR(S): P.J. Blau and W.M. Griffith  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLS  
PROJECT MONITOR: P.J. Blau (AFML/LLS)  
PROJECT NO: 7351  
TASK NO: 735105

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Past techniques used in monitoring stress corrosion crack growth in aluminum alloy double cantilever beam (DCB) specimens have used exterior optical methods for measurement. These techniques could lead to conservative values of crack growth rates in these specimens. This program evaluated a non-destructive ultrasonic method for monitoring crack growth rate. Aluminum alloy test specimens were used to calibrate the equipment and to assess the measurement accuracy and reproducibility. Together, the optical and ultrasonic techniques could lead to a more accurate assessment of stress corrosion crack growth in aerospace alloys through obtaining a truer picture of interior crack front shapes.

REPORT NO: AFML-TR-75-209 AD A026 520  
ACCESS NO: 204,336 April 1976  
TITLE: COMPOUNDS AND PROPERTIES OF THE Si-Al-O-N SYSTEM  
AUTHOR(S): P.L. Land, J.M. Wimmer, AFML and R.W. Burns and N.S. Choudhury, Technology Incorporated  
CONTRACT NO: F33615-71-C-1463  
CONTRACTOR: Technology Incorporated  
PROJECT MONITOR: P.L. Land (AFML/LLM)  
PROJECT NO: 7021  
TASK NO: 702103

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A product or quasi-equilibrium diagram for compounds formed in the system Si-Al-O-N at 1800°C in 1 atm N<sub>2</sub> is presented. X-ray diffraction spectra for several new phases are given and the reaction and sintering processes are discussed. Data for the lattice expansion of the  $\beta$ -Si<sub>3</sub>N<sub>4</sub> structure accompanying the incorporation of Al and O is presented and used to calculate theoretical densities.

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REPORT NO: AFML-TR-75-210 AD A031 004  
ACCESS NO: 204,483 April 1976  
TITLE: DIFFUSION BRAZING OF ALUMINUM ALLOYS  
AUTHOR(S): G.E. Metzger  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLM  
PROJECT MONITOR: G.E. Metzger (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735102  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The diffusion brazing of butt joints in 6061 and 7075 aluminum alloys in a vacuum atmosphere with mechanical pressure perpendicular to the joint was investigated. Filler metals included silver, gold, copper, magnesium, zinc, Al<sub>12</sub>Si and Ag<sub>28</sub>Cu in the form of foil, powder, electroplated deposits, and vapor deposits. Joints were examined by metallography, bend tests, tensile tests, and other mechanical tests. No successful filler metal for 7075 aluminum was developed. Both silver and Al<sub>12</sub>Si filler metal in foil form produced joints in 6061 aluminum with the tensile strength of the base metal in the T6 condition. The tensile elongation and bend ductility was good in both as-brazed and T6 conditions.

REPORT NO: AFML-TR-75-212 AD A023 622  
ACCESS NO: 204,249 December 1975  
TITLE: PROCEEDINGS OF THE ARPA/AFML REVIEW OF QUANTITATIVE NDE  
AUTHOR(S): D. O. Thompson  
CONTRACT NO: F33615-74-C-5180  
CONTRACTOR: Rockwell International  
PROJECT MONITOR: M.J. Buckley (AFML/LLP)  
PROJECT NO: 7351  
TASK NO: 735109  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The edited transcripts of the ARPA/AFML Review of Quantitative NDE held on July 15-17, 1975, at the Science Center, Rockwell International, are presented in this document. Several key topics form the core of these presentations and discussions. They include quantitative ultrasonics, adhesives, composites, and emissions related to the role of ultrasonic standards in the emerging quantitative ultrasonics area. It is believed that this document provides a reasonable summary of NDE research and development currently underway in the areas selected for presentation.

REPORT NO: AFML-TR-75-215 AD A025 165  
ACCESS NO: 204,297 March 1976  
TITLE: EFFECT OF IRON AND SILICON CONTENT ON STRESS CORROSION CRACKING IN A THERMOMECHANICALLY PROCESSED ALUMINUM ALLOY  
AUTHOR(S): P.J. Blau  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLS  
PROJECT MONITOR: P.J. Blau (AFML/LLS)  
PROJECT NO: 7351

TASK NO: 735105  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: A study of stress corrosion cracking in 7475 type aluminum alloy plates was conducted using five iron and silicon levels, chromium and zirconium minor additions, and two tempers: T651 and thermomechanical processing (TMP). The T651 specimens showed no clear effects of purity or minor addition on stress corrosion resistance; however, a large purity effect was seen in TMP specimens. As total iron and silicon content decreased from 0.31 to 0.02 weight percent, the 2000-hour threshold stress intensity about doubled in these alloys. In addition, TMP alloys showed a relationship between stress corrosion, threshold stress intensity, and precracked Charpy toughness.

REPORT NO: AFML-TR-75-216 AD A030 800  
 ACCESS NO: 204,467 September 1975  
 TITLE: DEVELOPMENT OF IMPACT RESISTANT METAL MATRIX COMPOSITES  
 AUTHOR(S): K.M. Prewo  
 CONTRACT NO: F33615-74-C-5062  
 CONTRACTOR: United Technologies Corporation  
 PROJECT MONITOR: J.S. Wilbeck (AFML/LLN)  
 PROJECT NO: 7351  
 TASK NO: 735107  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: Metal matrix composites consisting of boron reinforced aluminum, boron-aluminum-titanium, and Borsic reinforced titanium were fabricated to achieve improved impact tolerance. Test procedures included both static, instrumented pendulum impact, and ballistic impact. It was demonstrated that composite specimens can be fabricated and tested to achieve a wide range of impact resistance. Energy dissipation can exceed that of monolithic engineering alloys; however, this superiority is very geometry dependent.

REPORT NO: AFML-TR-76-8 AD A026 830  
 ACCESS NO: 204,360 February 1976  
 TITLE: USE OF THE EXPERIMENTAL POURBAIX DIAGRAM FOR D6ac STEEL TO INTERPRET ITS CORROSION BEHAVIOR IN AQUEOUS MEDIA  
 AUTHOR(S): E.D. Verink, Jr.  
 CONTRACT NO: F33615-73-C-5007  
 CONTRACTOR: University of Florida  
 PROJECT MONITOR: C. Lynch (AFML/LLN)  
 PROJECT NO: 7312  
 TASK NO: 731202  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: An experimental potential vs. pH diagram for D6ac high strength steel in 0.1 molar NaCl aqueous solutions was established based on cyclic potentiodynamic polarization, potentiostatic titration, and atomic adsorption analyses. This diagram is useful in assessing the tendency for general corrosion, crevice corrosion, pitting corrosion, and stress corrosion cracking. An artificial occluded cell was devised for crevice studies and the concept of crevice protection potential was verified for D6ac alloy in the aqueous solutions.

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REPORT NO: AFML-TR-76-17 AD A033 059  
ACCESS NO: 204,631 March 1976  
TITLE: RESPONSE OF MATERIALS TO IMPULSIVE LOADING  
AUTHOR(S): J.P. Barber and H.R. Taylor  
CONTRACT NO: F33615-73-C-5027  
CONTRACTOR: University of Dayton Research Institute  
PROJECT MONITOR: J.S. Wilbeck (AFML/LL)  
PROJECT NO: 7351  
TASK NO: 735106  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report describes work conducted on the response of composite materials to foreign object damage. The damage inflicted to both metal matrix and resin matrix composites was investigated by measuring the post impact residual mechanical properties of selected materials. Specimens were mounted as simply supported cantilevered beams and impacted with steel or rubber spheres. The residual tensile and fatigue strength of the material was then determined. The impact resistance of the composites investigated was shown to be much lower than that for titanium. The important mechanisms of material damage were identified and described in terms of a fracture mechanics based model.

REPORT NO: AFML-TR-76-22 AD A025 469  
ACCESS NO: 204,324 March 1976  
TITLE: CONSOLIDATION OF BETA III TITANIUM ALLOY SPHERICAL METAL POWDERS  
AUTHOR(S): N.C. Birla, V. DePierre and A.M. Adair  
CONTRACT NO: F33615-73-C-5097  
CONTRACTOR: University of Cincinnati  
PROJECT MONITOR: V. DePierre (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735108  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The AFML Tube Swaging Method was utilized for determining the processing parameters for producing fully consolidated products from Beta III titanium alloy spherical powders. Four temperatures (732°C, 760°C, 871°C and 954°C) and 4 percentage reductions (25.1, 37.5, 54.2 and 65.2) of the tube outside diameter were selected to study the consolidation effects of processing parameters. Fully consolidated powder products were obtained by 54.2 and 65.2% reductions at all four temperatures and 37.5% reduction at 954°C. The other processing conditions did not give fully dense products. Room temperature tensile and fracture toughness properties of the swaged powder products in the heat treated conditions were determined. The fully consolidated swaged powder products had tensile and fracture toughness properties equal to or better than reported properties of wrought products made from ingot Beta III titanium alloy. The properties of the other swaged powder products (not fully dense) reflected lower mechanical properties because of poor consolidation.

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REPORT NO: AFML-TR-76-23 AD A025 307  
ACCESS NO: 204,327 April 1976  
TITLE: HARDENING CHARACTERISTICS OF Ti-6Al-2Sn-4Zr-6Mo ALLOY  
AUTHOR(S): J.A. Hall  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLS  
PROJECT MONITOR: J.A. Hall (AFML/LLS)  
PROJECT NO: 7351  
TASK NO: 735105  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Research was conducted to develop heat treatments for Ti-6Al-2Sn-4Zr-6Mo alloy which have potential for minimizing microstructural and mechanical property variations in geometrically nonuniform components. Microstructure was found to be strongly dependent upon both the solution heat treating temperature and the cooling rate; solution heat treatments using two steps at differing temperatures appeared to minimize these differences. Certain heat treating conditions formed subgrain networks, called SERB, in the microstructure. Two maxima appeared to exist in the aging response curve for slowly cooled specimens aged at 1100°F and a potential mechanism for this phenomena was postulated. Fracture toughness was found to be inversely proportional to the amount of primary alpha phase present when relatively coarse acicular alpha exists. The fracture toughness for thick sections increased as the spread in the value of TUS-TYS increased.

REPORT NO: AFML-TR-76-31 AD A025 801  
ACCESS NO: 204,503 May 1976  
TITLE: ENVIRONMENTAL EFFECTS ON MAINTENANCE COSTS FOR AIRCRAFT EQUIPMENT  
AUTHOR(S): T.K. Moore  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LLN  
PROJECT MONITOR: L.T. Lynch (AFML/LLN)  
PROJECT NO: 7351  
TASK NO: 735106  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A series of mathematical models of the influence of environmental effects on maintenance costs was constructed using linear regression analysis. The equipment whose behavior was modeled was the KC-135 Doppler Radar and the F4E engine starter. Models explaining more than 20% of the variation in maintenance cost as a result of weather factors were developed (where only the two most current months' weather was considered). Recommendations for further research using more sophisticated model development techniques are presented. A limited economic analysis of some life cycle cost implications of failure countermeasures for increased environmental resistance is given.

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REPORT NO: AFML-TR-76-33 AD A025 968  
ACCESS NO: 204,504 April 1976  
TITLE: EFFECT OF INCLUSIONS ON THE MECHANICAL BEHAVIOR OF BERYLLIUM

AUTHOR(S): D.B. King, S.H. Gelles and T. Nicholas  
CONTRACT NO: F33615-74-C-5172  
CONTRACTOR: Brush Wellman, Incorporated  
PROJECT MONITOR: T. Nicholas (AFML/LLN)  
PROJECT NO: 7351  
TASK NO: 735106

DIST. STATEMENT: Approved for public release; distribution unlimited.

ABSTRACT: Samples of hot pressed and hot isostatically pressed S-65 beryllium were prepared from billets salted with iron base and graphite particles. Quasistatic tension, biaxial disc, and internally pressurized ring tests were performed to evaluate the effects of the resultant inclusions on the mechanical properties of beryllium. Inclusions in salted billets were characterized and compared with those found in production pressing. Fracture surfaces at inclusions were examined. Results indicate that inclusions degrade the mechanical properties of beryllium but not catastrophically. Surface inclusions were found to be more deleterious than internal inclusions. The salting technique was found to provide a convenient method for producing material for test specimens having inclusions of a predetermined type, size range and number which are representative of those found in production pressings.

REPORT NO: AFML-TR-76-34 AD A031 761  
ACCESS NO: 204,527 April 1976  
TITLE: ORDNANCE IMPACTS ON JET ENGINE FAN BLADES

AUTHOR(S): J.P. Barber and H.R. Taylor  
CONTRACT NO: F33615-75-C-5052  
CONTRACTOR: University of Dayton  
PROJECT MONITOR: J.S. Wilbeck (AFML/LLN)  
PROJECT NO: 7351  
TASK NO: 735106

ABSTRACT: This report describes the experimental section of a program to investigate the damage that a .50 cal of five inflicts on typical jet engine fan blade materials. Three materials, titanium, graphite epoxy composite and boron aluminum composite were perforated by .50 caliber ogives at 488 m/s. Two impact obliquities were investigated; 90° and 60° to trajectory. The momentum transfer during the impact was measured by use of a ballistic pendulum on which the targets were mounted. The momentum transfer was greatest for titanium, considerably lower for boron aluminum and even lower for graphite epoxy.

REPORT NO: AFML-TR-76-36  
ACCESS NO: 204,716 April 1976  
TITLE: PROPERTIES OF IONIC SOLIDS  
AUTHOR(S): E.C. Subbarao  
CONTRACT NO: AFSOR 71-2136  
CONTRACTOR: Indian Institute of Technology

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PROJECT MONITOR: J.M. Wimmer (AFML/LLM)  
PROJECT NO: 7021  
TASK NO: 702102  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report detailed the preparation of 'pure' and doped ionic solids, characterization of the defect structure, and the correlation of electrical transport properties with the defect structure. The three materials systems investigated were zirconia-base, thoria-base, and beta alumina. The zirconia monoclinic-tetragonal transformation was characterized as martensitic and a revised phase diagram for the system  $ZrO_2 - YO_{1.5}$  system was proposed. In the thoria-base system, electrical conductivity measurements in air indicated that isothermal conductivity increased with CaO content and reached a broad maximum. The electrical conductivity of sodium doped B and B"  $Al_2O_3$  was found to be a function of sodium content, frequency, temperature, and type of electrode employed. It was found that conductivity values obtained with molten  $NaNO_3$  electrodes were 10-15 times higher than values obtained with silver paste.

REPORT NO: AFML-TR-76-39 AD A025 734  
ACCESS NO: 204,328 March 1976  
TITLE: NEW APPROACHES TO TITANIUM ALLOY MICROSTRUCTURE-PROPERTY RELATIONSHIPS  
AUTHOR(S): J.J. Dreher and M. Rosenblum  
CONTRACT NO: F33615-75-C-5169  
CONTRACTOR: University of Cincinnati  
PROJECT MONITOR: J. Santner (AFML/LLS)  
PROJECT NO: 7353  
TASK NO: 735302  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report, in three sections, contains (1) a statistical sampling technique for determining photomicrograph homogeneity and replicability, (2) an optical structure-detection method using the stroboscope and color-separated prints, and (3) an opti-acoustical procedure for translating microstructure into sound. Also included is a description of a multiple platform turntable for simultaneous viewing of several photomicrographs. Significant and high correlations among microstructures and several mechanical properties are shown.

REPORT NO: AFML-TR-76-44 AD A031 464  
ACCESS NO: 204,541 June 1976  
TITLE: ADAPTIVE NONLINEAR SIGNAL PROCESSING FOR CHARACTERIZATION OF ULTRASONIC NDE WAVEFORMS TASK 2: MEASUREMENT OF SUBSURFACE FATIGUE CRACK SIZE  
AUTHOR(S): R. Shankar, A.N. Mucciard, D. Cleveland, W. Lawrie and H.L. Reeves  
CONTRACT NO: F33615-74-C-5122  
CONTRACTOR: Adaptronics, Incorporated  
PROJECT MONITOR: M.J. Buckley (AFML/LLP)  
PROJECT NO: 7351  
TASK NO: 735109

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DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A new NDE nonlinear signal processing system has been developed to detect and measure small, subsurface fastener hole fatigue cracks. The system synthesized from nondestructive evaluation (NDE) waveform parameter inputs is capable of detecting and measuring quantitatively subsurface fatigue cracks in the size range of 0 to 279 mils to within 70 percent of their nominally characterized lengths. The measurement system reported herein is the first known fatigue crack NDE system capable of detection and measurement for this wide range. The major conclusion regarding this new NDE signal processing software system is that subsurface fatigue crack length can be accurately measured from the information contained in the ultrasonic NDE signature. In particular, cracks below 30 mils, heretofore undetectable, can be detected and measured with reasonable accuracy.

REPORT NO: AFML-TR-76-45 AD A033 187  
ACCESS NO: 204,629 August 1976  
TITLE: FORMABLE SHEET TITANIUM ALLOYS  
AUTHOR(S): G. Lenning  
CONTRACT NO: F33615-74-C-5063  
CONTRACTOR: TIMET Division of Titanium Metals Corporation  
PROJECT MONITOR: W. Kerr (AFML/LLS)  
PROJECT NO: 7351  
TASK NO: 735105

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The objectives of this program were to evaluate three promising experimental alloys by optimizing mill processing using formability, forgeability, and uniformity and consistency of properties as the criteria. The three alloys were: 1) Ti-8V-7Cr-3Al-4Sn-1Zr, 2) Ti-8V-4Cr-2Mo-2Fe-3Al, and 3) Ti-15V-3Cr-3Al-3Sn. The three mill processes examined were: 1) conventional cold strip processing, 2) conventional hot mill processing to plate followed by cold hand mill rolling to sheet, 3) conventional hot mill processing. The materials from the two cold roll processes showed the better forming potential and were selected for extensive mechanical property and formability evaluation. All three alloys offer improved mechanical properties over those for existing titanium sheet alloy airframe materials.

REPORT NO: AFML-TR-76-48 AD A030 605  
ACCESS NO: 204,708 May 1976  
TITLE: SOLID MECHANICS OF FLOW, FRACTURE, CREEP, AND FATIGUE  
AUTHOR(S): T.S. Cook  
CONTRACT NO: F33615-73-C-4072  
CONTRACTOR: Pratt and Whitney  
PROJECT MONITOR: H. Lipsitt (AFML/LLM)  
PROJECT NO: 7021  
TASK NO: 702101  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The causes and consequences of plastic flow concentration were investigated in order to gain a better understanding of the major microstructural parameters affecting plastic flow concentration in precipitation

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hardened materials. Micromechanical models that contribute to the understanding of deformation and fracture of high strength precipitation hardened materials were developed. The models have enabled the important, microstructural parameters to be defined and quantitatively related to the propensity for plastic flow concentration. The results of this work will enable alloy developers to concentrate on the appropriate microstructural features to minimize flow concentration.

REPORT NO: AFML-TR-76-56, Part I AD A030 878  
ACCESS NO: 204,487 May 1976  
TITLE: IMPACT RESISTANCE OF STRUCTURAL CERAMICS PART I:  
INSTRUMENTED DROP-WEIGHT TESTS  
AUTHOR(S): I. Bransky, J.M. Wimmer and N.M. Tallan  
CONTRACT NO: F33615-73-C-4155  
CONTRACTOR: Technology, Incorporated  
PROJECT MONITOR: J.M. Wimmer (AFML/LLM)  
PROJECT NO: 7021  
TASK NO: 702102  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Two mechanisms can lead to failure of ceramics under impact, 1) failure due to flexural stresses and 2) failure due to Hertzian type cracks introduced locally by the impactor. An instrumented drop-weight test designed to study failure due to flexural stresses is described and used to study various forms of silicon nitride and silicon carbide up to 1300°C. Results on alumina sialon are included for comparison. From the standpoint of impact resistance, hot-pressed silicon nitride is the best material.

REPORT NO: AFML-TR-76-57  
ACCESS NO: 204,596 May 1976  
TITLE: OPTICAL DETECTION OF ULTRASOUND IN PARAMAGNETIC CRYSTALS  
AUTHOR(S): A. Attia and A.H. Francis  
CONTRACT NO: F33615-73-C-5048  
CONTRACTOR: University of Illinois  
PROJECT MONITOR: M. Buckley (AFML/LLP)  
PROJECT NO: 7353  
TASK NO: 735308  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Optical detection methods were employed to investigate the interaction of applied coherent phonons with the excited state spin system of molecular crystals. Results are reported and discussed concerning both single and double quantum resonant interactions as well as phonon-nuclear quadrupole interactions and non-resonant spin-phonon interactions.

REPORT NO: AFML-TR-76-60 AD A030 606  
ACCESS NO: 204,470 May 1976  
TITLE: METALLURGICAL FACTORS CONTROLLING STRUCTURE IN HIGH  
STRENGTH ALUMINUM P/M PRODUCTS  
AUTHOR(S): W.L. Otto, Jr.

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CONTRACT NO: F33615-74-C-5077  
CONTRACTOR: Aluminum Company of America  
PROJECT MONITOR: W. Griffith (AFML/LLS)  
PROJECT NO: 7351  
TASK NO: 735105  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The effects of process variables upon the structure/  
property relationships for Al-Zn-Mg-Cu-Co powder metallurgy alloys were investi-  
gated. Variations in alloy composition atomized powder characteristics, hot  
compacting procedures, hot work operations and heat treatments were evaluated by  
tensile, stress corrosion, toughness and fatigue crack growth rate testing, as  
well as microstructural examination. Optimum process steps were identified,  
resulting in P/M products with properties superior to those of commercial 7000  
series ingot alloys. In particular, the P/M MA87 alloy was reviewed. Of special  
significance was the improved resistance to fatigue crack growth rate of this  
alloy. P/M MA87 alloy forging fabricated from triple upset and drawn billet  
demonstrated fatigue crack growth rates 15 to 1000% slower than 7050 alloy  
forgings.

REPORT NO: AFML-TR-76-61 AD A027 266  
ACCESS NO: 204,368 May 1976  
TITLE: THEORIES ON FLOW AND FRACTURE IN METALWORKING PROCESSES  
PART I: A THEORY OF METAL FLOW IN AXISYMMETRIC PIERCING  
AND EXTRUSION PART II: A THEORY ON DUCTILE FRACTURE  
IN METALWORKING PROCESSES

AUTHOR(S): Part I: S.N. Shah and S. Kobayashi  
Part II: S.I. Oh and S. Kobayashi

CONTRACT NO: F33615-75-C-5151  
CONTRACTOR: University of California  
PROJECT MONITOR: V. DePierre (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735108  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The objective of this investigation was to establish  
theories on flow and fracture in order to apply workability theory to metal-  
working processes. In Part I, the matrix method was refined by the use of a  
different linearization technique, and the area of its application was expanded  
through the introduction of a technique for effectively treating the nonde-  
forming regions in the computation. The refined version of the method was then  
applied to a non-steady-state process of axisymmetric piercing and a steady-  
state process of axisymmetric extrusion. In Part II, the deformation mode of  
void growth was re-examined using the model proposed previously, but with formu-  
lations for large elastic-plastic deformation. The results show that the non-  
uniform mode, due to void interaction, could reduce the fracture strain by  
several times compared to the results based on uniform void growth. The results  
also lead to a question as to the effect of the void-free surface.

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REPORT NO: AFML-TR-76-80 AD A031 776  
ACCESS NO: 204,622 August 1976  
TITLE: DEVELOPMENT OF TITANIUM ALLOY CASTING TECHNOLOGY  
AUTHOR(S): D.R. Schuyler, J.A. Pelrusa, G.S. Hall, and S.R. Seagle  
CONTRACT NO: F33615-74-C-5055  
CONTRACTOR: Garrett Corporation  
PROJECT MONITOR: W. Kerr (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735108  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This program was conducted to develop the technologies necessary to establish a low-cost approach for producing titanium investment castings. This approach was based on using simpler and cheaper melting and casting techniques, common to steel and superalloy investment foundries, for producing high-quality, low-cost titanium castings. Program objectives included: (1) development of a low-melting titanium alloy displaying adequate tensile properties, (2) development of low reactivity ceramics for use in melting crucibles and investment mold facecoats, (3) establishing an induction melting and vacuum casting capability using the above technologies. The concept of producing titanium castings using low-melting alloys, vacuum induction melting in a ceramic crucible and low-reactivity investment molds was successfully demonstrated and offers the potential for further production of low-cost, high-quality, titanium castings.

REPORT NO: AFML-TR-76-89 AD A030 794  
ACCES NO: 204,539 June 1976  
TITLE: COMPARISON OF PROCESSING PROPERTIES AND PRODUCT PROPERTIES OF BETA III TITANIUM ALLOY POWDER METAL (PM) AND INGOT METAL (IM)  
AUTHOR(S): N. Birla, V. DePierre and A.M. Adair  
CONTRACT NO: F33615-73-C-5097  
CONTRACTOR: University of Cincinnati  
PROJECT MONITOR: V. DePierre (AFML/LLM)  
PROJECT NO: 7351  
TASK NO: 735108  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Processing properties of Beta III titanium alloy powder metal (PM) and ingot material (IM) were compared. Both materials were processed under the same conditions (extruded at 760°C and 954°C with 4:1, 6:1 and 10:1 reduction ratios, extruded and forged at 760°C and 954°C and given STA and STA+OA heat treatments). No significant differences were noted between the processing properties of these materials except for the slightly higher extrusion pressures required for the powder metal (PM) at 954°C. Room temperature mechanical properties of the powder metal (PM) and ingot material (IM) products processed under the same conditions were compared.

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REPORT NO: AFML-TR-76-90 AD A031 315  
ACCESS NO: 204,538 March 1976  
TITLE: THE INFLUENCE OF STRAIN-RATE HISTORY AND TEMPERATURE ON  
THE SHEAR STRENGTH OF COPPER, TITANIUM AND MILD STEEL  
AUTHOR(S): A.M. Eleiche and J.D. Campbell  
CONTRACT NO: AFSOR 71-2056  
CONTRACTOR: University of Oxford, England  
PROJECT MONITOR: T. Nicholas (AFML/LLN)  
PROJECT NO: 7353  
TASK NO: 735303  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Experiments have been carried out to determine the strain-  
rate sensitivity of the shear flow stress of OFHC copper, commercially-pure  
titanium and mild steel over the temperature range -150° to 400°C. All the  
tests were performed on thin-walled tubular specimens of short gauge length,  
mounted in a torsional split Hopkinson-bar apparatus adapted to permit quasi-  
static straining as well as dynamic straining. Comparison of the results ob-  
tained in the two series of tests shows that the response of all three materials  
depends on the strain-rate history, so that a 'mechanical equation of state'  
relating stress to strain, strain rate and temperature is not valid; however,  
the influence of strain-rate history is less marked for titanium than for copper  
or mild steel.

REPORT NO: AFML-TR-76-91 AD A032 554  
ACCESS NO: 204,609 August 1976  
TITLE: CONTROLLED COMPOSITION REACTION SINTERING PROCESS FOR  
PRODUCTION OF MCrAlY COATINGS  
AUTHOR(S): W.G. Stevens and A.R. Stetson  
CONTRACT NO: F33615-75-C-5268  
CONTRACTOR: Solar Division, International Harvester  
PROJECT MONITOR: J. Crosby (AFML/LLM)  
PROJECT NO: 7312  
TASK NO: 731201  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The feasibility of the fluidized bed-controlled composition  
reaction sintering process for depositing sulfidation resistant and ductile  
CoNiCrAlY coatings in simple clad shapes of nickel-based superalloys has been  
demonstrated. Critical process parameters of all steps in the process have been  
identified. Methods were developed for adjusting the coating composition to  
emphasize either the chemical or mechanical properties of these coatings.

REPORT NO: AFML-TR-76-97 AD A031 766  
ACCESS NO: 204,522 June 1976  
TITLE: HIGH TEMPERATURE CREEP OF CERAMICS  
AUTHOR(S): M.S. Seltzer  
CONTRACT NO: F33615-73-C-4111  
CONTRACTOR: Battelle, Columbus Laboratory  
PROJECT MONITOR: J.M. Wimmer (AFML/LLM)

PROJECT NO: 7021  
 TASK NO: 702102  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: Tensile and compression creep measurements were made on yttria-stabilized zirconia (YSZ), hot-pressed silicon nitride and silicon materials in atmospheres including air, nitrogen, argon, and vacuum. For relatively fine-grained YSZ (below 40 microns), the 1.5 power of the applied stress at low stresses and with the stress cubed at high stresses, but results for coarse grained specimens can generally be fitted by the cube dependence. Creep activation energies for YSZ are found to be 128 kcal/mole independent of yttria content, impurity level, grain size, and porosity distribution. For the silicon compounds, at least two different creep mechanisms are operative in the range of temperatures and stresses employed in this study. A grain boundary sliding mechanism, characterized by a stress dependence of two and an activation energy 168 kcal/mole, appears to be operative for hot-pressed silicon nitride; but a viscous creep mechanism predominates for some SiAlON materials, where a linear stress dependence and an activation energy of 94 kcal/mole have been measured.

REPORT NO: AFML-TR-76-105  
 ACCESS NO: 204,619 June 1976  
 TITLE: STUDY OF INTERMETALLIC COMPOUNDS  
 AUTHOR(S): C.G. Rhodes, A.G. Evans and N.E. Paton  
 CONTRACT NO: F33615-75-C-1090  
 CONTRACTOR: Rockwell International  
 PROJECT MONITOR: H. Lipsitt (AFML/LLM)  
 PROJECT NO: 7021  
 TASK NO: 702101  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: This report describes results of mechanical property tests and microstructure studies on a series of alloys based on the intermetallic compounds  $Ti_3Al$  and  $TiAl$ . This class of alloys has shown considerable promise for high temperature applications and the objective of this program has been to study the microstructure of a series of alloys containing both phases with a view to improving the mechanical properties. It has been shown that a variety microstructures can be produced in a Ti-26% Al - 10% Nb base alloy, either by addition of ternary and quaternary alloying elements or by heat treatment.

REPORT NO: AFML-TR-76-107 AD A032 012  
 ACCESS NO: 204,635 July 1976  
 TITLE: STUDY OF INTERMETALLIC COMPOUND  
 TASK A: DISPERSION-HARDENED  $TiAl$   
 AUTHOR(S): I.G. Wright and A.H. Clauer  
 CONTRACT NO: F33615-75-C-1168  
 CONTRACTOR: Battelle, Columbus Laboratories  
 PROJECT MONITOR: H. Lipsitt (AFML/LLM)  
 PROJECT NO: 7021  
 TASK NO: 702101  
 DIST. STATEMENT: Approved for public release; distribution unlimited.

**ABSTRACT:** The feasibility of increasing the high-temperature tensile and creep strength, the high-temperature oxidation resistance and the low temperature ductility of the titanium aluminide, TiAl, by means of a dispersion of inert particles of yttria has been studied. Alloys containing 1.5 and 3 volume percent  $Y_2O_3$  were produced by attritor milling of TiAl and  $Y_2O_3$  powders and hot extruding to bar stock.

REPORT NO: AFML-TR-76-120 AD A030 875  
 ACCESS NO: 204,488 August 1976  
 TITLE: INHIBITION OF CRACK PROPAGATION OF HIGH STRENGTH STEELS THROUGH SINGLE AND MULTIFUNCTIONAL INHIBITORS  
 AUTHOR(S): C.T. Lynch, K.J. Bhansali and P.A. Parrish  
 CONTRACT NO: Internal  
 CONTRACTOR: AFML/LLM  
 PROJECT MONITOR: C.T. Lynch (AFML/LLM)  
 PROJECT NO: 7351  
 TASK NO: 735106  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: Oxidizing inhibitors may be used to retard crack propagation for high strength low alloy steels. For D6AC, the use of such inhibitors gives promise of being able to avoid hydrogen embrittlement. The critical stress intensity factor  $K_{Isc}$  apparently may also be manipulated by use of oxidizing inhibitors. Preliminary data on multifunctional inhibitors indicates that combinations of cathodic and anodic types are more effective than the common anodic inhibitors such as chromate. Hydrazine and the related nitrite ion are more effective inhibitors than chromate for steel in the presence of chloride.

REPORT NO: AFML-TR-76-132 AD A029 477  
 ACCESS NO: 204,398 May 1976  
 TITLE: ELECTROMAGNETIC GENERATION OF ELECTRONICALLY STEERED ULTRASONIC BULK  
 AUTHOR(S): R. Panos and T. Moran  
 CONTRACT NO: Internal  
 CONTRACTOR: AFML/LLP  
 PROJECT MONITOR: R. Panos (AFML/LLP)  
 PROJECT NO: 7353  
 TASK NO: 735308  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: The frequency dependence of the propagation direction of ultrasonic shear and longitudinal waves generated by a meander-line electromagnetic transducer (EMAT) at MHz frequencies has been determined. The results are found to agree well with theory and demonstrate that electronic beam steering is possible using EMAT's. The relative efficiency of generation in aluminum was also studied, and for a specific meander-line geometry with a permanent magnet providing the necessary static magnetic field, it was found to be relatively flat versus frequency. Efficiency for shear-wave generation (frequency range, 5-9 MHz) was about 4 dB per conversion less than the Rayleigh -wave generation efficiency at 4.6 MHz and for longitudinal waves (frequency range, 10-24 MHz) about 10 dB less.

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REPORT NO: AFML-TR-76-139 AD A032 656  
ACCESS NO: 204,597 August 1976  
TITLE: FRACTURE OF BRITTLE MATERIALS AT HIGH TEMPERATURES  
AUTHOR(S): S.M. Wiederhorn  
CONTRACT NO: F33615-73-M-5601  
CONTRACTOR: U.S. Department of Commerce, National Bureau of Standards  
PROJECT MONITOR: J.M. Wimmer (AFML/LLM)  
PROJECT NO: 7021  
TASK NO: 702101  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report summarizes the results of a program to study the high-temperature fracture properties of ceramic materials that are anticipated for us in turbine applications. As a result of this program, new techniques have been developed for the study of fracture at high temperatures; new theories have been developed for the application of fracture mechanics to design; and new experimental data on high temperature fracture have been generated.

REPORT NO: AFML-TR-76-174 AD A033 574  
ACCESS NO: 204,637 October 1976  
TITLE: A CRACK GROWTH GAGE FOR ASSESSING FLAW GROWTH POTENTIAL IN STRUCTURAL COMPONENTS  
AUTHOR(S): R.L. Crane, A.F. Grandt and J.P. Gallagher  
CONTRACT NO: Interanl  
CONTRACTOR: AFML and AFFDL  
PROJECT MONITOR: R.L. Crane (AFML/LLP)  
PROJECT NO: 2279  
TASK NO: 227901  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A new concept for monitoring the potential for damage accumulation in structural materials is presented. Briefly, the method proposed is to install a preflawed gage on a critical component and to monitor its flaw growth nondestructively. The relationship between this flaw size and the potential flaw in the structure is derived using linear elastic fracture mechanics principles. Experimental flaw growth data produced by an aircraft spectrum was used to demonstrate the validity of a degenerate case of this concept. A discussion is also presented to show how this method could be implemented in fulfillment of the Mil-Std-1630 requirement to track potential flaw growth.

ELECTROMAGNETIC MATERIALS DIVISION (AFML/LP)

REPORT NO: AFML-TR-67-229 AD 820 357  
 ACCESS NO: 204,658 August 1967  
 TITLE: RESEARCH ON MATERIALS ESSENTIAL TO CRYOCOOLER TECHNOLOGY  
 AUTHOR(S): R.G. Clark, G.O. Kuebler, R.F. Weimer, and B. Bailey  
 CONTRACT NO: AF33(615)-2191  
 CONTRACTOR: Air Products and Chemicals  
 PROJECT MONITOR: E.J. Rolinski and P. Dimiduk  
 PROJECT NO: 1470  
 TASK NO: 147003  
 DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: This report presents what are considered to be the most useful sources of PVT, enthalpy, entropy, experimental heat capacity, viscosity, and thermal conductivity data for helium, neon, nitrogen, and argon. For each source selected, the source reference, the methods used or the basis of the data, the format for presentation of the results and the stated accuracy are discussed. Pressure-temperature diagrams are presented to show the regions covered by the various sources. The experimental program to provide PVT, thermal conductivity and viscosity data required for the correlation study is defined. The thermal conductivity apparatus is described. The use of binary mixtures of cryogenes as refrigerants is discussed as are the problems associated with the use of subliming solids as refrigerants.

REPORT NO: AFML-TR-74-37, Part II  
 ACCESS NO: 204,466 December 1975  
 TITLE: RESEARCH AND DEVELOPMENT ON CHARACTERIZATION OF ELECTROMAGNETIC MATERIALS  
 AUTHOR(S): D. Early, P. Franklin, R. Harris, and S. Stevens  
 CONTRACT NO: F33615-72-C-1666  
 CONTRACTOR: University of Dayton Research Institute  
 PROJECT MONITOR: P. Dimiduk (AFML/LPJ)  
 PROJECT NO: 7360  
 TASK NO: 736001  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: The first section of this report covers research on thermodynamic property measurements and calculations of (Hg, Cd, Te) system, CdTe, ZnSe, samarium, cobalt, and titanium-iron alloy systems. A bibliography on high temperature mass spectrometry from Chemical Abstracts from 1970-1973 includes 343 references. The second section includes chemical physical studies on dye laser materials. Dye laser materials were characterized as to: (1) absorption spectrum, (2) fluorescence emission spectrum, (3) radioactive decay lifetime of fluorescence, (4) intersystem crossing rate and triplet-triplet absorption spectrum, and (5) various laser emission parameters.

REPORT NO: AFML-TR-75-55 AD A031 740  
 ACCESS NO: 204,509 May 1976  
 TITLE: GALLIUM DIFFUSION IN SILICON DIOXIDE  
 AUTHOR(S): P.M. Hemenger  
 CONTRACT NO: Internal

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CONTRACTOR: AFML/LPO  
PROJECT MONITOR: P.M. Hemenger (AFML/LPO)  
PROJECT NO: 7371  
TASK NO: 737102  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The behavior of Ga in sputtered SiO<sub>2</sub> films is examined with the result that diffusion is observed during annealing at 850°C. The accumulated evidence indicates that SiO<sub>2</sub> is not an effective film to use on a GaP or GaAs for protection against Ga loss during high temperature anneals. The method employed to make the measurement, Rutherford backscattering (RBS) analysis of SiO<sub>2</sub>:Ga :SiO<sub>2</sub> sandwiches, is demonstrated to be effective and applicable to other systems. The value of RBS as a general tool for thin film analysis is demonstrated by measuring the thickness and compositions of several types of films as well as the concentrations and locations of impurities.

REPORT NO: AFML-TR-75-88 AD A011 749  
ACCESS NO: 204,702 April 1975  
TITLE: MEASUREMENT OF HIGH RESISTIVITY SEMICONDUCTORS USING THE VAN DER PAUW METHOD

AUTHOR(S): P.M. Hemenger  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LPO  
PROJECT MONITOR: P.M. Hemenger (AFML/LPO)  
PROJECT NO: 7371  
TASK NO: 737102  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Apparatus is described that permits measurement of the electrical transport properties of semiconductors with resistance values over 10<sup>12</sup>Ω. The system utilizes a guarded approach to the van der Pauw method which simplifies sample geometry and contacting and permits evaluation of thin layers. The equipment is easy to operate, reliable and constructed of readily available commercially purchased components.

REPORT NO: AFML-TR-75-99 AD A017 097  
ACCESS NO: 204,706 August 1975  
TITLE: DEVELOPMENT OF DEICING TECHNIQUES FOR DIELECTRIC WINDOWS  
AUTHOR(S): E.A. Strouse  
CONTRACT NO: F33615-73-C-1080  
CONTRACTOR: Perkin-Elmer Corporation  
PROJECT MONITOR: D.W. Fischer (AFML/LPO)  
PROJECT NO: 7371  
TASK NO: 737101  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report covers measurements and techniques that have led to the development of the first prototype windows coated with a continuous thin-film heater transparent in the 8 to 12 micron spectral region. The effort involved the measurement of the complex optical constants of indium-tin-oxide and the dependence of these values on both process parameters and the conductivity of the films. The performance of a full coated window has a transmission

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greater than 70%, and a sheet resistance of 160 /square is described. Also included is a thermo-optical analysis of conductive films and patterns for zinc sulfide, zinc selenide and zinc sulfoselenide windows.

REPORT NO: AFML-TR-75-162 AD A027 228  
ACCESS NO: 204,362 April 1976  
TITLE: ANALYSIS OF THE MOSSBAUER SPECTRA OF NdCo<sub>5</sub>  
AUTHOR(S): E.W. Skluzacek  
CONTRACT NO: Internal  
CONTRACTOR: AFIT  
PROJECT MONITOR: P. Hemenger (AFML/LPO)  
PROJECT NO: 7367  
TASK NO: 736703  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Permanent magnet production with rare-earth transition element compounds is not a well defined science because microscopic processes in these materials are not understood well. A study was conducted to analyze the Mossbauer spectra of NdCo<sub>5</sub> doped with 3% Fe<sup>57</sup> to determine the nuclear environment at each nonequivalent crystal lattice site. Absorption spectra were obtained for absorber temperatures of 300, 265, 255, 245, 235, 230 and 77K, but poor velocity information, faulty temperature control and vacuum pump vibrations caused uncertainties in the accuracy of the spectra, especially near zero velocity. Each spectrum was fit to a sum of Lorentzian profiles using a least-squares-minimization fitting program. Although the complex spectra were not accurately decomposed into individual site contributions, it was concluded that Fe<sup>57</sup> atoms may reside in four nonequivalent sites. Preliminary results also indicated that the two non-Co sites cause the temperature dependent changes in the spectra.

REPORT NO: AFML-TR-75-170 AD B011 470  
ACCESS NO: 204,304 October 1975  
TITLE: APPLICATION OF POLYCRYSTALLINE ZnSe PREPARED BY CHEMICAL VAPOR DEPOSITION TO HIGH POWER IR LASER WINDOWS  
AUTHOR(S): A.W. Swanson and J. Pappis  
CONTRACT NO: F33615-74-C-5058  
CONTRACTOR: Raytheon Research Division  
PROJECT MONITOR: G. Kuhl (AFML/LPO)  
PROJECT NO: 317J  
TASK NO: 317J00  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The significance of this research and development program to the Air Force is the proven demonstration of fabricating CVD zinc selenide for high power laser window applications by a fully automated process. The absorption coefficient of the material was lowered by eliminating foreign inclusions of greater than 1 mil size by filtration of the zinc vapor prior to deposition. Significant progress was also made in identifying the causes of visible scatter sites in the material. Based on experimental results, the best overall optical material is deposited when the H<sub>2</sub>Ze/Zn molar ratio is greater

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than 1. Finally, it has been shown that under carefully controlled conditions, low-loss surfaces and AR coatings can be applied to CVD ZnSe.

REPORT NO: AFML-TR-75-172 AD A023 631  
ACCESS NO: 204,248 November 1975  
TITLE: THE CRYSTAL GROWTH AND APPLICATION OF SULFOSALT MATERIALS  
AUTHOR(S): G.W. Roland, J.D. Feichtner, M. Rubenstein and W.E. Kramer  
CONTRACT NO: F33615-72-C-1976  
CONTRACTOR: Westinghouse Electric Corporation  
PROJECT MONITOR: V. Donlan (AFML/LPJ)  
PROJECT NO: 2071  
TASK NO: 207100  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Optimized crystal growth compositions were determined for  $Tl_3PS_4$  and  $Tl_3PSe_4$  and crystal growth from these compositions resulted in remarkably improved optical quality. The optical absorption was reduced to less than  $10\%/cm^{-1}$ . Two successful device applications of new single crystal sulfosalt materials were made.  $Tl_3AsSe_3$  was used in an infrared tunable collinear acousto-optic filter in the 3-5  $\mu m$  region. Operation to 5.3  $\mu m$  was achieved, which is the longest wavelength at which any such device has yet been used.  $Tl_3AsS_4$  was successfully used as a laser intracavity acousto-optic modulator and Q-switch with low drive power requirements. Technical difficulties believed to be associated with two-photon absorption of pump radiation or with phase matching problems prevented successful operation of a 2.1  $\mu m$ -pumped optical parametric oscillator on  $Tl_3AsSe_3$ .

REPORT NO: AFML-TR-75-183, Volume I AD A026 831  
ACCESS NO: 204,363 December 1975  
TITLE: EXPLORATORY DEVELOPMENT OF LASER-HARDENED MATERIALS AND MEASUREMENT OF LASER-BEAM PARAMETERS AND MATERIAL RESPONSE TO HIGH-POWER LASER RADIATION VOLUME I  
AUTHOR(S): C.T. Walters, R.E. Beverly, III, and T.J. Negrelli  
CONTRACT NO: F33615-73-C-5045  
CONTRACTOR: Battelle, Columbus Laboratories  
PROJECT MONITOR: D. Stevison (AFML/LPJ)  
PROJECT NO: 7360  
TASK NO: 736001  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This three-volume report summarizes research efforts undertaken in a two-year research program to develop two laboratories at AFML for studies of the interaction of high-power  $CO_2$  laser beams with materials of interest to the USAF. In Volume I, various elements of the laboratories developed by Battelle are discussed including systems for beam transport, event sequencing safety control, irradiation timing, alignment, target air flow, data acquisition, data reduction, and laser beam mapping. Target diagnostic techniques are also described in Volume I. Volume II contains Appendices A-E which present detailed schematics, listings, and drawings for some of the laser laboratory systems. Volume III contains Appendix F (classified) which presents a new concept for hardening materials to laser radiation.

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REPORT NO: AFML-TR-75-183, Volume II AD A026 915  
ACCESS NO: 204,363 December 1975  
TITLE: EXPLORATORY DEVELOPMENT OF LASER-HARDENED MATERIALS AND  
MEASUREMENTS OF LASER BEAM PARAMETER AND MATERIAL RESPONSE  
TO HIGH-POWER LASER RADIATION VOLUME II APPENDICES A-E  
AUTHOR(S): C.T. Walters, R.E. Beverly, III, and T.J. Negrelli  
CONTRACT NO: F33615-73-C-5045  
CONTRACTOR: Battelle, Columbus Laboratories  
PROJECT MONITOR: D. Steverson (AFML/LPJ)  
PROJECT NO: 7360  
TASK NO: 736001  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This three-volume report summarizes research efforts under-  
taken in a two-year research program to develop two laboratories at AFML for  
studies of the interaction of high-power CO<sub>2</sub> laser beams with materials of  
interest to the USAF. In Volume I, various elements of the laboratories devel-  
oped by Battelle are discussed including systems for beam transport, event se-  
quencing, safety control, irradiation timing, alignment, target air flow, data  
acquisition, data reduction, and laser beam mapping. Target diagnostic techniques  
are also described in Volume I. Volume II contains Appendices A-E which present  
detailed schematics, listings, and drawings for some of the laser laboratory  
systems. Volume III contains Appendix F (classified) which presents a new con-  
cept for hardening materials to laser radiation.

REPORT NO: AFML-TR-75-188 AD B011 596  
ACCESS NO: 204,305 January 1976  
TITLE: INVESTIGATION OF CRYSTAL ORIENTATION INFLUENCE ON THIN  
FILM COATINGS FOR CaF<sub>2</sub> LASER WINDOWS  
AUTHOR(S): S.J. Holmes and P. Kraatz  
CONTRACT NO: F33615-75-C-5190  
CONTRACTOR: Northrop Research and Technology Center  
PROJECT MONITOR: M.C. Ohmer (AFML/LPO)  
PROJECT NO: 317J  
TASK NO: 317J00  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The objective of this program was to obtain information  
on the relationship between the crystallographic orientation of CaF<sub>2</sub> substrate  
material and the structure and optical properties of deposited thin film coat-  
ings. This information will be used to design highly efficient (low reflectance  
and absorption losses) coatings on CaF<sub>2</sub> windows for use in high power laser  
applications in the 2-6 μm spectral region. Specific tasks include: 1) deter-  
mination of the refractive indices of thin film coatings of ThF<sub>4</sub>, PbF<sub>2</sub>, MgF<sub>2</sub>,  
BaF<sub>2</sub> and SrF<sub>2</sub> on (100), (110) and (111) oriented CaF<sub>2</sub> substrates; 2) determi-  
nation of crystalline structure of the thin films as a function of substrate ori-  
entation and 3) design of antireflection coatings for CaF<sub>2</sub>. The results of  
this program include: 1) determination of the optical properties of the var-  
ious thin films at 3 wavelengths; 2) determination of the crystalline structure  
and orientation properties of the deposited films and 3) design and deposition

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of antireflection coatings for the three substrate orientations and wavelengths, and 4) design and deposition of antireflection coatings at 3.8  $\mu\text{m}$  for polycrystalline  $\text{CaF}_2$ .

REPORT NO: AFML-TR-75-190 AD A027 398  
ACCESS NO: 204,377 December 1975  
TITLE: PHYSICAL PROPERTIES OF RARE EARTH-COBALT MAGNETS  
(ALTERNATOR SERVICE AGING STUDY)  
AUTHOR(S): H.F. Mildrum and K.J. Strnat  
CONTRACT NO: F33615-74-C-5056  
CONTRACTOR: University of Dayton  
PROJECT MONITOR: J.C. Olson (AFML/LPJ)  
PROJECT NO: 7371  
TASK NO: 737103  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The principal objective of this program was to investigate the long-term performance stability of an aircraft alternator under conditions simulating its operation in flight. This alternator uses sintered Sm-Co permanent magnets in its rotor. The report describes the design of a test stand for subjecting the machine to cyclic operation at speeds to 11000 rpm and thermal exposure in air up to 215°C. Photomicrographs of selected test specimens were examined and the observations correlated to the aging performance of the magnets.

REPORT NO: AFML-TR-75-198 AD A024 208  
ACCESS NO: 200,651 January 1976  
TITLE: ELECTRON IMPACT IONIZATION CROSS SECTIONS OF GOLD, CHROMIUM AND IRON  
AUTHOR(S): A.N. Nelson  
CONTRACT NO: F33615-71-C-1420  
CONTRACTOR: MIT  
PROJECT MONITOR: P. Dimiduk (AFML/LPJ)  
PROJECT NO: 7367  
TASK NO: 736704  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Relative and absolute electron impact ionization cross sections were measured for species of three elements. The data includes results on  $\text{Au}^+$ ,  $\text{Au}^{2+}$ ,  $\text{Au}^{3+}$ ,  $\text{Cr}^+$ ,  $\text{Cr}^{2+}$ ,  $\text{Fe}^+$ ,  $\text{Fe}^{2+}$ , and  $\text{Fe}^{3+}$ . Total cross sections results on the elements are also reported. A description of the procedure and equipment as well as some of the difficulties in the experiment are presented. Related information from the literature, both experimental and theoretical, are discussed in a comparative context.

REPORT NO: AFML-TR-75-217 AD A021 326  
ACCESS NO: 204,323 February 1976  
TITLE: CHEMISTRY OF HALIDE WINDOW GROWTH  
AUTHOR(S): R.C. Pastor and H.V. Winston  
CONTRACT NO: F33615-74-C-5115  
CONTRACTOR: Hughes Research Laboratories

PROJECT MONITOR: J. Fenter (AFML/LPO)  
 PROJECT NO: N/A  
 TASK NO: N/A  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: We have studied the chemistry of reactive atmosphere processing (RAP) for the growth of crystals of chlorides, bromides and halides. The purity and freedom from extrinsic absorption obtained by RAP are important in the application of halides as optical elements in high power lasers. The prototype of RAP is  $\text{CCl}_4$  in the growth of KCl; it reacts directly with water to scavenge all but traces of this contaminant and pyrolyzes with the formation of nascent halogen to react rapidly with hydroxide ions in the melt. Our approach with the bromides and fluorides has been to seek RAP agents which simulate the behavior of  $\text{CCl}_4$  with KCl. On the basis of its hydrolysis behavior, we selected  $\text{CH}_2\text{Br}_2/\text{He}$  as the RAP agent for KBr. We directed our work on KCl toward problems associated with the scale up of RAP to produce KCl crystals of greater than 10-cm diameter. Hydrogen fluoride, previously used alone as a RAP agent for fluoride crystal growth, is fast acting but does not achieve a low RAP index,  $\text{P}(\text{H}_2\text{O})/\text{P}(\text{HF})$ . We have supplemented it with a fluorocarbon and achieved improved transparency with  $\text{CF}_4$  admixtures.

REPORT NO: AFML-TR-75-219 AD A024 533  
 ACCESS NO: 204,279 January 1976  
 TITLE: FABRICATION OF  $\text{ZnSX}$  IR WINDOWS BY PHYSICAL VAPOR TRANSPORT TECHNIQUE  
 AUTHOR(S): A.L. Gentile, N.R. Kyle and E.L. Kern  
 CONTRACT NO: F33615-74-C-1022  
 CONTRACTOR: Hughes Research Laboratories  
 PROJECT MONITOR: D.Fischer (AFML/LPO)  
 PROJECT NO: 7371  
 TASK NO: 737101  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: A developmental investigation directed toward the fabrication of  $\text{ZnSe}$ ,  $\text{ZnS}$  and mixed crystal  $\text{ZnS}_{1-x}\text{Se}_x$  windows by a physical vapor transport (PVT) technique was conducted. It was found that the use of a liquid nitrogen trap greatly enhanced materials purification in both the dynamic vacuum sublimation purification process developed early in the program as well as in the PVT fabrication procedure. A second phase of the program emphasized scale-up to fabricate a window 4 in. x 6 in. x 1/2 in. thick which we selected to pursue in an 8-in. diameter size.

REPORT NO: AFML-TR-76-6 AD B014 012L  
 ACCESS NO: 204,464 February 1976  
 TITLE: BASIC RESEARCH ON LASER PLUME CHARACTERIZATION  
 AUTHOR(S): F.T. Greene and G. Radolovich  
 CONTRACT NO: F33615-73-C-5121  
 CONTRACTOR: Midwest Research Institute  
 PROJECT MONITOR: P. Dimiduk (AFML/LPJ)  
 PROJECT NO: 7360  
 TASK NO: 736001

DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: A research project was undertaken to characterize the processes which take place when militarily relevant materials are degraded in the atmosphere by a 10.6  $\mu$ CW. Measurements were made of properties of plumes produced by the irradiation of Lexan, Plexiglas and Graphite-epoxy, boron-epoxy composites. Plume compositions were determined by means of a molecular beam mass spectrometry together with fast data acquisition systems. Plume temperatures were measured by optical pyrometric and line reversal techniques. Measurements were also made of the laser beam-plume and plume-sampling probe interactions. It was found that Lexan plumes were not in thermochemical equilibrium. Plexiglas was found to vaporize to methyl methacrylate monomer. Combustion processes involving the surrounding air were observed in the formation of composite plumes. Evidence for significant attenuation of the incident laser beam by both Lexan and Plexiglas plumes was also found.

REPORT NO: AFML-TR-76-11 AD A031 762  
 ACCESS NO: 204,521 April 1976  
 TITLE: BASIC RESEARCH ON THE CORRELATION OF SUPERCONDUCTING PROPERTIES WITH SURFACE PROPERTIES IN BOTH THIN FILM AND BULK SUPERCONDUCTING

AUTHOR(S): C.R. Haden, R.C. Jerner and J.H. Peavey  
 CONTRACT NO: F33615-73-C-5049  
 CONTRACTOR: University of Oklahoma  
 PROJECT MONITOR: M.C. Ohmer (AFML/LPO)  
 PROJECT NO: 7367  
 TASK NO: 736703

DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: Thin films of niobium were sputter gun deposited under controlled conditions and subsequently analyzed using auger electron spectroscopy. The film thickness was varied and critical temperature measured. A technique for measuring the surface roughness was developed. Deposition of niobium carbonitride was attempted; however, unforeseeable difficulties were encountered and resolved until latter stages of the contract.

REPORT NO: AFML-TR-76-15 AD B010 631L  
 ACCESS NO: 204,250 March 1976  
 TITLE: RECLASSIFICATION OF MINUTEMAN COMPUTER DISKS BY POLARIZATION

AUTHOR(S): M.D. Wells  
 CONTRACT NO: Internal  
 CONTRACTOR: Aerospace Guidance and Metrology Center  
 PROJECT MONITOR: J. Olson (AFML/LPJ)  
 PROJECT NO: 7371  
 TASK NO: 737101

DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: This report describes a process called polarization which allows the reuse of expensive beryllium memory disks and eliminates the requirement for destruction while totally removing the classified information. The

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Air Force Materials Lab recommended a magnetic oversaturation of five to one. Engineering specification ABO 125-027 shows that the point of magnetic saturation for the iron oxide coating (which is where the information is stored on the disk) is 600 gauss. Therefore, a magnet in excess of 3000 gauss will be used. Also described in this report is a recommendation on handling procedures for those computers that fail to overwrite. Top Secret Crypto computers were also considered. It is recommended that a Hall Tester, which measures magnetic field strength, be designated as a critical component. This would require that the magnetic field used for polarization be checked for field strength each time it is used.

REPORT NO: AFML-TR-76-20 AD A026 363  
ACCESS NO: 204,340 April 1976  
TITLE: OPTICAL PROPERTIES OF EUROPIUM-DOPED POTASSIUM CHLORIDE  
LASER WINDOW MATERIALS  
AUTHOR(S): T.G. Stoebe, R.J. Spry and J.F. Lewis  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LPO  
PROJECT MONITOR: R.J. Spry (AFML/LPO)  
PROJECT NO: 7371  
TASK NO: 737101  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Optical properties of samples from a large KCl: Eu crystal, produced by the Harshaw Chemical Company as part of the AFML laser window development program, have been investigated over a wide spectral region. The overall Eu<sup>++</sup> content varies throughout the sample according to the expected distribution of this ion during solidification with the Eu<sup>++</sup> content increasing from cone to heel. Irradiation to 10<sup>18</sup>R is shown to modify the Eu<sup>++</sup> absorption spectrum, decreasing the Eu<sup>++</sup> absorption peak heights, and shifting the 2400 Å band toward longer wavelengths. The latter may be due to the growth of a new band near 2700 Å.

REPORT NO: AFML-TR-76-79 AD A033 640  
ACCESS NO: 204,662 May 1976  
TITLE: ADVANCED DEVELOPMENT ON GALLIUM PHOSPHIDE MATERIALS FOR  
SATELLITE ATTITUDE SENSORS  
AUTHOR(S): P.E. Petersen, R.G. Schulze and M.W. Scott  
CONTRACT NO: F33615-75-C-5244  
CONTRACTOR: Honeywell  
PROJECT MONITOR: R.J. Spry (AFML/LPO)  
PROJECT NO: 7371  
TASK NO: 737102  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The objective of this research program is to develop the solution-growth technology of FaP so that crystals of sufficient size and uniformity can be produced for Air Force photodetector applications. To accomplish this objective, two growth techniques, bulk solution growth (BSG) and liquid phase epitaxy (LPE) have been developed.

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REPORT NO: AFML-TR-76-83 AD B014 718  
ACCESS NO: 204,722 February 1976  
TITLE: PROCEEDINGS OF THE FIFTH CONFERENCE ON INFRARED LASER  
WINDOW MATERIALS  
AUTHOR(S): C.R. Andrews and C.L. Strecker  
CONTRACT NO: F33615-75-C-5011  
CONTRACTOR: University of Dayton Research Institute  
PROJECT MONITOR: C.L. Strecker (AFML/LPO)  
PROJECT NO: 7371  
TASK NO: 737101

DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The Fifth Conference of Infrared Laser Window Materials was sponsored by the Advanced Research Projects Agency and held in Las Vegas, Nevada on December 1, 2, 3 and 4, 1975. In the three years since the initiation of laser window programs, there has been a continual evolution and advancement in the applied and exploratory research and development of laser window materials. Within the past year, laser window design and hardware productions have been undertaken and completed. In addition, there have been numerous achievements in the fabrication and characterization of laser window materials. The progress in these and related technical areas was the basis of the subject matter treated at the conference.

REPORT NO: AFML-TR-76-96 AD B014 990L  
ACCESS NO: 204,621 June 1976  
TITLE: LASER WINDOW MATERIALS CHARACTERIZATION  
AUTHOR(S): J.A. Detrio, G.T. Johnston, R.J. Harris and D.A. Walsh  
CONTRACT NO: F33615-74-C-5001  
CONTRACTOR: University of Dayton Research Institute  
PROJECT MONITOR: G.A. Kepple (AFML/LPO)  
PROJECT NO: N/A  
TASK NO: N/A

DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This report summarized the results of laser window materials studies including optical evaluation, laser-induced degradation and thermal distortion experiments, and the production and evaluation of sputter-deposited optical coatings. The optical evaluations consist of calorimetric determinations of absorption, scattering measurements, thermo-optic measurements and polariscopic observations. Two modes of laser-induced degradation were studied; they are thermally induced mechanical failure and thermally induced optical distortion.

REPORT NO: AFML-TR-76-103  
ACCESS NO: 204,625 September 1976  
TITLE: ANTIREFLECTION COATINGS FOR CALCIUM FLUORIDE LASER  
WINDOWS FOR 5.3 MICRONS  
AUTHOR(S): M. Ohmer  
CONTRACT NO: Internal  
CONTRACTOR: AFML/LPO

AFML/LP

PROJECT MONITOR: M. Ohmer (AFML/LPO)

PROJECT NO: 7371

TASK NO: 737101

DIST. STATEMENT: Approved for public release; distribution unlimited.

ABSTRACT: For distinct antireflection (AR) and half-wave coatings of their constituent coating materials were evaluated for 5.3 microns on  $\text{CaF}_2$  and  $\text{BaF}_2$  substrates. The coating materials were lead and strontium fluoride, thorium tetrafluoride and zirconium dioxide. The coatings were evaluated with regard to absorption, peak transmission, bandwidth, residual strain and adhesion. The absorption measurements obtained with three different calorimeters are compared. Expressions for equivalent or Herpin three-layer films for the case of arbitrary equivalent index and phase thickness are also contained in the Appendix. These expressions are an extension of the work of Epstein, and they are not presently available from the literature.

MANUFACTURING TECHNOLOGY DIVISION (AFML/LT)

REPORT NO: AFML-TR-75-80 AD B016 343L  
 ACCESS NO: 204,577 May 1975  
 TITLE: ESTABLISHMENT OF A PLASMA MELTING MANUFACTURING PROCESS  
 FOR PRODUCTION OF NICKEL-BASE ALLOYS  
 AUTHOR(S): G.K. Bhat  
 CONTRACT NO: F33615-71-C-1681  
 CONTRACTOR: Carnegie-Mellon University  
 PROJECT MONITOR: K.L. Love (AFML/LTM)  
 PROJECT NO: 262-1  
 TASK NO: N/A  
 DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: Plasma melting equipment of production scale was estab-  
 lished by modification of an existing nonconsumable electrode melting facility.  
 A 1.2 megawatt power capability plasma torch was operated up to a power level  
 of 600 KW, and several melts were made using nickel base alloy and titanium  
 alloy scrap. The argon gas plasmarc has been shown to be a useful high heat  
 source for melt-consolidation of super alloy and types of scrap including re-  
 active metal scrap into suitable electrode shapes for subsequent consumable  
 remelting.

REPORT NO: AFML-TR-75-81 AD B008 420L  
 ACCESS NO: 204,150 August 1975  
 TITLE: MANUFACTURING METHODS FOR MOS-FET BIPOLAR INTEGRATED  
 CIRCUITS  
 AUTHOR(S): J.S. MacDougall, K.R. Stafford and A.J. Keet  
 CONTRACT NO: F33615-72-C-1522  
 CONTRACTOR: Fairchild Camera and Instrument Corporation  
 PROJECT MONITOR: E.H. Miller (AFML/LT)  
 PROJECT NO: 506-2  
 TASK NO: N/A  
 DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: The process for manufacturing compatible SIGFET's and  
 Bipolar devices on the same integrated circuit chip was modified and improved.  
 Five hundred "kit parts" were manufactured using this process to demonstrate  
 its reproducibility. Two circuits, an operational amplifier and a sample and  
 hold amplifier, were manufactured using the process to demonstrate its use in  
 data acquisition types of circuits. Specifications and performance figures for  
 the circuits are presented.

REPORT NO: AFML-TR-75-109 AD B014 622L  
 ACCESS NO: 204,523 September 1975  
 TITLE: MULTI-AXIS LASER CUTTING  
 AUTHOR(S): K.F. Skutley and J. Ginn  
 CONTRACT NO: F33615-74-C-5091  
 CONTRACTOR: Boeing  
 PROJECT MONITOR: J.R. Williamson (AFML/LTM)  
 PROJECT NO: 7801F  
 TASK NO: N/A  
 DIST. STATEMENT: U.S. Govt. Agencies Only

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**ABSTRACT:** The purpose of this program was to establish equipment, tooling, and process requirements for low-cost laser trimming of flat and formed sheet-metal parts. The program objectives were: (1) use a technique that involves manual manipulation of an articulated optical train about a template, (2) the equipment shall have at least 5° of motion, (3) nozzle-to-workpiece gap shall be controlled, (4) feedrate shall be measurable and controlable, (5) establish a low-cost technique for supporting parts being trimmed, (6) identify operating parameters, (7) provide operator protection, (8) material to be cut includes titanium (Ti-6Al-4V) and steel in the 0.025" to 0.125" thickness range, and (9) emphasis to be on a low-cost method for small-lot production. The purpose and objectives of this program have been met, and this report describes in detail how those objectives were accomplished.

REPORT NO: AFML-TR-75-120  
ACCESS NO: 202,637 August 1975  
TITLE: ESTABLISHMENT OF PRODUCTION MACHINABILITY DATA  
AUTHOR(S): N. Zlatin, M. Field, V.A. Tipnis, R.C. Garrison, J.D. Christopher, S. Buescher and J.B. Kohls  
CONTRACT NO: F33615-74-C-5025  
CONTRACTOR: Metcut Research Associates, Incorporated  
PROJECT MONITOR: W. Harris (AFML/LTM)  
PROJECT NO: 755-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only

**ABSTRACT:** A number of the newest tool materials such as coated carbides, composites (ceramics), micrograin carbides, and Borazon tools which appeared suitable for machining aerospace alloys were tested. Several of these new tools permitted appreciable higher production rates in the machining of 4340 steel, Ti-6Al-4V alloy and Rene' 41. Machinability data was developed on the following alloys: HY 180 steel, Gatorized AF2-1DA, P/M Ti-6Al-4V alloy, and Astroloy (as HIP'd). End mill finishing and roughing data were developed on the following alloys: annealed 4340 steel, 217 BHN; annealed Ti-6Al-4V alloy, 321 BHN and 7075-T651 aluminum, 179 BHN. This data involved machining parameters such as tool life, cutting forces, surface finish, cutter breakage forces, horsepower, and deflection. The tool life data was developed on the first two alloys only. These machining recommendations are directly applicable to conventional, N/C and adaptive control end milling of airframe structures.

REPORT NO: AFML-TR-75-124 AD 8007 541L  
ACCESS NO: 204,151 September 1975  
TITLE: HIGH-TEMPERATURE ROLLING PROCESS FOR HIGH-STRENGTH MATERIALS  
AUTHOR(S): T.G. Byrer, J.R. Douglas, D. Becker, J.D. Buzzanell, R.O. Kaufman, and H.L. Black  
CONTRACT NO: F33615-72-C-1265  
CONTRACTOR: Battelle, Columbus Laboratories  
PROJECT MONITOR: T.S. Felker (AFML/LTM)  
PROJECT NO: 107-2  
TASK NO: N/A

DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: Two production size mills were successfully modified for the heated roll rolling of high-strength alloy sheet and shape products. The Battelle 16x24 reversing rolling mill was successfully modified to a 4-high configuration with the use of radiant heaters for heating of the roll surfaces to temperatures up to 1500°F (816C). Except for the problems encountered in maintaining cooling fluid seals on the backup roll necks, performance of the mill was quite satisfactory. The modification of a production 10-inch shape rolling mill is described. Unitemp AF-1DA roll sleeves were installed on Type A-9 die steel arbors, lubrication systems modified and necessary air and water cooling facilities installed. Quartz tube radiant heaters were also used for heating these rolls to temperatures up to 1500°F (816C). The results suggest that pack rolling can be eliminated provided appropriate heating equipment can be positioned on either side of the mill so that rolling can progress on a semi-continuous basis.

REPORT NO: AFML-TR-75-126 AD B011 595L  
 ACCESS NO: 203,090 January 1976  
 TITLE: MANUFACTURING METHODS FOR LOW COST METAL MATRIX COMPOSITE MATERIAL (CONTINUOUS GREEN TAPE)  
 AUTHOR(S): V.J. Krukonis and T. Schoenberg  
 CONTRACT NO: F33615-74-C-5123  
 CONTRACTOR: Avco Systems Company  
 PROJECT MONITOR: C. Anderson (AFML/LTN)  
 PROJECT NO: 316-4  
 TASK NO: N/A

DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: A process to significantly reduce the manufacturing cost of boron acrylic and boron acrylic aluminum preform materials was established. Various fugitive binders were evaluated from the standpoint of product handleability, tape integrity, tack, ease of lay-up, and bake out characteristics. Techniques for collimating filaments and acrylic into 1/4" tape and 1/4" tapes into widths up to six inches were established. Techniques for applying aluminum foil to the boron/acrylic tape during fabrication were also demonstrated. Detailed cost comparisons between conventional drum wound boron/acrylic sheets and continuous tape manufacturing methods were accomplished.

REPORT NO: AFML-TR-75-152 AD B011 746  
 ACCESS NO: 204,357 September 1975  
 TITLE: MANUFACTURING METHODS FOR YTTRIUM ORTHOALUMINATE LASER MATERIALS  
 AUTHOR(S): R.F. Belt, R. Uhrin and D. Dentz  
 CONTRACT NO: F33615-73-C-5029  
 CONTRACTOR: Lambda/Airtron Division of Litton Systems  
 PROJECT MONITOR: E. Tarrant (AFML/LTE)  
 PROJECT NO: 505-3  
 TASK NO: N/A  
 DIST. STATEMENT: U.S. Govt. Agencies Only

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**ABSTRACT:** Pilot production methods were developed for Nd:YA10<sub>3</sub> solid state laser crystal rods of both b and axial orientations. The growth and materials problems were solved to produce high quality boules of 1-1.5 inch diameter and 6-9 inches long. Nearly 100 laser rods were subsequently fabricated from available material. Under the test portion of the program, 35 rods of different size and orientation were further characterized by active laser parameters, both in the long pulse and Q-switch modes. These rods were delivered to the Air Force as representative of commercially available items. A pilot line for a 25 rod per month capacity was completed with no difficulty. Present data indicate that there are finite limits to quality rod size and laser performance for anisotropic hosts such as YA10<sub>3</sub>.

**REPORT NO:** AFML-TR-75-156 AD B009 355L  
**ACCESS NO:** 204,181 September 1975  
**TITLE:** MANUFACTURING TECHNOLOGY FOR RADIATION-HARDENED MULTIPLE IC CHIP PACKAGE  
**AUTHOR(S):** C.J. Dell'oca, R.W. Marshall, R.J. Kopp, and D.K. Myers  
**CONTRACT NO:** F33615-72-C-1125  
**CONTRACTOR:** Fairchild Camera and Instrument Corporation  
**PROJECT MONITOR:** H.J. Garrett (AFML/LTE)  
**PROJECT NO:** 505-1  
**TASK NO:** N/A  
**DIST. STATEMENT:** U.S. Govt. Agencies Only  
**ABSTRACT:** Investigations are described which lead to the implementation of manufacturing methods and processes for fabrication by aluminum anodization of single and dual layer metal interconnects for radiation hardened integrated circuits. In addition, an all aluminum, radiation hardened, multichip assembly method is described that completely eliminates flying wires and achieves a high chip packing density in a hermetically sealed package. These manufacturing methods are demonstrated by the fabrication of anodized radiation hardened integrated circuits and by the fabrication of a multichip six bit adder, each containing twelve anodized and/or inverter TTL gates and four anodized quad two input NAND gates.

**REPORT NO:** AFML-TR-75-160 AD B009 740L  
**ACCESS NO:** 204,170 October 1975  
**TITLE:** IMPROVED CVD TECHNIQUES FOR DEPOSITING PASSIVATION LAYERS ON ICs  
**AUTHOR(S):** W. Kern, R.B. Comizzoli, A.W. Fisher, and G.L. Schnable  
**CONTRACT NO:** F33615-74-C-5146  
**CONTRACTOR:** RCA Laboratories  
**PROJECT NO:** 7371  
**TASK NO:** 737101  
**DIST. STATEMENT:** U.S. Govt. Agencies Only  
**ABSTRACT:** This report describes the results of studies to increase the understanding of the requirements for successful glass passivation, by chemical vapor deposition (CVD), of metallized silicon planar integrated circuits (ICs) to improve both performance and reliability. The composition and quality

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of passivation layers of commercially available ICs were determined to establish baseline CVD conditions. The fundamental properties of CVD PSG films were determined and correlated with mechanisms that can cause electrical degradation or catastrophic failure of ICs with inadequate CVD passivation; specifically, failure mechanisms of glass-passivated devices were induced on test devices using CVD films deposited by baseline conditions. The results of this program have significantly increased understanding of material and processing requirements for glass passivation of ICs.

REPORT NO: AFML-TR-75-164 AD B009 790L  
ACCESS NO: 204,213 August 1975  
TITLE: MANUFACTURING METHODS AND TECHNOLOGY FOR HIGH QUALITY,  
LOW COST GALLIUM ARSENIDE LASER ARRAYS  
AUTHOR(S): R.B. Gill  
CONTRACT NO: F33615-73-C-5072  
CONTRACTOR: Laser Diode Laboratories  
PROJECT MONITOR: E. Tarrant (AFML/LTE)  
PROJECT NO: 523-3  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The manufacturing technology for the production in quantity of superior quality, low cost GaAs stacked arrays is discussed with respect to GaAs epitaxial materials technology, array packaging methods and device production processes. Triple Heterojunction (TH) 5-stack laser diode arrays incorporating double-sided heat sinking and exhibiting excellent high temperature performance characteristics have been developed at Laser Diode Laboratories. To demonstrate the manufacturability of these devices, a pilot production run of 100 units was successfully completed utilizing the processes developed under this contract.

REPORT NO: AFML-TR-75-169 AD B012 426  
ACCESS NO: 202,598 November 1975  
TITLE: MANUFACTURING METHODS FOR MULTI-AXIS LASER CUTTING  
AUTHOR(S): W. Marx  
CONTRACT NO: F33615-74-C-5015  
CONTRACTOR: Grumman Aerospace Corporation  
PROJECT MONITOR: J. Williamson (AFML/LTM)  
PROJECT NO: 753-4A  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Multi-axis laser trimming was shown to be a cost-effective means of trimming high-strength aerospace hardware. Formed-part trimming capabilities were achieved through the design and fabrication of three new systems: manual rotary guide, adaptively controlled Z-axis and part manipulator. High-power (750 to 6000w) laser cutting tests showed the following: laser power requirements for 4340 steel increase rapidly with increasing material thickness; small increases in laser power for Waspaloy substantially improve cutting capability; cut quality of titanium does not improve at high power levels.

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REPORT NO: AFML-TR-75-184 AD B010 935L  
ACCESS NO: 203,160 January 1976  
TITLE: LOW COST MANUFACTURING USING ADVANCED COMPOSITE  
BROADGOODS

AUTHOR(S): O.E. Weiss, B.E. Chitwood and L.C. Spruill  
CONTRACT NO: F33615-74-C-5156  
CONTRACTOR: General Dynamics Corporation  
PROJECT MONITOR: H.S. Reinert (AFML/LTN)  
PROJECT NO: 419-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: This program has established that the forming or draping of uncured broadgoods is a viable low-cost manufacturing technique for fabricating advanced composite primary aircraft structure. The limitations of the draping technique have been established in areas such as fiber orientation, sheet thickness and size, impact of layup anomalies such as darts and folds, and material forms.

REPORT NO: AFML-TR-75-189 AD B013 964  
ACCESS NO: 204,473 July 1976  
TITLE: MANUFACTURING METHODS FOR RESIN MATRIX PROCESSING

AUTHOR(S): J.W. Sapp, Jr.  
CONTRACT NO: F33615-72-C-1486  
CONTRACTOR: McDonnell Douglas Astronautics Company-East  
PROJECT MONITOR: H.P. Materne (AFML/LTN)  
PROJECT NO: 410-2  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: The ultimate objective of this program is to establish a low cost manufacturing method for the production of three dimensionally woven phenolic resin matrix composites. This report describes a centrifugal impregnation and cure process for achieving this objective. Contained in this report is a general description of the centrifugal impregnation theory, a detailed description of the process as optimized during this program, and physical and mechanical properties results of both flat and cylindrically woven three dimensional composites from quartz carbon and graphite yarn. There is also chemical analysis data on properties of phenolic resin that provide best impregnation results.

REPORT NO: AFML-TR-75-195 AD B009 573L  
ACCESS NO: 202,193 December 1975  
TITLE: MANUFACTURING PROCESSES FOR ADVANCED CARBON/CARBON  
FABRICATION

AUTHOR(S): P.J. Roy and P.G. Rolincik  
CONTRACT NO: F33615-73-C-5138  
CONTRACTOR: Avco Systems Division  
PROJECT MONITOR: H.P. Materne (AFML/LTN)  
PROJECT NO: 402-3  
TASK NO: N/A

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DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The overall objective of this program was to establish manufacturing processes and specifications for the scale-up production of three-dimensionally (3D) reinforced carbon/carbon composite materials for use as heat shields in advanced missile reentry systems. Various conical shell configurations were fabricated/processed to establish baseline manufacturing technology and specifications and to serve as demonstrations of the scale-up producibility of 3D carbon/carbon composite materials. The forward, transition-region and aft sections of a full-scale frustum, as well as a full-scale (transition) frustum, were fabricated under the program. Details of the manufacturing methods and controls established for scale-up production of 3D carbon/carbon composite shells for eventual use as heat shielding material are presented in the report.

REPORT NO: AFML-TR-75-197 AD B010 863L  
ACCESS NO: 204,270 March 1976  
TITLE: MANUFACTURING METHODS PROGRAM TO PROVIDE A CAPABILITY FOR LONG LIFE ALKALI VAPOR LAMPS

AUTHOR(S): R. McRae and J. Richter  
CONTRACT NO: F33615-72-C-1735  
CONTRACTOR: ILC Technology, Incorporated  
PROJECT MONITOR: E. Tarrant (AFML/LTE)

PROJECT NO: 519-2

TASK NO: N/A

DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: An air-compatible, two kilowatt average power IRCM lamp with 100-hour, 25-cycle capability has been developed for the AN/AAQ-8 system. The pilot production run at the rate of 25 lamp starts per day was carried out with an overall yield of 21 lamps through Burn-In and Test. Technical goals of the program have been exceeded. The air-compatible lamp can operate in naturally convecting air at 600 degrees C for over 200 hours and eliminates the requirement for a protective gas environment in the equipment. Lamp fabrication details and test results are presented.

REPORT NO: AFML-TR-75-211 AD A025 479  
ACCESS NO: 200,987 December 1972  
TITLE: IMPROVEMENT OF RELIABILITY AND THE MECHANICAL PROPERTIES OF TITANIUM ALLOY FORGINGS

AUTHOR(S): T.B. Gurganus and G.S. Hall

CONTRACT NO: F33615-72-C-1030

CONTRACTOR: Alcoa

PROJECT MONITOR: N.E. Klarquist (AFML/LTM)

PROJECT NO: 120-2

TASK NO: N/A

DIST. STATEMENT: Approved for public release; distribution unlimited.

ABSTRACT: A series of fabrication and heat treatment sequences were evaluated to develop processing cycles that optimized property levels in Ti-6246 and Ti-38644 hand forgings. Die forgings were then produced using the optimum process for each alloy to demonstrate that reliable and consistent

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property levels could be obtained in airframe structural parts. Details of the processing cycles are given. Good combinations of fatigue endurance limits, stress corrosion cracking thresholds, fracture toughness, thermal stability, and resistance to cyclic crack growth rate were developed. These property levels make the Ti-6246 and Ti-38644 systems excellent candidates for thick section airframe applications.

REPORT NO: AFML-TR-75-213 AD A024 780  
ACCESS NO: 204,298 January 1976  
TITLE: FABRICATION AND EVALUATION OF HOT ISOSTATICALLY PRESSED BERYLLIUM  
AUTHOR(S): G.L. London and W.G. Lidman  
CONTRACT NO: F33615-75-C-5041  
CONTRACTOR: Kawecki Berylco Industries, Incorporated  
PROJECT MONITOR: K.L. Kojola (AFML/LTM)  
PROJECT NO: 7381  
TASK NO: 738102

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The production of beryllium substructure was undertaken as part of the Carbon-Carbon Design Program (CCDP). Because of a change in beryllium requirements, the program was delayed and then redirected. A study of machining and etching of internal and external thread was started, and it was terminated prior to the evaluation of parts produced. Four cylinders and one hollow cone frustum were made by direct hot isostatic pressing of electrolytic grade beryllium powder. Mechanical properties of the cylinders are reported and are found to meet the requirements established for the material.

REPORT NO: AFML-TR-76-3  
ACCESS NO: 204,529 January 1976  
TITLE: SLIDING-SEAL ELECTRON-BEAM WELDING  
AUTHOR(S): H.P. Ellison and R.H. Witt  
CONTRACT NO: F33615-73-C-5030  
CONTRACTOR: Grumman Aerospace  
PROJECT MONITOR: F. Miller (AFML/LTM)  
PROJECT NO: 846-3  
TASK NO: N/A

DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The results of a sequential, three-phase program beginning with the design, fabrication and evaluation of four welding fixtures (flat plate, cylindrical, special shapes and preheat) and ending with a process demonstration on F-14 beams are reported. A selected aerospace structure (F-14 wing beam) was successfully SSEB welded, thus demonstrating equipment capability to fabricate production parts. Tensile, fatigue, and fracture toughness results are presented for a welded wing beam. Recommendations for further improvement or refinement of the SSEB welding equipment are included. A recommended industry equipment and a welding specification for aluminum, titanium and steel alloys are also included.

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REPORT NO: AFML-TR-76-21 AD B011 989L  
ACCESS NO: 202,836 March 1976  
TITLE: MANUFACTURING METHODS FOR RESISTANCE SPOTWELD-ADHESIVE  
BOND JOINING OF TITANIUM  
AUTHOR(S): J. Mahon, C. Vizzi and W. Sisco  
CONTRACT NO: F33615-74-C-5073  
CONTRACTOR: Grumman Aerospace Corporation  
PROJECT MONITOR: D. Starks (AFML/LTN)  
PROJECT NO: 408-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The results of a sequential, three-phase program beginning with the selection of candidate materials and processes for Ti-6Al-4V titanium alloy weld-bonding and ending with a production demonstration of the established processes are reported.

REPORT NO: AFML-TR-76-35 AD B014 690L  
ACCESS NO: 204,530 April 1976  
TITLE: FEEDBACK-CONTROLLED SPOTWELDING  
AUTHOR(S): R.L. Szabo  
CONTRACT NO: F33615-75-C-5229  
CONTRACTOR: General Dynamics  
PROJECT MONITOR: P. Blau (AFML/LTM)  
PROJECT NO: 817-5  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This report covers work accomplished on F33615-75-C-5229. The objective of this program is to establish a production method of feedback-controlled spotwelding that provides consistent spotweld quality for aluminum weldbonding. It is the scope of this program to combine special resistance welding control equipment with a conventional spotwelding machine to achieve consistent spotweld quality through environmentally durable surface treatments and adhesives. The program is composed of two tasks. Task 1 is a weldbonding process optimization effort. Task 2 - weldbonding process verification was established for both the paste and film adhesives. A weldbonding process specification documenting the aluminum alloy and gages, adhesives, and surface preparations successful in this program is provided in this report.

REPORT NO: AFML-TR-76-43 AD B014 563  
ACCESS NO: 204,715 April 1976  
TITLE: MANUFACTURING METHODS AND TECHNOLOGY FOR FLIR COST  
REDUCTION  
AUTHOR(S): F.E. Johnson  
CONTRACT NO: F33615-75-C-5042  
CONTRACTOR: Honeywell  
PROJECT MONITOR: L. Yarrington (AFML/LTE)  
PROJECT NO: 521-5  
TASK NO: N/A

AFML/LT

DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This report describes the results of a first year effort on an MM&T Program for FLIR Cost Reduction with the overall objective to prove that advanced materials and methods can be applied to reduce FLIR system cost without degrading system performance. Phase I - a three-month Cost Effectiveness Study; and Phase II - established feasibility test results which are production potential pay-backs expressed as a factor of funding invested. A plan for a second year follow-on program is included.

REPORT NO: AFML-TR-76-59 AD B015 971L  
ACCESS NO: 204,709 May 1976  
TITLE: AN IMPROVED PRODUCTION PROCESS FOR TITANIUM ALLOY  
HYDRAULIC TUBING  
AUTHOR(S): R.S. Paul  
CONTRACT NO: F33615-72-C-2170  
CONTRACTOR: International Harvester  
PROJECT MONITOR: R. Schafrik (AFML/LTM)  
PROJECT NO: 109-2  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: The purpose of the program was to explore the production capabilities of the High Precision Tube Reduces (HPTR). The program consisted of four phases, and each phase was structured for at least one reduction on the HPTR. Phase I - the goal size, in Ti-3Al-2.5V, was 0.250" OD x 0.016" wall. Seven process routes were investigated. Three process routes used tube blanks of welded origin, and the four remaining routes used tube blanks of seamless origin. Phase II - a production run and product qualification was required using the best welded and seamless process developed in Phase I. As no process using welded tube was developed in Phase I, an alternate process using welded tube was proposed. Phase III - established to develop a manufacturing process for Ti-6Al-4V and Ti-3Al-2.5V alloy hydraulic tubing. Phase IV - a manufacturing method was to be developed for a new alloy, Ti-10V-2Fe-3Al; however, manufacturing problems developed.

REPORT NO: AFML-TR-76-62 AD B014 987L  
ACCESS NO: 204,602 July 1976  
TITLE: MANUFACTURING METHODS FOR PRODUCTION OF RARE EARTH-  
COBALT MAGNETS FOR APPLICATION IN MOTORS  
AUTHOR(S): P.F. Weihrauch  
CONTRACT NO: F33615-73-C-5059  
CONTRACTOR: Raytheon Company  
PROJECT MONITOR: H.J. Garrett (AFML/LTE)  
PROJECT NO: 610-3  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Manufacturing and processing methods for the fabrication of rare-earth cobalt magnets for application in airborne electric motors were established. These methods were implemented in a manufacturing environment and

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a large number of motor magnets were fabricated. A jet fuel starter motor designed to take advantage of high energy products, high coercivity Sm-Co magnets, demonstrated a clear performance gain over series field production versions of the same volume. In a 7-hp servomotor, test performance exceeded design predictions.

REPORT NO: AFML-TR-76-73 AD B014 324L  
ACCESS NO: 204,520 May 1976  
TITLE: MANUFACTURING TECHNOLOGY FOR RADIATION-HARDENED  
MSI/LSI CIRCUITS  
AUTHOR(S): D.K. Myers and R.W. Marshall  
CONTRACT NO: F33615-72-C-1200  
CONTRACTOR: Fairchild Semiconductor Division of FCI  
PROJECT MONITOR: J. Garrett (AFML/LTE)  
PROJECT NO: 500-1  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This report discusses the manufacturing methods for radiation-hardened MSI/LSI Integrated Circuits. The design considerations, the processes, the processing problems and solutions, the electrical characteristics and the radiation tolerance are presented for 5mW/gate, 10 nsec typical delays, Schottky-clamped TTL multiplexers, shift registers, counters and arithmetic logic units.

REPORT NO: AFML-TR-76-76, Volume I AD B014 488L  
ACCESS NO: 204,685 June 1976  
TITLE: MULTI-LAYER FASTENER SYSTEMS: VOLUME I - DISCUSSION  
AND SUMMARY  
AUTHOR(S): J.L. Phillips  
CONTRACT NO: F33615-74-C-5014  
CONTRACTOR: Boeing  
PROJECT MONITOR: N. Klarquist (AFML/LTM)  
PROJECT NO: 752-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Two new technology drill units, an ultrasonic unit and a computer-controlled hydraulic drill unit, have been developed to improve the hole-generation capability for large-diameter fastener holes in multilayer stacks of aluminum, titanium and steel. The drill units were equipped with torque and thrust sensors for surveillance of drill unit performance and, in the case of the hydraulic unit, with computer control functions. The formation of burrs at material interfaces has been characterized for the materials of concern as well as the effect of such burrs upon fatigue performance. One of the new drill units has demonstrated a 75% increase in drilling rate and has been evaluated relative to defined burr constraints and to practicality in production applications.

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REPORT NO: AFML-TR-76-76, Volume II AD B014 261  
ACCESS NO: 202,979 June 1976  
TITLE: MULTI-LAYER FASTENER SYSTEMS: VOLUME II - ILLUSTRATIONS  
AUTHOR(S): J.L. Phillips  
CONTRACT NO: F33615-74-C-5014  
CONTRACTOR: Boeing  
PROJECT MONITOR: N. Klarquist (AFML/LTM)  
PROJECT NO: 752-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Two new technology drill units, an ultrasonic unit and a computer controlled hydraulic drill unit, have been developed to improve the hole-generation capability for large-diameter fastener holes in multilayer stacks of aluminum, titanium and steel. The drill units were equipped with torque and thrust sensors for surveillance of drill unit performance and, in the case of the hydraulic unit, with computer control functions. The formation of burrs at material interfaces has been characterized for the materials of concern as well as the effect of such burrs upon fatigue performance. One of the new drill units has demonstrated a 75% increase in drilling rate and has been evaluated relative to define burr constraints and to practicality in production applications.

REPORT NO: AFML-TR-76-76, Volume III AD B014 261  
ACCESS NO: 202,979 June 1976  
TITLE: MULTI-LAYER FASTENER SYSTEMS: VOLUME III  
AUTHOR(S): J.L. Phillips  
CONTRACT NO: F33615-74-C-5014  
CONTRACTOR: Boeing  
PROJECT MONITOR: N. Klarquist (AFML/LTM)  
PROJECT NO: 752-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Two new technology drill units, an ultrasonic unit and a computer-controlled hydraulic unit, have been developed to improve the hole-generation capability for large-diameter fastener holes in multilayer stacks of aluminum, titanium and steel. The drill units were equipped with torque and thrust sensors for surveillance of drill unit performance and, in the case of the hydraulic unit, with computer control functions. The formation of burrs at material interfaces has been characterized for the materials of concern as well as the effect of such burrs upon fatigue performance. One of the new drill units has demonstrated a 75% increase in drilling rate and has been evaluated relative to defined burr constraints and to practicality in production applications.

REPORT NO: AFML-TR-76-76, Volume IV AD B014 493L  
ACCESS NO: 204,531 June 1976  
TITLE: MULTI-LAYER FASTENER SYSTEMS: VOLUME IV  
AUTHOR: J.L. Phillips

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CONTRACT NO: F33615-74-C-5014  
CONTRACTOR: Boeing  
PROJECT MONITOR: N. Klarquist (AFML/LTM)  
PROJECT NO: 752-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Two new technology drills, an ultrasonic unit and a computer-controlled hydraulic drill unit, have been developed to improve the hole-generation capability for large-diameter fastener holes in multilayer stacks of aluminum, titanium and steel. The drill units were equipped with torque and thrust sensors for surveillance of drill unit performance and, in the case of the hydraulic unit, with computer control functions. The formation of burrs at material interfaces has been characterized for the materials of concern as well as the effect of such burrs upon fatigue performance. One of the new drill units has demonstrated a 75% increase in drilling rate and has been evaluated relative to defined burr constraints and to practicality in production applications.

REPORT NO: AFML-TR-76-88 AD B014 989L  
ACCESS NO: 204,604 April 1976  
TITLE: FABRICATION, MATERIAL CHARACTERIZATION AND MACHINING  
PROCESS EVALUATION OF S-65 GRADE HOT-PRESSED BERYLLIUM  
AUTHOR(S): B. King  
CONTRACT NO: F33615-74-C-5119  
CONTRACTOR: Brush Wellman, Incorporated  
PROJECT MONITOR: K. Kojola (AFML/LTM)  
PROJECT NO: 7381  
TASK NO: 738102  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Part I describes the manufacture and testing of large S-65 hot-pressed beryllium billets. The billets were made to provide machining blanks for reentry body substructure components. Tensile and biaxial test results are reported along with tensile stress-strain curves and biaxial load-deflection curves. Part II describes machining studies. A large number of lathe-turning experiments were performed in developing improved procedures for finishing large conical structures. Procedures were developed which allow high quality finish cuts to be made without excessive tool wear.

REPORT NO: AFML-TR-76-108 AD B014 564  
ACCESS NO: 204,528 June 1976  
TITLE: HIGH QUALITY GALLIUM ARSENIDE PRODUCTION  
AUTHOR(S): S.R. Steele and R. Bierig  
CONTRACT NO: F33615-74-C-5031  
CONTRACTOR: Raytheon  
PROJECT MONITOR: E. Tarrants (AFML/LTE)  
PROJECT NO: 538-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only

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ABSTRACT: Manufacturing processes, techniques, controls, and processing equipment have been established for the economical and routine production of high-quality gallium arsenide epitaxial layers for use in the fabrication of microwave devices. This report gives a detailed description of the procedures developed in this manufacturing technology program including specifications for the single-crystal gallium arsenide substrates, pregrowth procedures, growth processes for the four devices made under this contract: (IMPATT avalanche devices, field-effect transistors, transferred-electron oscillators and microwave mixers). Quality assurance procedures, including electrical characterization, epitaxial layer thickness and thickness uniformity measurements, surfacing inspection and packaging procedures are also given in the body of the report and in the appended process specs.

REPORT NO: AFML-TR-76-140  
ACCESS NO: 204,632 August 1976  
TITLE: MANUFACTURING METHODS FOR METAL-MATRIX STRUCTURAL COMPONENTS  
AUTHOR(S): A.R. Robertson  
CONTRACT NO: F33615-74-C-5151  
CONTRACTOR: General Dynamics  
PROJECT MONITOR: C. Anderson (AFML/LTN)  
PROJECT NO: 304-4  
TASK NO: N/A  
DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: A boron aluminum composite wing rib was designed that could be directly substituted for the baseline titanium rib located at wing station  $X_{RS}$  188.5 on the B-1. The composite configuration consists of a machined 2124-T851 aluminum frame to which is attached by titanium lockbolts an isotropic boron/aluminum web of  $(0_3/45_3/90_2/135_3/0_2/45_2/90_3/135_2)_S$  lay-up. The composite wing rib was designed to the basic design parameters, loads and ground rules used for the titanium rib design. A detailed stress analysis of the boron/aluminum rib design was conducted that indicated it satisfied all the strength and stiffness requirements. Cost savings in conjunction with the 33% weight savings clearly demonstrate that the boron/aluminum design is cost and performance competitive with the baseline titanium design.

NON-METALLIC MATERIALS DIVISION (AFML/MB)

REPORT NO: AFML-TR-70-278, Part VI AD Bo15 901L  
 ACCESS NO: 204,703 May 1976  
 TITLE: ELEVATED TEMPERATURE ELASTOMERS FOR INTEGRAL FUEL  
 TANK SEALANTS PART VI  
 AUTHOR(S): O.R. Pierce, M.O. Riley and K.M. Lee  
 CONTRACT NO: F33615-74-C-5046  
 CONTRACTOR: Dow Corning  
 PROJECT MONITOR: W.R. Griffith (AFML/MBE)  
 PROJECT NO: 7340  
 TASK NO: 734005  
 DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: The concept of using the activation energy for viscous flow,  $\Delta E_{\text{visc}}$ , which correlates the dependence of viscosity on temperature as a means of screening channel sealant candidates, has been demonstrated. It has been shown that structured carbon blacks are very effective in lowering  $\Delta E_{\text{visc}}$  of FCS-210. Antioxidants dissolved in fluorocarbon-fluorosilicone hybrid polymers were screened by Differential Thermal Analysis and the results indicate that the hybrid polymer system can be protected from oxidative attack. Particular attention was given to ferrocene derivatives which showed promise for protecting both filleting and channel sealants.

REPORT NO: AFML-TR-70-305, Part II AD A026 028  
 ACCESS NO: 204,347 March 1976  
 TITLE: SIGNIFICANT PROPERTIES OF EPOXY RESINS AS MATRICES  
 IN GRAPHITE COMPOSITES  
 AUTHOR(S): R.J. Kuhbander and N.J. Pagano  
 CONTRACT NO: F33615-72-C-1620  
 CONTRACTOR: University of Dayton  
 PROJECT MONITOR: N.J. Pagano (AFML/MBM)  
 PROJECT NO: 7340  
 TASK NO: 734003  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: It is desirable, for purposes of developing better resins, to know what properties of thermosetting resins are most significant in affecting the structural properties of graphite fiber/resin matrix composites. Unidirectional and multidirectional composites were fabricated and evaluated using five resin matrix system. The influence of these resin properties on composite performance was examined through the experimental evaluation of composites fabricated from several resin materials possessing rather widely varying mechanical properties. Composite properties measured include: initial modulus, proportional limit and ultimate strength.

REPORT NO: AFML-TR-71-2, Part V AD B009 603L  
 ACCESS NO: 204,178 October 1975  
 TITLE: PHYSICAL CHEMICAL PROPERTIES OF COMPLEX AROMATIC-  
 HETEROCYCLIC POLYMERS, PART V: RHEOLOGICAL STUDIES  
 ON CONCENTRATED SOLUTIONS OF HETEROCYCLIC POLYMERS;  
 COMMENTS ON THE "EQUILIBRIUM PARTIONING" THEORY

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AUTHOR: G.C. Berry, C.Wong and E.F. Cassassa  
CONTRACT NO: F33615-70-C-1058  
CONTRACTOR: Carnegie-Mellon University  
PROJECT MONITOR: T. Helminak (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: U.S. Govt. Agenices Only  
ABSTRACT: Rheological measurements in dry MSA (methanesulfonic acid) on the heterocyclic polymer BBB (obtained by condensing 3,3' diaminobenzidine with k, 4, 5, 8-naphthalenesulfonic acid) display flexible chain behavior despite the bulky rigid repeating unit. Small amounts of moisture cause aggregation to structures resembling randomly branched chains. With BBB, aggregation also occurs and profoundly alters flow behavior with the appearance of yield phenomena at low associations and gels exhibiting slow Andrade on further association. Comparison of theoretical results for flexible-chain and rod-like polymers show that the production of intrinsic viscosity and molecular weight is not a "universal" calibration parameter for gel permeation chromatography; but the correlation is probably a good one for series of molecules of similar architecture.

REPORT NO: AFML-TR-71-35 AD 726 104  
ACCESS NO: 204,633 April 1971  
TITLE: A STATISTICAL APPROACH IN PREDICTING THE ISOTOPIC CLUSTER OF COMPLEX SPECIES BY MASS SPECTROMETRY  
AUTHOR(S): A.K. Bhattacharya  
CONTRACT NO: F33615-70-C-1021  
CONTRACTOR: Miami University  
PROJECT MONITOR: F.F. Bentley (AFML/MBP)  
PROJECT NO: 7360  
TASK NO: 736005  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The isotopic cluster to be expected for the molecular ion of decachlororuthenocone has been evaluated through a statistical approach. Ruthenium has seven naturally occurring isotopes of mass 96, 98, 99, 100, 101, 102, and 104 having a natural abundance of 5.51%, 1.87%, 12.72%, 12.62%, 17.07%, 31.61%, and 18.58% respectively. Chlorine has two isotopes of mass 35 and 37 with a natural abundance of 75.4% and 24.6%, while the two isotopes of carbon of mass 12 and 13 have a natural abundance of 98.89% and 1.11% respectively. The complete details of the calculations have been incorporated. A graph has been finally drawn after normalizing the above data. The applicability of this method has been discussed.

REPORT NO: AFML-TR-71-59, Part III AD B014 688L  
ACCESS NO: 204,524 January 1976  
TITLE: ELASTOMERS FOR LIQUID ROCKET PROPELLANT CONTAINMENT  
AUTHOR(S): J.W. Martin, C.D. Bertino and E.A. Burns  
CONTRACT NO: F33615-74-C-5099  
CONTRACTOR: TRW Systems

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PROJECT MONITOR: J.K. Sieron (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This report covers the third portion of a technical effort intended to provide advanced elastomers meeting Air Force positive expulsion and fluid sealing needs. Four main areas were studied: 1) AF-E-124T elastomer was developed for use with dinitrogen tetroxide; 2) a new perfluorinated elastomeric polymer was synthesized and cross-linked; 3) the degree of contamination (particularly silicon) of hydrazine by AF-E-332 elastomer was determined; 4) in-tank compatibility tests evaluated AF-E-124T elastomer with dinitrogen tetroxide and AF-E-332 elastomer with hydrazine. Parameters investigated during the in-tank compatibility tests were: 1) propellant permeation across the diaphragms, 2) expulsion lifetime capability, 3) creep in the seal bead, 4) property retention of the elastomers, and 5) some propellant analyses.

REPORT NO: AFML-TR-72-92, Part IV AD B009 378L  
ACCESS NO: 204,145 September 1975  
TITLE: HIGH PERFORMANCE ELASTOMER REINFORCING MATERIALS, PART IV  
AUTHOR(S): E.F. Abrams and R.G. Shaver  
CONTRACT NO: F33615-75-C-5085  
CONTRACTOR: Versar, Incorporated  
PROJECT MONITOR: J.K. Sieron (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734005  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The acetate technique of the textile conversion process was used to prepare MgO fibers for sintering, fluoroelastomer compositing and samples for evaluation at the AFML. CaF<sub>2</sub> fibers were also prepared by a different version of the textile conversion process. Flat sheet and O-ring composites of MgO and CaF<sub>2</sub> fibers with a fluoroelastomer matrix were fabricated and evaluated. An O-ring test procedure was developed and used to evaluate the extrusion resistance at 400F and 4,000 psi of static seals containing MgO and CaF<sub>2</sub> reinforcing fibers with varying sizes, concentrations and orientations. It was found that seals containing the MgO and CaF<sub>2</sub> reinforcing fibers were significantly improved with regard to extrusion resistance.

REPORT NO: AFML-TR-72-92, Part V AD B015 624L  
ACCESS NO: 204,663 September 1976  
TITLE: HIGH PERFORMANCE ELASTOMERIC SEALING SYSTEMS, PART V  
AUTHOR(S): I. Frankel  
CONTRACT NO: F33615-74-C-5085  
CONTRACTOR: General Technology Division, Versar, Incorporated  
PROJECT MONITOR: J.K. Sieron (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734005  
DIST. STATEMENT: U.S. Govt. Agencies Only

**ABSTRACT:** An in-depth study of hydraulic sealing systems based on back-up rings and O-rings was initiated. Commercially available back-up rings failed to perform satisfactorily above 400°F, but thermosetting polyimide back-up rings perform well under static hydraulic conditions at 500°F and 8000 psig. The textile conversion process for producing reinforcing MgO and CaF<sub>2</sub> fibers for fluoroelastomer O-rings was improved, and MgO fiber having an average diameter of 1.25u was prepared.

**REPORT NO:** AFML-TR-72-133, Part III AD A024 716  
**ACCESS NO:** 204,334 November 1975  
**TITLE:** THE RELATIONSHIPS OF STRUCTURE TO PROPERTIES IN GRAPHITE FIBERS  
**AUTHOR(S):** R.J. Diefendorf and E.W. Tokarsky  
**CONTRACT NO:** F33615-72-C-1422  
**CONTRACTOR:** Rensselaer Polytechnic Institute  
**PROJECT MONITOR:** J.H. Ross (AFML/MBC)  
**PROJECT NO:** 7342  
**TASK NO:** 734202  
**DIST. STATEMENT:** Approved for public release; distribution unlimited.  
**ABSTRACT:** Three-dimensional structural characterization of a variety of carbon fibers has been completed following determination of the axial and radial structures in the fibers studied. Results indicate that longitudinal surface structure becomes better aligned and more crystalline and radial skin morphology more uniform with increasing fiber modulus. Surface crystallinity and non-uniform surface axial structure degrade strength while uniform radial skin morphology will result in micro-compressive buckling upon cool-down from final heat-treatment temperatures. Fiber interiors tend to have poorer axial preferred orientation and crystalline perfection. Fibers tend to fail from brittle fracture to fibril decoupling to plastic deformation as modulus increases.

**REPORT NO:** AFML-TR-72-133, Part IV AD A024 759  
**ACCESS NO:** 204,291 November 1975  
**TITLE:** THE RELATIONSHIPS OF STRUCTURE TO PROPERTIES IN GRAPHITE FIBERS  
**AUTHOR(S):** R.J. Diefendorf, D.M. Riggs, I.W. Sorenson  
**CONTRACT NO:** F33615-72-C-1422  
**CONTRACTOR:** Rensselaer Polytechnic Institute  
**PROJECT MONITOR:** J.H. Ross (AFML/MBC)  
**PROJECT NO:** 7342  
**TASK NO:** 734202  
**DIST. STATEMENT:** Approved for public release; distribution unlimited.  
**ABSTRACT:** Modes of failure in Fiber B and Kevlar I, III and IV fibers have been studied. The buckling of these fibers in compression is manifested as oblique strain markings. Abrasion does not appear to cause drastic reductions in strength. The differences among the carbon fiber cloths and their precursors are substantial and can be expected to result in performance changes when CCA-1 is replaced by either substitute. Variations in fiber shape

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and optical activity are related to the presence of both isotropic and mesophitic portions in the precursor pitch.

REPORT NO: AFML-TR-72-229, Part IV AD B014 153L  
ACCESS NO: 204,485 January 1976  
TITLE: DEVELOPMENT OF HIGH TEMPERATURE FUNCTIONAL FLUIDS  
AUTHOR(S): R. Hamon and T. Psarras  
CONTRACT NO: F33615-71-C-1406  
CONTRACTOR: PCR, Incorporated  
PROJECT MONITOR: C.E. Snyder (AFML/MBT)  
PROJECT NO: 7340  
TASK NO: 734008  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Tetrafluoroethylene Oxide (TFEO) was prepared by photo-chemical oxidation of tetrafluoroethylene and oligomerized to the penamer, hexamer and heptamer acyl fluorides. The corresponding 6e, 6e, 6e and 7e, 7e, 7e triazines were prepared. The addition of hexafluoropropylene oxide (HFPO) to TFEO- penamer acyl fluoride was studied and the corresponding (5e,1p)-triazine was prepared. Carbonyl fluoride oligomers were prepared by photo-chemical oxidation of hexafluoropropene and end-capped by addition of HFPO. Several mixed carbonyl fluoride/HFPO triazines were prepared.

REPORT NO: AFML-TR-73-90, Part III AD B011 768  
ACCESS NO: 204,378 March 1976  
TITLE: LONG LIFE ELASTOMERIC AIRCRAFT HYDRAULIC SEALS PART III  
AUTHOR(S): J.D. Shafer, R.G. Ramsdell and L.G. Hiltner  
CONTRACT NO: F33615-73-C-5122  
CONTRACTOR: Parker Hannifin Corporation  
PROJECT MONITOR: T.L. Graham (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734005  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Long life elastomeric hydraulic seals have been under development for a period of four and one-half years. The compound development approach and the dynamic evaluation of O-rings as both rod and piston type seals has been described in previous reports. One principle development was a compound that met the concept of a Type II system. This compound AFE-XN1925-33 (Parker N756-75) was responsible for the creation of the interim specification MIL-R-83461 which may eventually replace MIL-R-25632. Another accomplishment was the successful dynamic performance of fluorocarbon O-rings for at least 1000-hour service in two types of service. The major accomplishment was the successful 1000-hour rod seal performance of three nitrile compound tested at 325F. Other accomplishments concerned the performance of the backup system chosen for evaluations of O-rings above 275F.

REPORT NO: AFML-TR-73-147, Part IV AD B015 476  
ACCESS NO: 204,628 September 1976  
TITLE: GRAPHITE FIBERS FROM PITCH  
AUTHOR(S): R. Didchenko

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CONTRACT NO: F33615-75-C-5109  
CONTRACTOR: Union Carbide  
PROJECT MONITOR: W.H. Gloor (AFML/MBC)  
PROJECT NO: 7320  
TASK NO: 732001  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Type P fibers are capable of achieving a tensile strength of 4.0 GPa (app. 600 Kpsi) with an elongation to break approaching 2.0 percent. However, such properties have been measured only on monofilaments with  $\leq 7.5 \mu\text{m}$  diameter, carbonized at 1700°C and prepared from a mesophase pitch derived from a carefully filtered precursor. The modulus of the fibers is easily increased by heating to higher temperatures, but the tensile strength is usually reduced by such treatment. The tensile strength of the fiber shows a strong dependence on the gauge length down to about .3mm. Frequency-of-break analysis revealed a bimodal distribution. Fiber failure below 2.0 GPa (300Kpsi) is induced by macro-flaws such as foreign particles, voids and surface cracks; all of which were indentified by optical and electron microscopy.

REPORT NO: AFML-TR-73-207, Part III AD B009 323L  
ACCESS NO: 204,137 November 1975  
TITLE: ELECTRICALLY CONDUCTIVE COATING MATERIALS  
AUTHOR(S): R.N. Griffin and M.J. Noone  
CONTRACT NO: F33615-72-C-1657  
CONTRACTOR: General Electric  
PROJECT MONITOR: J.H. Weaver (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734007  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Antistatic coatings for aircraft radomes were formulated with polyurethane and fluoroelastomer binders and with antimony-doped tin oxide pigment. A continuous process was developed for firing the tin oxide pigment in a laboratory size kiln. Resistivity of the pigment from the continuous process was the same as that obtained in the earlier batch process, and color was lighter than most of the batch processed pigment. Coatings with specification surface resistivity were formulated from both polymeric binders. Better reproducibility was obtained with the fluorelastomer binder. Radar transmission of the fluoroelastomer-based coatings exceeded 90%. Rain erosion resistance up to 148 minutes at 500 mph was attained. The thermal flash resistance of all the coatings was lower than desired.

REPORT NO: AFML-TR-73-243, Volume III AD B011 456L  
ACCESS NO: 202,596 January 1976  
TITLE: EXPLORATORY DEVELOPMENT OF PROCESSABLE LAMINATING RESINS WITH IMPROVED TOUGHNESS AND MODERATE TEMPERATURE CAPABILITY: VOLUME III, PHASE II AND III  
AUTHOR(S): R.W. Vaughan, M.K. O'Rell and C.H. Sheppard  
CONTRACT NO: F33615-72-C-2122  
CONTRACTOR: TRW Systems

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PROJECT MONITOR: L. Picklesimer (AFML/MBC)  
PROJECT NO: 7340  
TASK NO: 734003  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Resin optimization studies and adhesive development work were continued with the DONA polyimide resin developed under Phase I of this program. Objectives of the Phase II and III studies during this twelve-month period were to identify a lower boiling solvent than DMF or NMP and to develop an adhesive using the DONA polyimide resin. The PMR approach was evaluated as a route to obtaining resin stability in low boiling solvents. It was demonstrated that the use of DMF is key to obtaining sufficient imidization prior to cure at 400°F. Attempts to develop an adhesive using the DONA polyimide resin were unsuccessful.

REPORT NO: AFML-TR-73-253 AD B011 680  
ACCESS NO: 204,415 March 1976  
TITLE: THERMAL DEGRADATION OF HIGH TEMPERATURE FIBERS  
AUTHOR(S): W.L.S. Lauhuf  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: I. Goldfarb (AFML/MBP)  
PROJECT NO: 7342  
TASK NO: 734203  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Thermal degradation and mass spectrometric studies were made on two Nomex samples (one dyed and the other undyed), two Nomex II samples (both dyed) and three PBI samples (one undyed and two dyed). The kinetic parameters of activation energy, pre-exponential factor and reaction order for each degradation reaction was determined for each fiber sample. From this investigation, it was found that PBI loses 40 percent of its weight during degradation to 900°C; whereas, Nomex II loses 50 percent and Nomex loses 60 percent of its weight. PBI is also more thermally stable since a considerably higher temperature is required to initiate polymer degradation. Nomex II is significantly improved over Nomex, but still it begins to degrade before the degradation of PBI commences.

REPORT NO: AFML-TR-73-270, Part II AD B009 419L  
ACCESS NO: 204,139 August 1975  
TITLE: IMPROVED SURFACE TREATMENTS OF TITANIUM ALLOYS FOR ADHESIVE BONDING  
AUTHOR(S): W.W. Ladyman  
CONTRACT NO: F33615-72-C-1588  
CONTRACTOR: Vought Systems Division/LTV Aerospace Corporation  
PROJECT MONITOR: E. Arvay (AFML/MBC)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: U.S. Govt. Agencies Only

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ABSTRACT: Further refinements of the Vought Abrasive Surface Treatment (VAST) process were required for production applications as well as proving the basic structural design data for use of the process in future aircraft designs. In addition, further work was needed in the search for an understanding of the degradation mechanism of adhesively bonded titanium subjected pursued: (1) establishment of parametric limits for the process, (2) development of a reliable testing technique to measure the effect of environmental exposure in adhesive bonded joints, (3) investigation to find the locus of failure and cause of interface deterioration, and (4) analysis of the surface that gives the best bond to discover the reason for good bonds. Analysis by infrared attenuated total reflectance of four adhesives after exposure to heat and moisture are also presented and indicate that the adhesive is also critical to the bond when the joint is exposed to hostile environment.

REPORT NO: AFML-TR-74-73, Part II AD A025 256  
ACCESS NO: 204,348 October 1975  
TITLE: MECHANISMS OF ADHESION FAILURE BETWEEN POLYMERS AND METALLIC SUBSTRATES: PART II, ALUMINUM 2024-T3 AND TITANIUM 6Al-4V WITH HT424 ADHESIVE

AUTHOR(S): T. Smith  
CONTRACT NO: F33615-72-C-1641  
CONTRACTOR: Rockwell International  
PROJECT MONITOR: E.A. Arvay (AFML/MBC)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report describes the continuation of a study of aluminum 2024-Te alloy and titanium 6Al-4V alloy adherends adhesively bonded with epoxy HT424 adhesive. The adherend surface properties, after standard preparation treatments, were characterized with a number of surface tools: Ellipsometry, surface optical microscopy, contact angle, photo electron emission, and light scattering. By calibrating the above mentioned instruments for hydroxide and organic films of known chemistry, it has been possible to discern the mechanism of aging degradation. The mechanisms of bond failure have been greatly elucidated by a careful study of the data.

REPORT NO: AFML-TR-74-89, Part II AD B006 549L  
ACCESS NO: 203,818 May 1975  
TITLE: HIGH TEMPERATURE RESINS HAVING IMPROVED PROCESSIBILITY  
AUTHOR(S): B.G. Kimmel, N. Bilow and A.L. Landis  
CONTRACT NO: F33615-73-C-5063  
CONTRACTOR: Hughes Aircraft Company  
PROJECT MONITOR: T.J. Aponyi (AFML/MBC)  
PROJECT NO: 7340  
TASK NO: 734003  
DIST. STATEMENT: U.S. Govt. Agencies Only

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**ABSTRACT:** Acetylene-terminated polyimide oligomers were evaluated in combination with high performance graphite fibers as molding compounds. A molding formulation was developed which consisted of Hercules A-S tow impregnated with HR 600 (40 percent resin) and chopped to a fiber length of one inch. High strength HR 600/A-S moldings were prepared which gave flexural strength values as high as 80,000 psi and modulus values as high as  $7 \times 10^6$  psi. Resistance to thermal aging was excellent up to 800°F (57 percent retention of original flexural strength after 2 hours aging in air at 800°F). As part of the general evaluation of HR 600, fiberglass laminates prepared from this resin were tested for dielectric properties at a typical radar frequency as copper clad laminated stock for printed wiring board applications.

REPORT NO: AFML-TR-74-115, Part II AD B008 852L  
ACCESS NO: 204,220 August 1975  
TITLE: EXPLORATORY DEVELOPMENT ON FORMATION OF HIGH STRENGTH,  
HIGH MODULUS BORON NITRIDE CONTINUOUS FILAMENT YARNS  
AUTHOR(S): R. Lin and R. Ohnsorg  
CONTRACT NO: F33615-74-C-5092  
CONTRACTOR: Carborundum Company  
PROJECT MONITOR: J.H. Ross (AFML/MBC)  
PROJECT NO: 7320  
TASK NO: 732001  
DIST. STATEMENT: U.S. Govt. Agencies Only

**ABSTRACT:** A program has been carried out to produce continuous boron nitride filament yarn with a diameter in the range of 3 to 4 microns. The feasibility for producing the fiber with this diameter range was demonstrated by reducing the tip orifice size from 0.076" to 0.048". Three 100 tip bushings and two 450 tip bushings were constructed and evaluated. The critical parameters affecting the fiber drawing operations were identified. The results led to the decision to construct a 950 tip Pt-bushing. This work is currently in process. The technique to reduce the effect of filamentizing was developed by a new sizing. This facilitates the unwinding of filament yarn for continuous nitriding operations.

REPORT NO: AFML-TR-74-136 AD A025 622  
ACCESS NO: 204,356 March 1976  
TITLE: DYNAMIC BEHAVIOR OF LAMINATED POLYMERIC MATRIX COMPOSTIES  
AUTHOR(S): R.W. Mortimer and P.C. Chou  
CONTRACT NO: F33615-73-C-5102  
CONTRACTOR: Drexel University  
PROJECT MONITOR: J.M. Whitney (AFML/MBM)  
PROJECT NO: 7342  
TASK NO: 734202  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
**ABSTRACT:** The primary goal of this two-year program is to quantify, numerically and experimentally, the dynamic response of idealized laminated graphite-epoxy fan blades subjected to impact loads. Two impact cases will be studied: one is the short-time local response, idealized by wave propagation in laminated plates; the other is the structural response idealized by laminated

beam. This report includes results of the theoretical and experimental predictions of wave velocities and strain histories for the case of inplane impact of aluminum, graphite epoxy cross-ply and graphite epoxy angle-ply plates. In addition, preliminary results for the shear-loading impact of the aluminum plate are presented.

REPORT NO: AFML-TR-74-151, Part II AD B012 033  
 ACCESS NO: 204,335 December 1975  
 TITLE: HIGH STRENGTH CARBON ABLATIVE MATERIALS: PART II,  
 CHOPPED/CONTINUOUS PAN BILLETS AND ALTERNATIVE PRECURSORS  
 AUTHOR(S): G.K. Leyden  
 CONTRACT NO: F33615-73-C-5131  
 CONTRACTOR: United Technologies Research Center  
 PROJECT MONITOR: R. Farmer (AFML/MBC)  
 PROJECT NO: 7340  
 TASK NO: 734001  
 DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: Carbon specimens were produced by the pyrolysis of hot compacted precursor fibers. Precursor fibers investigated were polybenzimidazole (PBI), aromatic polyamide (PRD-49), and polyacrylonitrile (Dralon T). The latter material was found to offer superior fabricality and mechanical properties. Substantial improvements in longitudinal and transverse flexural strengths and in longitudinal strain to failure accompanying lower Young's modulus resulted from a relaxation of the Dralon T precursor during the precompaction treatment. Attempts to improve the oxidation resistance of fibrous carbon billets by incorporating silicon into the precursor structure were unsuccessful.

REPORT NO: AFML-TR-74-169, Part II AD B009 505L  
 ACCESS NO: 204,215 December 1975  
 TITLE: IMPROVED FATIGUE STRENGTH ADHESIVE: PART II, ADHESIVE OPTIMIZATION  
 AUTHOR(S): D. Klapprott, C. Mahoney, P. Stifel, and E. Fannin  
 CONTRACT NO: F33615-73-C-5133  
 CONTRACTOR: Hysol Division/Dexter Corporation  
 PROJECT MONITOR: T.J. Aponyi (AFML/MBC)  
 PROJECT NO: 7340  
 TASK NO: 734002  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: Addition of high strength, high modulus fibers, such as graphite, to the adhesive system has been found to improve the fatigue durability of such assemblies. An increase in allowable fatigue loading to as much as 50% of static strengths was demonstrated in the initial portion of this contract by addition of PWA, a graphite fiber fabric, to ADX-653, a 350F service system. The fatigue resistance of the ADX-653/PWA combination, as measured by a single load test, was doubled by the application of a silane finishing agent to the graphite surface prior to resin impregnation. A five-fold increase in the expected bond lifetime under advanced fighter aircraft spectrum fatigue testing was demonstrated using the PWA reinforced ADX-653 system as

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compared to a state of the art nylon fabric supported system. The ADX-653/PWA system, although showing significantly improved spectrum fatigue resistance over control, is inferior in this parameter to an adhesive system currently used in constructing an advanced fighter aircraft.

REPORT NO: AFML-TR-74-177, Part III AD A019 957  
ACCESS NO: 204,132 November 1975  
TITLE: STRUCTURE-STABILITY RELATIONSHIPS OF POLYMERS BASED ON  
THERMOGRAVIMETRIC ANALYSIS DATA: PART III, SEMIORGANIC  
POLYMERS

AUTHOR(S): G.F.L. Ehlers  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: G.F.L. Ehlers (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: To provide guidance for research in polymer synthesis for high temperature nonmetallic materials, two previous reports were issued (AFML-TR-74-177, Parts I and II) in which the structures of aliphatic, aromatic and heterocyclic polymers were correlated with their thermal stabilities based on TGA data. Additional stabilities of repeat units and moieties were determined, and the effect of ortho, meta and para substitution, crosslinking, molecular weight, pendant groups, and other factors were discussed. The present report concludes this structure-stability correlation with the discussion of semi-organic polymers.

REPORT NO: AFML-TR-74-189, Part II AD A021 512  
ACCESS NO: 204,177 January 1976  
TITLE: ANALYSIS OF FILM THICKNESS EFFECT IN SLOW-SPEED LIGHTLY-  
LOADED ELASTOHYDRODYNAMIC CONTACTS: PART II, MEASURE-  
MENT OF FILM THICKNESSES IN VACUUM

AUTHOR(S): J.C. Tyler, H.J. Carper, R.D. Brown, and P.M. Ku  
CONTRACT NO: F33615-73-C-5123  
CONTRACTOR: Southwest Research Institute  
PROJECT MONITOR: W. Ward (AFML/MBT)  
PROJECT NO: 7343  
TASK NO: 734303  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report presents a summary of the second year's effort in a two-year program to study the influence of oil film thickness on bearing-lubricant life expectancy in despin mechanical assembly-type bearings operating in vacuum. The measurements show that, in general, lubricant starvation occurs in the bearings with the result that the EHD film thicknesses are less than those predicted by the theoretical equations for flooded EHD lubrication. Examination of the bearings after test termination reveals that substantially full EHD lubrication (not flooded, but separation of bearing surfaces) at the ball-race contacts apparently prevailed for the duration of the tests.

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REPORT NO: AFML-TR-74-197 AD A026 408  
ACCESS NO: 204,338 March 1976  
TITLE: RELIABILITY PREDICTION FOR COMPOSITE JOINTS-BONDED AND BOLTED  
AUTHOR(S): R.V. Wolff and G.H. Lemon  
CONTRACT NO: F33615-73-C-5061  
CONTRACTOR: General Dynamics  
PROJECT MONITOR: J.M. Whitney (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: An experimental program was conducted on coupon-sized graphite-epoxy laminate-to-metal joints. Both adhesively bonded and mechanically fastened joints were tested in fatigue to the same random (flight-by-flight) spectrum to provide lifetime and residual strength data. The empirical data developed for both types of joints was analyzed using structural reliability techniques that included the use of a probabilistic fatigue model previously introduced by Dr. J.C. Halpin of AFML and M.E. Waddoups of the Fort Worth Division of General Dynamics. The program also included the development of methods for pooling dispersion data to estimate the Weibull shape parameter. Three methods were developed and directly compared: parameter averaging, normalization and maximum likelihood.

REPORT NO: AFML-TR-74-201, Part II AD A031 621  
ACCESS NO: 204,545 October 1975  
TITLE: FLUIDS, LUBRICANTS, FUELS AND RELATED MATERIALS  
AUTHOR(S): E.E. Klaus and E.J. Tewksbury  
CONTRACT NO: F33615-73-C-5101  
CONTRACTOR: Penn State University  
PROJECT MONITOR: G.J. Morris (AFML/MBT)  
PROJECT NO: 7343  
TASK NO: 734303  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A diffusion effect at the gas liquid interface during the determination of pressure viscosity values in a capillary instrument is shown to be a problem. A method to minimize the effects of gas diffusion is proposed. Pressure coefficients for fluids such as mineral oils, "dumbbell" blends of mineral oil fractions and paraffinic resin-solvent blends are shown to be independent of pressure at pressures up to at least 3000 psig at a variety of temperatures. The correlations developed are shown to require less physical property data, apply to a wider range in fluidity, apply to a wide range of chemical type fluids, and to provide better accuracy when compared to a number of leading correlations from the literature. Wear debris analysis can be used to measure the production of metal particles, metal oxides and organometallic reaction products produced in the wear conjunction.

REPORT NO: AFML-TR-74-247, Part II AD A027 068  
ACCESS NO: 204,358 December 1975  
TITLE: DEVELOPMENT OF A GAS TURBINE ENGINE OIL FOR BULK OIL TEMPERATURES OF -40 TO 465°F

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AUTHOR(S): F.S. Clark, J.F. Herber and S.L. Reid  
CONTRACT NO: F33615-73-C-5079  
CONTRACTOR: Monsanto Research Corporation  
PROJECT MONITOR: G. Morris (AFML/MBT)  
PROJECT NO: 7343  
TASK NO: 734303  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This contract involved advanced characterization of three MIL-L-27502 lubricants. These were ester blends designated MCS 1710, MCS 1709 and Fluid 12. Oxidation-corrosion and storage life tests were run on all fluids. MIL-L-27502 bearing tests were run on MCS 1710 and MCS 1709; each gave very good results. Moreover, both of these blends have satisfactory Ryder loads. Two hundred gallons MCS 1710 plus a metal deactivator were blended and sent to AFML for further evaluation. The deactivator was added to reduce magnesium corrosion of MCS 1710.

REPORT NO: AFML-TR-74-258 AD A025 906  
ACCESS NO: 204,325 March 1976  
TITLE: DYNAMIC RESPONSE OF ANISOTROPIC LAMINATED PLATES UNDER INITIAL STRESS TO IMPACT OF A MASS

AUTHOR(S): C.T. Sun and S. Chattopadhyay  
CONTRACT NO: F33615-73-C-5112  
CONTRACTOR: Purdue University  
PROJECT MONITOR: J. Whitney (AFML/MBM)  
PROJECT NO: 7342  
TASK NO: 734202  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The central impact of a mass on a simply-supported laminated composite plate under initial stress is investigated. The contract force and the dynamic response of the plate are obtained by solving a non-linear integral equation. The energy transferred from the mass to the plate during impact is also obtained by use of a normalized contact force. It is found that a higher initial tensile stress elevates the maximum contact force, but reduces the contact time, the deflections and the stresses. It is also noted that a higher tensile initial stress results in less energy transfer from the striking mass to the plate.

REPORT NO: AFML-TR-75-13, Part I AD B009 824L  
ACCESS NO: 204,216 November 1975  
TITLE: ADVANCED ABLATIVE HEATSHIELD CONCEPTS: PART I, SEAMLESS CARBON-QUARTZ WOVEN TAPE/PHENOLIC RESIN COMPOSITES

AUTHOR(S): R. Farmer  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBC  
PROJECT MONITOR: R. Farmer (AFML/MBC)  
PROJECT NO: 7340  
TASK NO: 734001  
DIST. STATEMENT: U.S. Govt. Agencies Only

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ABSTRACT: State of the art tape-wrapped carbon/phenolic composites are inadequate for lightweight, seamless, hydrometeor erosion resistant and shock resistant heatshields for future AF reentry missile systems.

REPORT NO: AFML-TR-75-22 AD B009 465L  
ACCESS NO: 204,219 September 1975  
TITLE: EVALUATION OF A PREAMBITED SEALANT SELF-SEALING  
CONCEPT FOR PROTECTING AIRCRAFT FUEL TANKS AGAINST SMALL  
ARMS PROJECTILES  
AUTHOR(S): T.L. Graham and J.K. Klein  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBE  
PROJECT MONITOR: T.L. Graham and J.K. Klein (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734005

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This investigation was conducted to evaluate the merits of a novel self-sealing materials concept proposed by Dynamic Science Division of Ultrasystems, Incorporated that offers the potential of sealing cored or misaligned wound punctures beyond the capability of conventional self-sealing fuel cells developed in the past. The concept is based on pre-activated sealant which is in a pressurized state and thus, flows into and fills a cored-out or misaligned wound. In this case, a mechanical technique for placing a fluid sealant under pressure was investigated. On the strength of encouraging preliminary ballistic test results, the ASD has initiated a program to further exploit the pre-activated sealant approach for improved self-sealing fuel cells in protecting aircraft against destruction by small arms.

REPORT NO: AFML-TR-75-33 AD A024 537  
ACCESS NO: 204,278 June 1975  
TITLE: INVESTIGATION OF STRESS LEVELS CAUSING SIGNIFICANT  
DAMAGE IN COMPOSITES  
AUTHOR(S): G.C. Grimes and P.H. Francis  
CONTRACT NO: F33615-71-C-1574  
CONTRACTOR: Southwest Research Institute  
PROJECT MONITOR: J.M. Whitney (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734003

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This program presents flat specimen and tube mechanical performance data on graphite/epoxy composites. The experimental program was designed to study significant damage stress levels in these materials. The objective of the investigation was to establish an experimental definition of the stress level within a composite specimen at which physical damage and/or degradation of mechanical properties are initiated such that the material resistance to subsequent loadings is seriously impaired. This stress level is referred to herein as the "significant damage" stress level. In addition, related experimental methods were developed, and a laminate strength criterion was compared with the experimental data generated.

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REPORT NO: AFML-TR-75-38, Part II AD A031 096  
ACCESS NO: 204,482 April 1975  
TITLE: INVESTIGATION OF CAGE AND BEARING INSTABILITY IN DESPUN  
ANTENNA BEARINGS DUE TO CHANGES IN LUBRICATION PROPERTIES  
PART II

AUTHOR(S): J.W. Kannel, S.S. Bupara and C.J. Pentlicki  
CONTRACT NO: F33615-74-C-5012  
CONTRACTOR: Battelle, Columbus Laboratories  
PROJECT MONITOR: M.P. Rivera (AFML/MBT)  
PROJECT NO: 7343  
TASK NO: 734303

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A computer program has been developed for the purpose of  
investigating cage instability in a despun antenna bearing. As a result of  
the experimental and analytical studies, a stability criterion is presented  
which relates stability to lubricant and cage properties. In general, it is  
shown that a cage in a bearing can be unstable (regardless of the guiding sur-  
face) provided the cage is not externally constrained and the ball-race trac-  
tions are very high.

REPORT NO: AFML-TR-75-70, Part II AD B011 050L  
ACCESS NO: 204,292 December 1975  
TITLE: ADVANCED PROTECTIVE MATERIALS FOR REENTRY MISSILE NOSE-  
TIPS: PART II, THREE-DIMENSIONAL REINFORCED CARBON/  
PLASTIC NOSE TIP SKIRTS

AUTHOR(S): R.J. Popp  
CONTRACT NO: F33615-74-C-5048  
CONTRACTOR: McDonnell Douglas Astronautics, East  
PROJECT MONITOR: R.D. Craig (AFML/MBT)  
PROJECT NO: 7340  
TASK NO: 734001

DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Advanced thermal protection materials are required for  
missile reentry systems to assure survival in natural and hostile environments.  
The new composites consist of a 3D carbon reinforcement woven on an automated  
circular loom and impregnated with phenolic resin using a centrifugal process.  
These composites demonstrated the following improved characteristics relative  
to conventional 20 layup two-dimensional materials: 28 percent less ablative  
surface recession, 50 percent greater rain erosion resistance, 30 percent lower  
radial thermal conductivities, 100 percent greater circumferential direction  
tension and shear strengths, and significantly greater stress attenuation.

REPORT NO: AFML-TR-75-74 AD B009 466L  
ACCESS NO: 204,142 October 1975  
TITLE: MULTIPLE IMPINGEMENT RAIN EROSION BEHAVIOR OF REENTRY  
VEHICLE CARBON-CARBON AND QUARTZ/SILICA COMPOSITE MATERIALS  
AND MONOLITHIC CERAMIC RADOME MATERIALS

AUTHOR(S): G.F. Schmitt, Jr.

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CONTRACT NO: Internal  
CONTRACTOR: AFML/MBE  
PROJECT MONITOR: G.F. Schmitt (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734007  
DSIT. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Investigation of the influence of materials construction variables effects and environmental parameter effects on the rain erosion behavior of reentry vehicle nose tip, heat shield, and antenna window materials and radome materials at velocities of 4000 to 65000 fps has been conducted by firing multistaged rocket sleds equipped with special specimen holders through the artificial rainfield at Holloman Air Force Base.

REPORT NO: AFML-TR-75-85, Part II AD B015 699L  
ACCESS NO: 204,664 August 1976  
TITLE: SYNTHESIS OF THERMALLY STABLE POLYMERS, PART II  
AUTHOR(S): C.S. Marvel  
CONTRACT NO: F33615-74-C-5113  
CONTRACTOR: University of Arizona  
PROJECT MONITOR: G.A. Loughran (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Further work has been done on the synthesis of a sample of aromatic polyether, -ketone, -sulfone polymer with acetylenic side groups for adequate evaluation, but evaluation results are not yet forthcoming. A program on the synthesis of aromatic polyether, -ketone, -sulfone polymers with units of p-p-diphenic acid with 2,2'-diphenylethynyl side groups has been carried out. The polymers cure by an intramolecular cyclization reaction. The copolymers made from the diphenic acid and isophthalic acid have properties that make them interesting as matrix resins for glass laminates.

REPORT NO: AFML-TR-75-116 AD B010 467  
ACCESS NO: 204,229 September 1975  
TITLE: TANTALOCENE/POLYPHENYLENE MATRIX FOR TaC-LOADED CARBON/  
CARBON COMPOSITES  
AUTHOR(S): N. Bilow, A.L. Landis, T.W. Giants, and R.H. Boschan  
CONTRACT NO: F33615-74-C-5054  
CONTRACTOR: Hughes Aircraft Company  
PROJECT MONITOR: R. Farmer (AFML/MBC)  
PROJECT NO: 7340  
TASK NO: 734001  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Research was conducted on organometallic compounds in a study aimed at the production of metallated resins or composites which upon pyrolysis would produce carbonaceous chars having "near" atomically dispersed metal atoms or "near" molecularly dispersed metal carbides. Metallocenes were considered as primary candidates for this application. Solutions of tantalocene in benzene were completely compatible with solutions of H-Resin

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(polyphenylene) in benzene and when solvent was removed from these solutions, homogeneous tantalocene/H-Resin blends were achieved. Molded specimens made from these compositions, when pyrolyzed produced chars with tantalum carbide particles of about 25-270 $\text{\AA}$  and after graphitization, the particles averaged 150-450 $\text{\AA}$ . X-ray diffraction studies and transmission electron microscopic analyses confirmed that these particles were tantalum carbide.

REPORT NO: AFML-TR-75-130 AD B011 796L  
ACCESS NO: 204,389 July 1975  
TITLE: THERMOGRAVIMETRIC-MASS SPECTROMETRIC POLYMER ANALYSIS  
AUTHOR(S): E.G. Jones and P.A. Banadum  
CONTRACT NO: F33615-72-C-1537  
CONTRACTOR: Systems Research Laboratories  
PROJECT MONITOR: I.J. Goldfarb (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Thermogravimetric-mass spectral (TGMS) analyses of the volatile products of thermal degradation of 16 polymers are reported. Perfluoro- and perfluoroether-substituted benzoxazoles comprise the majority of the samples. Perfluoro-substituted benzoxazoles, in general, display one temperature region of volatile product formation. The volatile products tend to be perfluoro-carbons. Perfluoroether-substituted benzoxazoles, depending upon the structure and location of the substitution, tend to display one or two regions of volatile-product formation. The temperature at which the high-temperature process occurs coincides with that for decomposition of the perfluoro-substituted benzoxazoles. Some of the other samples analyzed include acetylene-terminated imides and quinoxolines. No appearance of volatile products from the imides or quinoxolines was noted at or below the curing temperature (200°C).

REPORT NO: AFML-TR-75-131, Part IV AD B008 955L  
ACCESS NO: 204,705 September 1975  
TITLE: NUCLEAR VULNERABILITY OF THERMAL PROTECTION MATERIALS  
PART IV: ELECTRON BEAM TESTS TO DETERMINE THE RESPONSE  
OF 3-DIMENSIONAL CARBON-PHENOLIC COMPOSITES  
AUTHOR(S): D. Keller and E.A. Anderson  
CONTRACT NO: F33615-74-C-5053  
CONTRACTOR: Ktech Corporation  
PROJECT MONITOR: R. Craig (AFML/MBC)  
PROJECT NO: 7340  
TASK NO: 734001  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Material response tests were conducted at the NEPTUNE-C pulsed electron beam facility. Three types of 3-dimensional carbon phenolic composites were exposed to the 100-nsec pulse of electrons with a mean energy of about 300 keV. Impulse, stress, damage, and beam diagnostic measurements were made. Tape wrapped, angle interlock, and orthogonal carbon phenolic produced stresses of about 10 kbar at 120 cal/cm<sup>2</sup>. Impulse measurements were

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made only for the angle interlock composite which produced up to about 6 ktaps at 120 cal/cm<sup>2</sup>. All three materials exhibited some rear surface damage at this fluence level. The considerable scatter in the material response data could not be directly attributed to electron beam variance.

REPORT NO: AFML-TR-75-154 AD B011 677L  
ACCESS NO: 204,326 January 1976  
TITLE: EXPLORATORY DEVELOPMENT ON ANTISTATIC COATINGS FOR USE  
ON AIRCRAFT TRANSPARENCIES

AUTHOR(S): W. Boord, H. Mar and P. Zimmer  
CONTRACT NO: F33615-74-C-5050  
CONTRACTOR: Honeywell, Incorporated  
PROJECT MONITOR: T.L. Peterson (AFML/MBE)  
PROJECT NO: ILIR  
TASK NO: ILIROO

DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: The objective of this program was to develop conductive and protective coatings for polycarbonate and acrylic. The approach taken was to develop multilayer coatings in which each component displayed the desired properties necessary to meet one or more of the program requirements, and such that the coating system as a whole would satisfy all the program requirements. Four deposition techniques were used to deposit transparent ceramics, oxide semiconductors, thin metal films and/or organic polymer films. Two methods of achieving antistatic coatings were used. Both methods produced abrasion, thermal cycling, and solvent resistant antistatic coatings. However, the antistatic coating systems suffered a decrease in adhesion with prolonged exposure to humidity and accelerated weathering.

REPORT NO: AFML-TR-75-157, Volume I AD B009 604L  
ACCESS NO: 204,180 September 1975  
TITLE: EXPLORATORY DEVELOPMENT AND INVESTIGATION OF CARBON-CARBON COMPOSITE MATERIALS HAVING IMPROVED HYPERSONIC PARTICLE EROSION RESISTANCE CHIP CARBON HYPERSONIC IMPACT PROGRAM: VOLUME I, MATERIALS SELECTION AND CHARACTERIZATION

AUTHOR(S): J.A. Zelik, D.A. Eitman and K. Ktatsch  
CONTRACT NO: F33615-73-C-5140  
CONTRACTOR: McDonnell Douglas Astronautics  
PROJECT MONITOR: G.F. Schmitt (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734001

DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: The CHIP Program objectives and the overall approach to achieve them are presented in this volume of the CHIP final report. The carbon-carbon erosion data in existence prior to this study is reviewed, and the material erosion trends observed from the data are presented. To further investigate these erosion trends, the material variables which should influence erosion are identified, and a rationale is established for selecting and

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evaluating to determine the effects on properties of the material variables: constituents, weave parameter and processing. Nineteen different carbon-carbon materials were selected and characterized for their physical thermal and mechanical properties and microstructures. The microstructures and properties are presented. The data is analyzed for trends relating to the material variables. Conclusions based on the observed trends are presented.

REPORT NO: AFML-TR-75-157, Volume II AD B009 584L  
ACCESS NO: 204,180 September 1975  
TITLE: EXPLORATORY DEVELOPMENT AND INVESTIGATION OF CARBON-CARBON COMPOSITE MATERIALS HAVING IMPROVED HYPERSONIC PARTICLE EROSION RESISTANCE CHIP CARBON HYPERSONIC IMPACT PROGRAM: VOLUME II, EROSION AND ABLATION OF CARBON-CARBON COMPOSITES  
AUTHOR(S): D.D. Woolley and K.M. Kratsch  
CONTRACT NO: F33615-73-C-5140  
CONTRACTOR: McDonnell Douglas Astronautics  
PROJECT MONITOR: G. Schmitt (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734001  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This volume of the CHIP final report describes the objectives of this exploratory development program for improvement of carbon-carbon composites for severe erosion and ablation applications. Selected single and multiple particle impact data are reviewed which apply to these objectives, and preliminary conclusions are stated regarding these data. Results of post-test analysis of Holloman Sled Tests of rain erosion of CCAP carbon-carbon are included.

REPORT NO: AFML-TR-75-167 AD B012 017L  
ACCESS NO: 204,351 March 1976  
TITLE: THERMAL FLUX PROTECTION FOR AIRCRAFT SYSTEMS  
AUTHOR(S): J.H. Weaver and D.K. Wade  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBE  
PROJECT MONITOR: J.H. Weaver (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734007  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The experimental white and camouflage silicone coating systems were examined for infrared suppression capabilities by comparison of their optical behavior with that of the white polyurethane system. These new coatings offered a 50% increase in IR reflectance over that of the conventional white polyurethane. Both the polyurethane and silicone aluminized coatings showed tendencies to blister during irradiation. Comparison of results illustrated that the white silicone provided the best thermal flash resistance although the white polyurethane also performed well. Due to their low thermal conductivity, composite substrates tended to reduce the effectiveness of the

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applied coatings since more of the absorbed energy was concentrated at the surface of the panels, causing adhesion and binder instability problems.

REPORT NO: AFML-TR-75-173 AD A020 957  
ACCESS NO: 204,144 October 1975  
TITLE: STATIC PROPENSITY OF AIR FORCE UTILITY GARMENTS AND THE  
N-38 MODIFIED JACKET  
AUTHOR(S): P.C. Opt and J.H. Ross  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MB  
PROJECT MONITOR: J. Ross (AFML/MB)  
PROJECT NO: 7320  
TASK NO: 732002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report describes and gives the results of tests performed to measure the static propensity of the Air Force regular issue cotton utility uniform, a proposed polyester/cotton utility uniform and the N-3B modified flying jacket. Static potential (voltage) was measured on the test subject after rubbing contact and separation of various garments. Tests were conducted in an environmental chamber at 70°F-20% RH, 90°F-20% RH, 70°F-55% RH and 15°F with resulting humidity. On the basis of the tests conducted and on analysis of the results, the proposed polyester/cotton utility uniform and the N-3B modified flying jacket present no greater hazard in the generation of static electricity than the 100% cotton utility uniform now in service.

REPORT NO: AFML-TR-75-175, Part I AD A021 954  
ACCESS NO: 204,143 December 1975  
TITLE: DEVELOPMENT OF SELF-LUBRICATING COMPOSITES CARBONIZED  
PHENOLIC MATRIX  
AUTHOR(S): M.T. Lavik and V. Hopkins  
CONTRACT NO: F33615-75-C-5101  
CONTRACTOR: Midwest Research Institute  
PROJECT MONITOR: B.D. McConnell (AFML/MBT)  
PROJECT NO: 7343  
TASK NO: 734302  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Exploratory development and evaluation has been conducted on self-lubricating composites which utilize a carbonized phenolic resin (CPR) matrix. Composites have been prepared with as much as 38% (vol.) graphite fibers. Additives such as Sb<sub>2</sub>O<sub>3</sub>, ZnO and tetrafluoroethylene powders have provided beneficial synergistic effects within the CPR-MoS<sub>2</sub>-fiber composites. The composites with more than 30% fiber performed better at the high loads than those with lower fiber content.

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REPORT NO: AFML-TR-75-175, Part II AD A031 009  
ACCESS NO: 204,533 April 1976  
TITLE: DEVELOPMENT OF SELF-LUBRICATING COMPOSITES UTILIZING  
CARBONIZED PHENOLIC MATRIX PART II: A SUMMARY REPORT  
AUTHOR(S): M.L. Lavik and V. Hopkins  
CONTRACT NO: F33615-75-C-5101  
CONTRACTOR: Midwest Research Institute  
PROJECT MONITOR: B.D. McConnell (AFML/MBT)  
PROJECT NO: 7343  
TASK NO: 734302  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Exploratory development and evaluation has been conducted on self-lubricating composites which utilize a carbonized phenolic resin (CPR) matrix. Composites have been prepared with as much as 59% (vol.) graphite fibers. Specimens have been compression-molded directly as journal liners within a metal housing or as blanks which can be machined into desired test configurations. Additives such as  $Sb_2O_3$ , ZnO and tetrafluoroethylene powders have provided beneficial synergistic effects within the CPR-MoS<sub>2</sub>-fiber composites.

REPORT NO: AFML-TR-75-178 AD A024 988  
ACCESS NO: 204,293 December 1975  
TITLE: DEVELOPMENT OF HIGHLY ORIENTED POLYMERS WITH IMPROVED  
MECHANICAL PROPERTIES  
AUTHOR(S): E.A. Meinecke and D. McIntyre  
CONTRACT NO: F33615-73-C-5113  
CONTRACTOR: University of Akron  
PROJECT MONITOR: R.L. VanDeusen (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The first general method adopted in this study to produce oriented polymer films involves the crystallization of polyethylenes in dilute solutions under shear. The data indicates a trend towards greater orientation with increased shear rate; however, the films lack good physical integrity. Consequently, the mechanical properties are low compared to theoretical expectations. The second general method adopted involves the simultaneous application of a shear field and high pressure on dilute solutions of polyethylene in a top-shirred high pressure reactor kept at constant stirring rates. The films had greater physical integrity in this experiment than in the first method, but the dependence of the mechanical properties on the pressure and stirring rate is not clear. A third general method uses a very rigid polymer backbone structure. The high crystallite orientation of these polymers suggests that they are more likely to produce desirable mechanical properties.

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REPORT NO: AFML-TR-75-194  
ACCESS NO: 204,387  
TITLE: DEVELOPMENT OF HME LAMINATING RESIN  
AUTHOR(S): R.W. Vaughan and G.A. Zakrzewski  
CONTRACT NO: F33615-73-C-5094  
CONTRACTOR: TRW Systems  
PROJECT MONITOR: C.E. Browning (AFML/MB)  
PROJECT NO: 7340  
TASK NO: 734003  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The HME resin formulation and synthesis procedure were optimized to yield a stable resin. Composite and honeycomb sandwich panels were vacuum bag molded and provided low resin flow during cure. The resultant composite and sandwich panels demonstrated excellent moisture resistance and suitability for service at 275°F. Also, the cocured sandwich panels provided equivalent flatwise tensile strength values to secondary bonded panels.

AD B012 352  
February 1976

REPORT NO: AFML-TR-75-202, Part I  
ACCESS NO: 204,247  
TITLE: CORRELATIONS BETWEEN POLYMER STRUCTURE AND GLASS TRANSITION TEMPERATURE : PART I - POLYSILOXANES, POLYARYLENESILOXANES AND POLYXYLENESILOXANES

AD B009 388L  
October 1975

AUTHOR(S): G.F.L. Ehlers and K.R. Fisch  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: G.F.L. Ehlers (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: The glass transition temperatures of a number of polysiloxanes, polyarylenesiloxanes, poly(fluoro) alkylene siloxanes and polyxylenesiloxanes were determined to provide much needed structure-property correlations for concurrent research efforts focused upon the tailoring of molecular backbone structures as a means of achieving desired property balance in novel polymers. This data, supplemented with data from the literature, was used to determine the effect of structural features on the glass transition temperature. Increases in glass transition temperatures were observed for polymers with larger and bulkier substituents on the silicone. The presence of aliphatic and aromatic moieties in the siloxane chain also coincided with higher glass transition temperatures.

REPORT NO: AFML-TR-75-204  
ACCESS NO: 204,310  
TITLE: BONDING OF ELEVATED TEMPERATURE STRAIN GAGES TO HUMID AGED GRAPHITE TENSILE SPECIMENS THROUGH THE USE OF ANAEROBIC ADHESIVES

AD A025 920  
December 1975

AUTHOR(S): C.C. Fowler, Jr.  
CONTRACT NO: F33615-75-C-5093  
CONTRACTOR: University of Dayton Research Institute

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PROJECT MONITOR: K.A. Davis (AFML/MB)  
PROJECT NO: 7340  
TASK NO: 734003  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: In order to study the effects of moisture on graphite composites at elevated temperatures, new techniques of adhesively bonding strain gages to test specimens had to be developed. All of the current elevated temperature strain gage adhesives require heat and pressure with varying lengths of time and temperature in order to cure. A room temperature curing, elevated temperature adhesive would be very desirable in order not to negate the moisture effect (dry-out the specimens) or further cure the specimens. The use of anaerobic adhesives was found to be the solution to this problem. New techniques were developed for gage application, and other applications were found to utilize this adhesive's unique characteristics.

REPORT NO: AFML-TR-75-207 AD A027 591  
ACCESS NO: 204,376 April 1976  
TITLE: AN INVESTIGATION OF STRUCTURE-PROPERTY CORRELATIONS IN POLYETHYLENE TEREPHTHALATE FILMS  
AUTHOR(S): A. Visanathan, D.R. Wiff and W.W. Adams  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: E. Goldfarb (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Six characteristic types of polyethylene terephthalate (Mylar) films were studied by x-ray diffraction techniques. The degree of crystallinity extent of preferred orientation, crystallite sizes and paracrystalline disorder were evaluated. The exceptionally high strength in the machine direction of type 142T film may be associated with the high degree of orientation achieved by a two-way stretch followed by a post-stretch in the machine direction. The balanced physical properties in type 1000S film are likewise attributable to the presence of two-way stretches in mutually perpendicular directions. The influence of crystallinity was masked by the anisotropic disorder arising from varying degrees of preferred orientation.

REPORT NO: AFML-TR-75-214 AD A025 897  
ACCESS NO: 204,543 February 1976  
TITLE: PRELIMINARY EVALUATION OF ATQ POLYMER AS A POTENTIAL MATRIX RESIN  
AUTHOR(S): A. Wereta  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: F.E. Arnold (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: Approved for public release; distribution unlimited.

ABSTRACT: AFML Polymer Branch research on acetylene terminated quinoxaline (ATQ) polymers has been extended to determine the potential of this newly discovered material as a matrix resin for reinforced composites. Preliminary investigations of mechanical properties of ATQ research samples have been conducted and the results compared with those obtained on the HR-600 resin which is under AF development. Preliminary findings and others indicate great potential for ATQ and that additional quantities should be made available for the fabrication and evaluation of composite test specimens.

REPORT NO: AFML-TR-76-5 AD B014 104L  
 ACCESS NO: 204,496 March 1976  
 TITLE: INVESTIGATION OF CONTAMINATION EFFECTS ON THERMAL CONTROL MATERIALS  
 AUTHOR(S): T.A. Hughes, T.E. Bonham and T.H. Allen  
 CONTRACT NO: F33615-73-C-5091  
 CONTRACTOR: McDonnell Douglas Astronautics Company - East  
 PROJECT MONITOR: B.C. Price (AFML/MBE)  
 PROJECT NO: 7340  
 TASK NO: 734007  
 DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: Contamination kinetics studied on thick films from DC-704 and RTV-602 (commercial grade) using both infrared ellipsometry and quartz microbalances, confirmed that monomers experience constant deposition rates and reevaporation rates, while polymers have an exponential decay in such areas. Kinetics data was also obtained on a purified form of RTV-602 and on SR-585 silicone adhesive. Limited data was also obtained for RTV's -106 and -506. The effects of specific contaminants, such as multilayer insulations, a non-reflective black paint and a bonded silica fabric, was determined on critical properties of different substrates. Potential materials that might be used as Reststrahlen reflectors to reduce the effects of an electromagnetic encounter were indentified. Also, the effect of contamination on a dielectric stack proposed for this same purpose was examined. The effect of contamination on polarization mixing of the laser communication system optics was experimentally measured and compared with calculated values.

REPORT NO: AFML-TR-76-9 AD B011 769  
 ACCESS NO: 204,495 March 1976  
 TITLE: SYNTHESIS AND MODIFICATION OF CARBOXYLATED POLYPHENYLENES AND PHENYLATED POLYIMIDES  
 AUTHOR(S): F.W. Harris, B.A. Reinhardt, R.D. Case, Jr., S.M. Padaki, V. Sudarsanan, and W.A. Feld  
 CONTRACT NO: F33615-75-C-5073  
 CONTRACTOR: Wright State University  
 PROJECT MONITOR: F.E. Arnold (AFML/MBP)  
 PROJECT NO: 7342  
 TASK NO: 734201  
 DIST. STATEMENT: Approved for public release; distribution unlimited.

**ABSTRACT:** Carboxylated and phenylated biscyclopentadienones have been copolymerized with aromatic dialkynes to afford a series of carboxylated phenylated-polyphenylenes. The polyphenylenes were converted to the corresponding potassium, magnesium and barium salts to afford a series of aromatic ionomers. A phenylated biscyclopentadienone containing a pyridine linkage has also been prepared and polymerized with p-diethynylbenzene. Several phenylated polyimides have been prepared by the polymerization of phenylated dianhydrides with aromatic diamines. An ethynyl-substituted diamine was prepared and polymerized to afford a phenylated polyimide with pendent ethynyl substituents. Finally, acetylene-terminated polyphenylene oligomers were prepared from a biscyclopentadienone and excess p-diethynylbenzene. Solubility, thermal cross-linking and thermal-stability of the polymers are discussed.

REPORT NO: AFML-TR-76-10 AD B014 121L  
 ACCESS NO: 204,507 March 1976  
 TITLE: LOW COST ORTHOGONAL REINFORCED CARBON/CARBON COMPOSITES  
 FOR MISSILE HEATSHIELDS  
 AUTHOR(S): P.J. Roy  
 CONTRACT NO: F33615-74-C-5042  
 CONTRACTOR: Avco Corporation Systems Division  
 PROJECT MONITOR: R. Farmer (AFML/MB)  
 PROJECT NO: 7340  
 TASK NO: 734001  
 DIST. STATEMENT: U.S. Govt. Agencies Only

**ABSTRACT:** The overall technical objective of this program was to explore the potential of developing low cost three-dimensional (3D) orthogonal reinforced carbon/carbon heatshield composites having ablative-structural performance characteristics comparable to or better than the established state-of-the-art composite material. Technical efforts under the program were primarily directed at evaluating new low cost reinforcements and matrix materials having potential for reducing overall 3D carbon-carbon composite cost. Preliminary characterization evaluations and radial material, lateral material and matrix processing developmental evaluations were performed. The most promising materials resulting from these studies were utilized to fabricate a 3D carbon-carbon cylinder as demonstration of a lower cost composite material. Mechanical, thermal, and ablative tests were performed on the cylinder material to determine material property characteristics.

REPORT NO: AFML-TR-76-12 AD A030 770  
 ACCESS NO: 204,484 February 1976  
 TITLE: STRESS ANALYSIS OF PLASTIC ROTATING BANDS  
 AUTHOR(S): M.H. Wagner and K.N. Kreyenhagen  
 CONTRACT NO: F33615-75-C-5206  
 CONTRACTOR: California Research and Technology, Incorporated  
 PROJECT MONITOR: S.W. Tsai (AFML/MBM)  
 PROJECT NO: ILIR  
 TASK NO: ILIROO  
 DIST. STATEMENT: Approved for public release; distribution unlimited.

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**ABSTRACT:** Dynamic stress analysis of plastic rotating bands used on projectiles to impart spin have been obtained by means of a two-dimensional finite-difference computer code. The first phase of the interaction within the barrel, involving the axisymmetric convergence of the plastic band into the forcing cone, has been investigated in this study. Numerical solutions for three rotating band problems were obtained. The results showed that shearing forces acting along the band/barrel interface due to friction can have a major effect on rotating performance, and that with the current design, the rear section of the band becomes grossly distorted. The third case considered a design modification to alleviate the extrusion problem. These initial analyses show that finite-difference code solutions of the dynamics of rotating bands are practical and can provide a useful tool in investigating a number of key factors bearing on plastic band performance.

**REPORT NO:** AFML-TR-76-13 AD A025 736  
**ACCESS NO:** 204,355 March 1976  
**TITLE:** SURFACE ANALYSIS OF 6061 AND 7050 ALUMINUM ALLOYS AFTER  
CONDITIONING BY CHEMICAL TREATMENTS  
**AUTHOR(S):** N.T. McDevitt, W.L. Baun and J.S. Solomon  
**CONTRACT NO:** Internal  
**CONTRACTOR:** AFML/MBM  
**PROJECT MONITOR:** N.T. McDevitt (AFML/MBM)  
**PROJECT NO:** 7340  
**TASK NO:** 734002  
**DIST. STATEMENT:** Approved for public release; distribution unlimited.  
**ABSTRACT:** This investigation was carried out to determine the effect of various chemical treatments on the surface of 6061-T6 and 7050-T76 bare aluminum alloys. After treatments, various chemical elements can be found on the surface arising from the alloy constituents, the chemical solution or tap water rinse. The chemical signature of each surface should be known to assess adhesive bond durability.

**REPORT NO:** AFML-TR-76-16 AD B014 124L  
**ACCESS NO:** 204,535 March 1976  
**TITLE:** CHARACTERIZATION OF TRANSPARENT MATERIALS FOR  
EROSION RESISTANCE  
**AUTHOR(S):** W. Adler and S.V. Hooker  
**CONTRACT NO:** F33615-73-C-5057  
**CONTRACTOR:** Textron's Bell Aerospace  
**PROJECT MONITOR:** T. Peterson (AFML/MBE)  
**PROJECT NO:** 7340  
**TASK NO:** 734007  
**DIST. STATEMENT:** U.S. Govt. Agencies Only  
**ABSTRACT:** This program is directed toward an assessment of the effects of rain erosion damage on loss in transmission of radiation through window materials. The general influence of the progression of the material removal process on the spectral transmittance of polymeric materials (polymethylmethacrylate, polysulfone, polycarbonate, and nylon) and soda lime glass was evaluated for wavelengths from 0.5 to 2.1 microns. An analogous erosion

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sequence occurred in the plastics in which crevice propagation was also important. For very resistant materials, an array of minute pits and polishing digs were observed after extended exposure at higher velocity (845 fps).

REPORT NO: AFML-TR-76-18 AD A026 172  
ACCESS NO: 204,502 March 1976  
TITLE: SURFACE CHARACTERIZATION OF HONEYCOMB CORE MATERIALS  
AUTHOR(S): W.L. Baun, N.T. McDevitt and J.S. Solomon  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBM  
PROJECT MONITOR: W.L. Baun (AFML/MBM)  
PROJECT NO: 7304  
TASK NO: 730402  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Surface characterization studies are carried out on honeycomb core materials by Auger Electron Spectroscopy (AES), Secondary Ion Mass Spectroscopy (SIMS), Ion Scattering Spectroscopy (ISS), and Secondary Electron Microscopy (SEM). Core materials which were studied included 5052, 5056 and 2024 aluminum alloys; titanium, c.p., titanium-6 aluminum-4 vanadium, and stainless steels. Effects of thermal segregation and chemical treatments were studied.

REPORT NO: AFML-TR-76-27 AD A030 877  
ACCESS NO: 204,498 June 1976  
TITLE: SYNTHESIS AND PROPERTIES OF AROMATIC POLYIMIDES CONTAINING THE SIX-MEMBERED RING SYSTEM  
AUTHOR(S): G.A. Loughran and F.E. Arnold  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: F.E. Arnold (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This work was performed to determine the best synthetic procedure for the preparation of six-membered polyimides and the extent to which processability parameters such as solubility and fusibility could synthetically be altered in the polymer system. Hydrolytic stability of this six-membered imide ring system is discussed. A number of new arylenoxy and arylenethio-bis-'pere' anhydrides have been synthesized for use as monomers for the preparation of soluble and fusible polyimides containing six-membered rings. The bis-anhydrides were converted to polyimides by solution polycondensation with oxyarylenediamines. The polyimides were soluble in m-cresol and exhibited glass transition temperatures in the 260-360°C range. All of the polymers displayed good thermal and thermal oxidation properties although high molecular weights were not achieved.

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REPORT NO: AFML-TR-76-28 AD A031 328  
ACCESS NO: 204,489 June 1976  
TITLE: REACTIVE PLASTICIZERS FOR HIGH TEMPERATURE QUINOXALINE  
THERMOPLASTICS  
AUTHOR(S): R.F. Kovar, G.F.L. Ehlers and F.E. Arnold  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: F.E. Arnold (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report is concerned with a novel approach to the  
processing of high temperature thermoplastics. A series of bis(ethynyl-  
quinoxaline) monomers was prepared to demonstrate the feasibility of using  
reactive plasticizers in the processing of polyphenylquinoxaline thermo-  
plastics. The monomers were prepared by the reaction of 4(3-ethynylphenoxy)-o-  
phenelenediamine with various aromatic 1,2-dicarbonyl compounds in m-cresol.  
The reactive plasticizer lowers the effective softening point of the ther-  
moplastic resin during processing and then becomes dormant by reacting with  
itself or the host thermoplastic. Mixtures of monomers and thermoplastic were  
studied with respect to compatibility, Tg depression, and plasticizer deactivation.

REPORT NO: AFML-TR-76-29, Part I AD A027 134  
ACCESS NO: 204,354 March 1976  
TITLE: SURFACE CHARACTERIZATION OF TITANIUM ALLOYS, PART I:  
EFFECT ON TITANIUM-6 ALUMINUM-4 VANADIUM ALLOY OF  
COMMERCIAL TREATMENTS  
AUTHOR(S): W.L. Baun  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBM  
PROJECT MONITOR: W.L. Baun (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report describes a study using a combination of ion  
scattering spectrometry (ISS) and secondary ion mass spectrometry (SIMS) along  
with scanning electron microscopy (SEM) to determine chemistry and morphology  
of surfaces produced by commercial treatments on Ti-6Al-4V alloy. Treatments  
include: alkaline clean, alkaline etch, phosphate-fluoride, Pasa-Jell 107,  
and Vought Abrasive Slurry Treatment (VAS).

REPORT NO: AFML-TR-76-29, Part II AD A025 334  
ACCESS NO: 204,714 May 1976  
TITLE: SURFACE CHARACTERIZATION OF TITANIUM AND TITANIUM ALLOYS,  
PART II: EFFECT ON Ti-6Al-4V ALLOY OF LABORATORY CHEMICAL  
TREATMENTS  
AUTHOR(S): W. Baun and N.T. McDevitt  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBM

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PROJECT MONITOR: W. Baun (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This investigation is part two of a program which looks at the effects of surface treatments on surface chemistry and morphology of titanium and titanium alloys. This part considers the effect of six surface treatments on the alloy titanium-6 aluminum-4 vanadium.

REPORT NO: AFML-TR-76-29, Part III AD A032 954  
ACCESS NO: 204,608 September 1976  
TITLE: SURFACE CHARACTERIZATION OF TITANIUM AND TITANIUM ALLOYS, PART III: EFFECT ON Ti (c.p.) AND Ti-8Mn OF LABORATORY CHEMICAL TREATMENTS

AUTHOR(S): W. Baun, N.T. McDevitt and J.S. Solomon  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBM  
PROJECT MONITOR: W. Baun (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This investigation is part three of a program which looks at the effects of surface treatments on surface chemistry and morphology of titanium and titanium alloys. This part discusses the effects of six laboratory surface treatments on titanium, commercially pure and Ti-8Mn alloy.

REPORT NO: AFML-TR-76-30 AD A025 615  
ACCESS NO: 204,353 March 1976  
TITLE: SCANNING ELECTRON MICROSCOPY, ION SCATTERING AND SECONDARY ION MASS SPECTROMETRY TO CHARACTERIZE APPARENT "ADHESIVE" FAILURE IN AN ADHESIVE BOND

AUTHOR(S): W.L. Baun  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBM  
PROJECT MONITOR: W.L. Baun (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Elemental analysis techniques such as ion scattering spectrometry and secondary ion mass spectrometry combined with Scanning Electron Microscopy are capable of determining the locus of failure in an adhesive joint. The use of ISS and SIMS in combination is shown for investigating adhesive bonding phenomena. The operating parameters, as well as advantages and disadvantages of each, are summarized. ISS-SIMS data are shown for two adherend surfaces which broke in a lap shear test by apparent cohesive failure in both the adhesive and adherend. Data is also shown for failure surfaces from peel test and thin adherend double cantilever beam (wedge test) specimens.

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REPORT NO: AFML-TR-76-32 AD A031 432  
ACCESS NO: 204,506 April 1976  
TITLE: THREE-DIMENSIONAL STRESS ANALYSIS OF A LAMINATED PLATE  
CONTAINING AN ELLIPTICAL CAVITY  
AUTHOR(S): E.F. Rybicki and D.W. Schmueser  
CONTRACT NO: F33615-74-R-5096  
CONTRACTOR: Battelle, Columbus Laboratories  
PROJECT MONITOR: N.J. Pagano (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734003  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: An analysis procedure is developed to study the stress  
distribution in a laminated plate containing an elliptical cavity under tensile  
loading and a uniform temperature change. Also considered is the stress field  
around a radial crack emanating from a hole in a laminate. The analysis fol-  
lows from an extension of a previously developed finite element approach.

REPORT NO: AFML-TR-76-40 AD B014 724L  
ACCESS NO: 204,532 January 1976  
TITLE: HIGH STRENGTH CARBON RESIN COMPOSITES FOR RE-ENTRY  
VEHICLE NOSETIP SKIRTS  
AUTHOR(S): P.J. Roy  
CONTRACT NO: F33615-75-C-5166  
CONTRACTOR: Avco Systems Division  
PROJECT MONITOR: R.D. Craig (AFML/MBC)  
PROJECT NO: 7340  
TASK NO: 734001  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: This final report presents the results of work performed  
under AFML Project 7340. The technical objective of this program was to  
develop multi-directional reinforced plastic composite materials which exhibit  
balanced ablation/insulation and improved mechanical performance character-  
istics as compared to state-of-the-art carbon fabric/phenolic composites. The  
newly developed materials were intended for use as the insulative collar portion  
of nosetip configurations. Technical efforts under the program were directed  
at characterizing two 3D carbon fiber reinforced phenolic resin matrix com-  
posite materials based on newly-developed Avco pierced fabric construction  
for nosetip skirt collar evaluation.

REPORT NO: AFML-TR-76-46 AD B014 122L  
ACCESS NO: 204,623 April 1976  
TITLE: A UNIFIED ABLATIVE MATERIAL THERMAL RESPONSE ANALYSIS  
PROCEDURE  
AUTHOR(S): K.E. Suchsland and R.E. Maurer  
CONTRACT NO: F33615-74-C-5030  
CONTRACTOR: Acurex  
PROJECT MONITOR: R. Farmer (AFML/MBC)  
PROJECT NO: ILIR  
TASK NO: ILIROO  
DIST. STATEMENT: U.S. Govt. Agencies Only

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**ABSTRACT:** This document summarizes the development of a unified ablative material thermal response analysis procedure by the Aerotherm Division of Acurex Corporation. Advanced computational technology developed during the past 15 years for predicting material response under hyperthermal environments has been assembled into a cohesive unified analysis procedure. This analysis capability is suited for (1) routine material thermal analyses of nosetips, heatshields and rocket nozzles and (2) the more difficult problem of guiding advanced material development. This study has illustrated that the lack of high quality thermophysical data and the inability to model three-dimensional phenomena restricts predictions to be qualitative rather than quantitative. Recommendations are made regarding the extension of these analysis procedures to better provide guidance for advanced material development.

REPORT NO: AFML-TR-76-47 AD B014 691L  
ACCESS NO: 204,620 April 1976  
TITLE: HEAT RESISTANT AND NONFLAMMABLE MATERIALS  
AUTHOR(S): N.J. Abbott, M.M. Schoppee and J. Skelton  
CONTRACT NO: F33615-75-C-5168  
CONTRACTOR: Fabric Research Laboratories  
PROJECT MONITOR: S. Schulman (AFML/MBC)  
PROJECT NO: 7320  
TASK NO: 732002  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The tensile properties of spun-yarn, flight-suit weight HT-4, Durette, Nomex I, Kynol, cotton, nylon, and polyester fabrics have been measured during exposure to bilateral radiant heat fluxes in the range 0.2 to 0.9 cal/cm<sup>2</sup>/sec. Specially designed test equipment allows testing at times as short as a few seconds after initiation of exposure. All of the fabrics tested lost at least 50% of their strength in the first 6 seconds of exposure at flux levels of 0.4 cal/cm<sup>2</sup>/sec and at least 75% of their strength after 6 seconds at 0.7 cal/cm<sup>2</sup>/sec and above. Of these fabrics tested, HT-4 provides the greatest degree of protection, and polyester provides the least protection against a high heat flux. Studies were also made of launderability HT-4 fabric, abrasion of Kevlar webbing, weaving of BBB fabric, and other analyses requested by AFML.

REPORT NO: AFML-TR-76-49 AD B014 155L  
ACCESS NO: 204,534 June 1976  
TITLE: EXTENDED FLOW LIFE LAMINATING RESIN SYSTEM  
AUTHOR(S): D. Harrison  
CONTRACT NO: F33615-74-C-5181  
CONTRACTOR: Acurex  
PROJECT MONITOR: T.J. Aponyi (AFML/MBC)  
PROJECT NO: ILIR  
TASK NO: ILIROO  
DIST. STATEMENT: U.S. Govt. Agencies Only

**ABSTRACT:** Epoxy resin/curing agent/catalyst combinations were investigated in efforts to obtain state-of-the-art performance (350°F) from graphite fiber reinforced composites coupled with prolonged prepreg out-times (>75 days) under ambient shop conditions. Resins evaluated included multi-functional commercially available glycidyl ethers and glycidyl amines. Curing agent studies were limited to potentially latent, high functionality systems and included hydrazides, amino-hydrazides and aromatic diamines with attenuated reactivity.

REPORT NO: AFML-TR-76-69 AD A027 557  
 ACCESS NO: 204,375 June 1976  
 TITLE: MOLECULAR ORBITAL EFFECTS ON THE Ti LMV AUGER SPECTRA OF TiO and TiO<sub>2</sub>  
 AUTHOR(S): J.S. Solomon and W.L. Baun  
 CONTRACT NO: Internal  
 CONTRACTOR: AFML/MBM  
 PROJECT MONITOR: W.L. Baun (AFML/MBM)  
 PROJECT NO: 7340  
 TASK NO: 734002

**DIST. STATEMENT:** Approved for public release; distribution unlimited.  
**ABSTRACT:** The fine features of the Auger valence band spectra of TiO and TiO<sub>2</sub> have been related to transitions arising from oxygen 2s and titanium 3d, 4s molecular orbitals. The auger bands investigated include the L<sub>III</sub>, M<sub>1</sub>N<sub>1</sub>, L<sub>III</sub>M<sub>1</sub>M<sub>4,5</sub>, L<sub>III</sub>M<sub>2,3</sub>N<sub>1</sub>, and L<sub>III</sub>M<sub>4,5</sub> transitions. The N (E) valence band spectra has been unfolded, and the resulting components correlated with X-ray emission data and a molecular orbital (MO) model. Differences in spectral shapes are shown to be linked with differences in the density of state of oxygen-titanium molecular orbitals.

REPORT NO: AFML-TR-76-70 AD A032 524  
 ACCESS NO: 204,505 January 1976  
 TITLE: CHARACTERIZATION OF THIN ANODIZED FILMS ALUMINUM WITH SOFT X-RAY SPECTROSCOPY  
 AUTHOR(S): W.L. Baun, T.J. Wild and J.S. Solomon  
 CONTRACT NO: Internal  
 CONTRACTOR: AFML/MBM and University of Dayton  
 PROJECT MONITOR: W.L. Baun (AFML/MBM)  
 PROJECT NO: 7340  
 TASK NO: 734002

**DIST. STATEMENT:** Approved for public release; distribution unlimited.  
**ABSTRACT:** Two methods utilizing x-ray spectra from the electron microbeam probe for the determination of aluminum oxide film thickness for a broad range of thicknesses are described. One method uses the direct measurement of oxygen K emission while the other uses the changes in fine features of the x-ray spectra with changes in oxide film thickness. For oxide formed by barrier anodization technique, films as thin as 20-30A and as thick as several thousand angstroms could be measured by these methods.

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REPORT NO: AFML-TR-76-71 AD A031 003  
ACCESS NO: 204,497 June 1976  
TITLE: ACETYLENE TERMINATED QUINOXALINES ATQ  
AUTHOR(S): R.F. Kovar, G.F.L. Ehlers and F.E. Arnold  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: F.E. Arnold (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A series of acetylene terminated phenylquinoxaline oligomers have been prepared which cure by addition without the evolution of volatiles. The synthesis utilized the novel terminal acetylene end-capping reagent, 3-(3,4-diaminophenoxy)phenyl acetylene. The end-capped oligomers were soluble (20-30%) in low boiling organic solvents and exhibited a high degree of flow at their softening temperatures. Thermal analytical data obtained on the oligomers indicated initial softening in the vicinity of 160°C and a strong polymerization exotherm maximizing at 274°C. Cured samples (8 hrs at 280°C) exhibited Tg's of approximately 320°C. Mass spectrometry-thermogravimetric analysis of the polymers demonstrated that no volatiles were emitted during cure, and that decomposition of the resins initiated at 465°C.

REPORT NO: AFML-TR-76-74 AD A029 968  
ACCESS NO: 204,461 June 1976  
TITLE: SOME OBSERVATIONS OF THE RELATION BETWEEN CHEMICAL SURFACE TREATMENTS AND THE GROWTH OF ANODIC BARRIER LAYER FILMS  
AUTHOR(S): N.T. McDevitt and W.L. Baun  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBM  
PROJECT MONITOR: N.T. McDevitt (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Composite oxide films on bare 2024-T3 aluminum were produced by surface chemical treatments followed by anodic oxidation in a barrier forming electrolyte. The chemical characteristics of the composite film are dependent on the pretreatment solution. This type of information can be important in determining the overall corrosion resistance and durability of adhesively bonded structures.

REPORT NO: AFML-TR-76-75 AD A027 187  
ACCESS NO: 204,361 June 1976  
TITLE: MOLECULAR SPECTROSCOPY BY INELASTIC ELECTRON TUNNELING  
AUTHOR(S): K.P. Roenker  
CONTRACT NO: 7340  
CONTRACTOR: AFML/MBM  
PROJECT MONITOR: W.L. Baun (AFML/MBM)

PROJECT NO: 7340  
 TASK NO: 734002  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: This report examines the capabilities and limitation of the technique of inelastic electron tunneling as a molecular spectroscopic tool for surface studies. Following a brief review of the literature, an outline of the theory is given and the experimental technique discussed. The tunneling spectra of both clean and doped Al-Al oxide-Pb junctions are considered in detail. A comparison with existing surface analysis techniques concludes the report.

REPORT NO: AFML-TR-76-81 AD A031 809  
 ACCESS NO: 204,508 April 1976  
 TITLE: DEFECT-PROPERTY RELATIONSHIPS IN COMPOSITE MATERIALS  
 AUTHOR(S): K.L. Reifsnider, E.G. Henweke and W.W. Stinchcomb  
 CONTRACT NO: F33615-75-C-5119  
 CONTRACTOR: Virginia Polytechnic Institute and State University  
 PROJECT MONITOR: N. Pagano (AFML/MBM)  
 PROJECT NO: 7340  
 TASK NO: 734003  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: This report describes the initial results of an investigation which has as its objectives the determination of the nature of damage in two graphite-epoxy (GEp) laminates under various combinations of loading as completely and precisely as possible, and the investigation of the corresponding mechanical property changes. The results include several new findings, the development of unique investigative methods and substantial deviations from the predictions of common models.

REPORT NO: AFML-TR-76-82 AD A024 722  
 ACCESS NO: 204,296 May 1976  
 TITLE: INTERLAMINAR STRENGTH OF LAMINATED POLYMERIC MATRIX COMPOSITES  
 AUTHOR(S): R.B. Pipes  
 CONTRACT NO: 7340  
 CONTRACTOR: Drexel University  
 PROJECT MONITOR: N.J. Pagano (AFML/MBM)  
 PROJECT NO: 7340  
 TASK NO: 734002  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: An experimental program was conducted to examine the parameters involved in interlaminar strength criteria. Results indicate that for the boron-epoxy material treated, the interlaminar normal strength was approximately 11 ksi, but poor material quality clouded these results as well as the remaining issues in the proposed effort.

REPORT NO: AFML-TR-76-86  
 ACCESS NO: 204,594 July 1976  
 TITLE: STRENGTH BEHAVIOR OF GRAPHITE/EPOXY COMPOSITE LAMINATES UNDER BIAXIAL LOAD  
 AUTHOR(S): P.H. Francis, D.E. Walrath and D.N. Weed

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CONTRACT NO: F33615-75-C-5115  
CONTRACTOR: Southwest Research Institute  
PROJECT MONITOR: N. Pagano (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734002  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The room temperature mechanical ply properties of Fiberite hy-E 1034C graphite/epoxy composite material were characterized using unidirectional thin wall tubes and flat coupons. Four ply laminated tubes having (0/90)<sub>s</sub> and (+45)<sub>s</sub> stacking sequences were fabricated in preparation for biaxial experiments to determine first ply failure (FPF) thresholds. Initial results using acoustic emission techniques to detect FPF on (0/90)<sub>s</sub> tubes are reported.

REPORT NO: AFML-TR-76-87 AD A030 781  
ACCESS NO: 204,486 June 1976  
TITLE: AN ANALYTICAL METHOD FOR EVALUATING IMPACT DAMAGE ENERGY OF LAMINATED COMPOSITES

AUTHOR(S): C.T. Sun  
CONTRACT NO: F33615-73-C-5112  
CONTRACTOR: Purdue University  
PROJECT MONITOR: J. Whitney (AFML/MBM)  
PROJECT NO: 7342  
TASK NO: 734202  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A higher order beam finite element is developed for dynamic response of beams subjected to impact of elastic shears. Hertzian law is used to evaluate the contact force. A step by step finite difference method is employed to integrate the time variable. The finite elements are first evaluated for homogeneous isotropic beams, and excellent results are found. Impact of glass-epoxy laminates are then considered. The total energy imparted from the projectile to the laminate is computed and compared with experimental data. Good agreement is found. The present finite element procedure also allows one to separate the vibrational energy from the energy which is to be related to the residual strength of the composite after impact.

REPORT NO: AFML-TR-76-92 AD A032 428  
ACCESS NO: 204,605 August 1976  
TITLE: THREE-DIMENSIONAL FINITE ELEMENT STRESS ANALYSIS OF LAMINATED PLATES CONTAINING A CIRCULAR HOLE

AUTHOR(S): E.F. Rybicki and D.W. Schmueser  
CONTRACT NO: F33615-74-C-5096  
CONTRACTOR: Battelle  
PROJECT MONITOR: N.J. Pagano (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734003  
DIST. STATEMENT: Approved for public release; distribution unlimited.

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ABSTRACT: One of the modes of failure of laminated plates is delamination which initiates at a free edge. Experimental results and theoretical stress analyses found in the literature point to the interlaminar normal stress  $\sigma_z$  as a governing factor for this mode of failure. In this report, the stress behavior around a circular hole in a laminated plate is investigated using a three-dimensional finite element stress analysis. Attention is focused on the interlaminar normal stress distribution around the edge of the circular hole.

REPORT NO: AFML-TR-76-93 AD A029 920  
ACCESS NO: 204,462 June 1976  
TITLE: ISOTHERMAL DECOMPOSITION STUDIES OF AROMATIC AND AROMATIC-HETEROCYCLIC POLYMERS IN AIR  
AUTHOR(S): G.F.L. Ehlers, W.A. Rubey and D.S. Duvall  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: G.F.L. Ehlers (AFML/MBP)  
PROJECT NO: 7340  
TASK NO: 734004

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Ten aromatic and aromatic-heterocyclic polymers were subjected to aging in air at temperatures of 316°C (600°F) and 371°C (700°F) for up to 600 hours, and the volatile decomposition products were determined by gas chromatography. The predominant volatiles by far were carbon dioxide and carbon monoxide being 91 to 99.6% of the total volatiles. Small amounts of water, methane and traces of other aliphatic hydrocarbons were found. Nitrogen containing polymers produced small amounts of nitrogen oxides, cyanogen and hydrogen cyanide, all of which tend to form and reach a maximum later than the other volatiles. The volatiles reach their peak concentration only after a certain aging time, roughly related to the thermal stability of the polymers and ranging between  $\frac{1}{2}$  and 500 hours at 371°C.

REPORT NO: AFML-TR-76-94 AD A030 876  
ACCESS NO: 204,499 July 1976  
TITLE: ELASTIC RESPONSE OF ROSETTE CYLINDERS UNDER AXISYMMETRIC LOADING  
AUTHOR(S): N.J. Pagano  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBM  
PROJECT MONITOR: N.J. Pagano (AFML/MBM)  
PROJECT NO: 2279  
TASK NO: 227901

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The problem of the elastic response of a rosette cylinder, i.e., a cylindrical body formed by reinforced composite layers wrapped along spiral trajectories, is formulated and solved through the application of the theory of heterogeneous elasticity. It is shown that 21 elastic coefficients enter the elastic constitutive equations. Certain geometric

preliminaries and tensor transformation laws establish the relation between these coefficients and orthotropic moduli of the basic sheet material. It is also demonstrated that problems involving axisymmetric boundary conditions can be formulated in terms of one space variable and this class of boundary value problem is solved through a numerical procedure. Included in the response is the influence of environmental dilation. An example problem indicates the potential of rosette construction to drastically reduce stress concentration factors and illustrates significant errors resulting from improper modeling of the material structure.

REPORT NO: AFML-TR-76-99, Part I AD B014 123L  
 ACCESS NO: 204,537 April 1976  
 TITLE: DEVELOPMENT OF HIGH TEMPERATURE THICKENERS FOR HIGH PERFORMANCE GREASES  
 AUTHOR(S): J.P. King and P. Nannelli  
 CONTRACT NO: F33615-75-C-5187  
 CONTRACTOR: Pennwalt Corporation  
 PROJECT MONITOR: J.B. Christian (AFML/MBT)  
 PROJECT NO: ILIR  
 TASK NO: ILIROO  
 DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: A number of poly(chromium phosphinates) were screened as thickeners for three base fluids---MC066-18, a perfluoropolyether; MC066-21, a high phenyl content polysiloxane and MC070-75, a fluorinated polysiloxane. Three thickening techniques were employed depending on solubility and gelling efficiency of the poly(chromium phosphinates). Each poly(chromium phosphate) was selected on the basis of its thermal stability, compatibility with the fluids and lubricating properties.

REPORT NO: AFML-TR-76-102 AD A031 436  
 ACCESS NO: 204,501 June 1976  
 TITLE: MOISTURE ABSORPTION AND DESORPTION OF COMPOSITE MATERIALS  
 AUTHOR(S): G.S. Springer and C. Shen  
 CONTRACT NO: F33615-75-C-5165  
 CONTRACTOR: University of Michigan  
 PROJECT MONITOR: S.W. Tsai (AFML/MBM)  
 PROJECT NO: 7340  
 TASK NO: 734003  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: Expressions are presented for the moisture distribution and the moisture content as a function of time of one dimensional homogeneous and composite materials exposed either on one side or both sides to humid air or to water. The results apply during both moisture absorption and desorption when the moisture content and the temperature of the environment are constant. Test procedures are described for determining experimentally the values of the moisture content and the diffusivity of composite materials. A series of tests using unidirectional and  $1/4$  Graphite T-300 Fiberite 1034 composites were performed. The test data support the analytical results and provide the

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moisture absorption and desorption characteristics of such composites. Attempts were made to correlate the moisture content of the material with a) changes in electric resistance and b) changes in the hardness of the material.

REPORT NO: AFML-TR-76-104 AD B015 773L  
ACCESS NO: 204,665 September 1976  
TITLE: SYNTHESIS OF PERFLUOROALKYLEETHER MONOMERS AND MODEL COMPOUNDS FOR LOW GLASS TRANSITION POLYMERS  
AUTHOR(S): C. Tamborski and G.J. Moore  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBP  
PROJECT MONITOR: C. Tamborski (AFML/MBT)  
PROJECT NO: 7342  
TASK NO: 734201  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Synthesis of perfluoroalkylether monomers with a variation of oxygen to CF<sub>2</sub> or CF(CF<sub>3</sub>) ratio has been accomplished. The difunctional monomers have been prepared via a sequence of reactions using organomagnesium intermediates and zinc coupling reactions of perfluoroalkylether alpha-iodo-omega-esters. Bis acids, esters, amides, nitriles, and imidate esters with molecular weights in the 500-1700 range have been polymerized in a subsequent work (Ref 4) to thermooxidatively stable bibenzoxazole polymers with low glass transition properties (to -58°C, -78°F).

REPORT NO: AFML-TR-76-109  
ACCESS NO: 204,666 August 1976  
TITLE: RESEARCH ON HEAT RESISTANT TRANSPARENT INTERLAYERS BASED ON THE ETHYLENE TERPOLYMER  
AUTHOR(S): G.L. Ball, I.O. Salyer and D.W. Werkmeister  
CONTRACT NO: F33615-75-C-5090  
CONTRACTOR: Monsanto  
PROJECT MONITOR: E.A. Arvay (AFML/MBC)  
PROJECT NO: 2914  
TASK NO: 291403  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: An ethylene terpolymer aircraft glazing interlayer, designated ETA-XXX032, was developed that has reasonable strength to 350° while retaining excellent high elongation down to -65°F. The high temperature performance was achieved while retaining thermoplastic sheet formability at 250°F required for polycarbonate. The improved mechanical performance to 350°F introduced no changes in the basic (550°F) thermal stability or transparency of the ethylene terpolymer.

REPORT NO: AFML-TR-76-112  
ACCESS NO: 204,710 June 1976  
TITLE: EXPLORATORY DEVELOPMENT OF CHEMICAL QUALITY ASSURANCE AND COMPOSITION OF EPOXY FORMULATIONS  
AUTHOR(S): C. May, J.S. Fritzen and D.K. Whearty

CONTRACT NO: F33615-75-C-5136  
 CONTRACTOR: Lockheed  
 PROJECT MONITOR: T. Helminak (AFML/MBC)  
 PROJECT NO: 7340  
 TASK NO: 734004  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: This report is the first step in the development of physiochemical methods for the quality assurance of epoxy adhesives and prepregs. To establish such procedures, the chemical composition of the formulations must be known. Since this data was not available, three adhesive formulations and three advanced composite prepregs were chemcially characterized. The techniques used included: infrared spectroscopy, differential scanning calorimetry, liquid chromatography, thin layer chromatography, atomic absorption emission spectroscopy, organic functional group analysis and elemental analysis. The components of each system were identified and determined quantitatively. Formulations were reconstructed and subjected to mechanical, physical, and chemical tests. A number of the analytical procedures are described in detail, and their value as quality assurance procedures are discussed.

REPORT NO: AFML-TR-76-115 AD B015 339  
 ACCESS NO: 204,606 July 1976  
 TITLE: EXPLORATORY DEVELOPMENT OF HEAT AND ABRASION RESISTANT COATINGS FOR TRANSPARENT PLASTICS

AUTHOR(S): W.T. Boord  
 CONTRACT NO: F33615-74-C-5080  
 CONTRACTOR: Honeywell  
 PROJECT MONITOR: T. Peterson (AFML/MBE)  
 PROJECT NO: 7340  
 TASK NO: 734007  
 DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: The basic objective of this program was to develop heat and abrasion-resistant coatings for use on new high temperature plastics being considered for aircraft windshields and canopies. The approach taken was to develop multilayer coatings in which each component displayed the desired properties necessary to meet one or more of the program requirements, and such that the coating system as a whole would satisfy all the program requirements. The results of the testing suggest two coating systems which utilize the best of the material combinations in the four evaluated systems.

REPORT NO: AFML-TR-76-116 AD B015 175L  
 ACCESS NO: 204,595 July 1976  
 TITLE: EXPLORATORY DEVELOPMENT OF ANTISTATIC COATINGS FOR USE ON AIRCRAFT TRANSPARENCIES

AUTHOR(S): W.T. Boord  
 CONTRACT NO: F33615-74-C-5050  
 CONTRACTOR: Honeywell  
 PROJECT MONITOR: T. Peterson (AFML/MBE)  
 PROJECT NO: ILIR  
 TASK NO: ILIROO

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DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: The objective of this program was to develop conductive and protective coatings for polycarbonate and acrylic. The approach taken was to develop multilayer coatings in which each component displayed the desired properties necessary to meet one or more of the program requirements, and such that the coating system as a whole would satisfy all the program requirements. Two new techniques were developed for depositing conducting SnO<sub>2</sub> films. The new techniques are fast, easily controlled, processes which are more favorable to scale-up than is the rf-sputtering technique. An investigation of organic polymer coatings produced a method of coating acrylic with a commercially available urethane material which displays good adhesion and solvent resistant properties. Eleven antistatic coating systems were prepared and subjected to physical testing. The results suggest an antistatic coating system which utilizes the best materials of the eleven systems.

REPORT NO: AFML-TR-76-124 AD A033 078  
ACCESS NO: 204,627 July 1976  
TITLE: INFLUENCE OF CROSSLINKING ON THE MECHANICAL PROPERTIES OF HIGH T<sub>g</sub> POLYMERS  
AUTHOR(S): J.A. Manson, L.H. Sperling and S.L. Kim  
CONTRACT NO: F33615-75-C-5167  
CONTRACTOR: Lehigh University  
PROJECT MONITOR: A. Wereta (AFML/MBP)  
PROJECT NO: 7342  
TASK NO: 734203

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: Research was begun on the effects of crosslinking on the mechanical properties of high-T<sub>g</sub> polymers, with particular emphasis on the role of crosslink density, variations in the distribution of crosslink segment lengths and the role of network imperfections. Two systems were selected: one based on the use of the Bamford synthesis to provide model, well defined networks and the other based on the use of bisphenol-A-type epoxy/methylene dianiline resins synthesized to provide controlled variations in network properties. To date, the feasibility of varying network characteristics in a model system by introducing hydrolyzable or permanent crosslinks has been demonstrated using copolymers of styrene or ethyl acrylate with acrylic acid anhydride. The creep and stress relaxation behavior was found to reflect the characteristics of the networks.

REPORT NO: AFML-TR-76-128 AD B014 721L  
ACCESS NO: 204,526 July 1976  
TITLE: RESEARCH ON CHARACTERIZATION OF SOLID SURFACES AND SURFACE INTERACTION PHENOMENA  
AUTHOR(S): J.S. Solomon, J.A. Mescher, T.J. Wild, T.P. Graham, and R.G. Keil  
CONTRACT NO: F33615-73-C-5099  
CONTRACTOR: University of Dayton Research Institute  
PROJECT MONITOR: W.L. Baun (AFML/MBM)

AD-A048 892

AIR FORCE MATERIALS LAB WRIGHT-PATTERSON AFB OHIO  
ABSTRACTS OF AF MATERIALS LABORATORY REPORTS JANUARY 1976 - DEC--ETC(U)  
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PROJECT NO: 7340  
 TASK NO: 734002  
 DIST. STATEMENT: U.S. Government Agencies Only  
 ABSTRACT: This report presents a summary of the work performed by the University of Dayton Research Institute under Contract No. F33615-73-C-5099 during 1 March 1973 to 29 February 1976. This report covers work conducted in the exploratory development and evaluation of characterization of solid surfaces and surface interaction phenomena. All work was accomplished under the direction of the Nonmetallic Materials Division, Air Force Materials Laboratory, Wright-Patterson AFB, Ohio.

REPORT NO: AFML-TR-76-135 AD B013 912L  
 ACCESS NO: 204,465 July 1976  
 TITLE: LUBRICANT VARIABLES INFLUENCING MINIATURE BEARING TORQUE  
 AUTHOR(S): J.B. Christian  
 CONTRACT NO: Internal  
 CONTRACTOR: Air Force Materials Laboratory  
 PROJECT MONITOR: J.B. Christian (AFML/MBT)  
 PROJECT NO: 7343  
 TASK NO: 734301  
 DIST. STATEMENT: U.S. Government Agencies Only  
 ABSTRACT: A study has been made of the starting and running torque characteristics of grease lubricated miniature bearings. The study was based on fluorinated polysiloxane, fluorinated polyether, and polyol ester base fluids. The fluids were thickened by fluorinated ethylenepropylene (FEP), polytetrafluoroethylene (PTFE), and a triazine material. Consideration was given to fluid viscosity, fluid pour point, thickener concentration, grease consistency, and the amount of the grease used to lubricate the bearings. The study shows the effect of these parameters on starting and running torque.

REPORT NO: AFML-TR-76-144 AD B015 293L  
 ACCESS NO: 204,607 August 1976  
 TITLE: SYNTHESIS OF PERFLUOROALIPHATIC ETHER MONOMERS  
 AUTHOR(S): Theodore Psarras  
 CONTRACT NO: F33615-75-C-5075  
 CONTRACTOR: PCR, Inc.  
 PROJECT MONITOR: A. Sicree (AFML/MBP)  
 PROJECT NO: 7342  
 TASK NO: 734201  
 DIST. STATEMENT: U.S. Government Agencies Only  
 ABSTRACT: Perfluoroalkylene oxide alpha-omega diacyl fluorides were prepared by addition of tetrafluoromethylene oxide (TFEO) to hexafluoroglutaric fluoride (HFGF). Addition of two equivalents of hexafluoropropylene oxide (HFPO) gave the corresponding HFPO terminated TFEO oligomers which were converted to alpha-omega dinitriles. A perfluoroether alpha-omega diiodide was prepared by addition of tetrafluoroethylene and iodine monochloride to HFGF. Symmetrical perfluoroalkylene oxide alpha-omega diesters were obtained by zinc coupling of the corresponding omega iodoperfluoroalkylene oxide methyl esters.

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REPORT NO: AFML-TR-76-147 AD B014 993L  
ACCESS NO: 204,603 August 1976  
TITLE: WEATHERING EFFECTS ON AIRCRAFT COATING SYSTEMS  
AUTHOR(S): J.H. Weaver and D.K. Wade  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBE  
PROJECT MONITOR: J.H. Weaver (AFML/MBE)  
PROJECT NO: 7340  
TASK NO: 734007  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Samples of the MIL-C-83286 white polyurethane exterior aircraft coating which had been weathered, using various accelerated techniques, and then subjected to thermal flash simulation, showed moderate to severe yellowing when exposed to fluences at which unweathered specimens would have been unharmed. The white silicone coating system, however, showed little degradation during weathering, thus performing well during thermal flash testing. The camouflage silicone systems, while maintaining their high-temperature resistance, suffered from pigment bleaching with some evidence of reduction in primer-topcoat adhesion. Pigment oxidation, due to weathering in the aluminized polyurethane, severely affected the coating's thermal flash capability. The aluminized system showed a 22% decrease in average visible reflectance and a 44% decrease in infrared reflectance (1-6 um).

REPORT NO: AFML-TR-76-148  
ACCESS NO: 204,713 September 1976  
TITLE: THE SURFACE COMPOSITION AND ENERGETICS OF TYPE A GRAPHITE FIBERS  
AUTHOR(S): L.T. Drzal, J.A. Mescher and W. Baun  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MBM and University of Dayton  
PROJECT MONITOR: W. Baun (AFML/MBM)  
PROJECT NO: 7340  
TASK NO: 734003  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report documents the results of an in-house program to determine what type of interactions occur between graphite reinforcing fiber and the polymeric matrix in advanced composites and how these interactions effect interfacial mechanical properties and durability. Surface treatments applied to Type A fiber of PAN-based material increase the surface energetics as measured by krypton adsorption on 30% of the surface. In addition, the affinity of the treated surface is increased for adsorption of typical ambient gases over the untreated surface by a factor of eight. Finally, the surface of this fiber contains a significant amount of sodium which affects the fiber surface properties.

SYSTEMS SUPPORT DIVISION (AFML/MX)

REPORT NO: AFML-TR-72-165, Part II AD A021 068  
 ACCESS NO: 204,140 March 1975  
 TITLE: EVALUATION OF A RADIOGRAPHIC PAPER SYSTEM USING ULTRA-VIOLET FLUORESCENT SCREENS: PART II, SUMMARY OF PART I, TECHNIQUE AND SENSITIVITY FOR F-2 SCREEN, APPLICATIONS  
 AUTHOR(S): J.A. Holloway  
 CONTRACT NO: F33615-70-C-1337 (in part)  
 CONTRACTOR: University of Dayton- Lab assistance  
 PROJECT MONITOR: J.A. Holloway (AFML/MXA)  
 PROJECT NO: 7351  
 TASK NO: 735109  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: A radiographic paper system with and without screens has been evaluated over an X-ray energy range from 25 KVCP to 160 KVCP. The system offers the potential for obtaining radiographic images equivalent to Class II X-ray film at a cost saving of as much as two-thirds over film costs. Detail sensitivity using pentrameters for selected thicknesses of aluminum together with sensitometric properties such as: gradient, exposure latitude, and speed are reported. Field trials were conducted at Kelly AFB, Texas, on the C-5A and F-106 and at MacDill AFB, Florida, on the F-4E where the radiographic paper system successfully detected foreign objects; verifying its applicability.

REPORT NO: AFML-TR-74-39, Supplement 4 AD B011 679L  
 ACCESS NO: 204,349 March 1976  
 TITLE: THE CARBON-CARBON ASSESSMENT PROGRAM, SUPPLEMENT 4: APPENDIX D - LAMINAR FLOW TESTING AND RESULTS  
 AUTHOR(S): E. Heinonen  
 CONTRACT NO: Internal  
 CONTRACTOR: AFML/MXS  
 PROJECT MONITOR: E. Heinonen (AFML/MXS)  
 PROJECT NO: 7381  
 TASK NO: 738102  
 DIST. STATEMENT: U.S. Govt. Agencies Only  
 ABSTRACT: Seven carbon-carbon composite materials and one graphite were comparatively assessed for ablation performance. Recession rates, pre- and post-test photographs and post-test roughness levels were taken. ATJ-S graphite, GE 7D and Philco-Ford 3D materials exhibited the lowest recession rates while Avco Mod 3 and Mod 3e exhibited the highest. This correlated well to both the post-test photographs and roughest materials having the highest recession rates.

REPORT NO: AFML-TR-74-234, Part II AD A021 122  
 ACCESS NO: 204,138 October 1975  
 TITLE: BIRD STRIKE CAPABILITIES OF TRANSPARENT AIRCRAFT WIND-SHIELD MATERIALS, PART II: SUPPLEMENTAL EVALUATION OF PARAMETERS AFFECTING MATERIALS RESPONSE  
 AUTHOR(S): A.O. Ingelse, G.E. Wintermute, M.H. Gaynes, and E.L. Waters

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CONTRACT NO: F33615-72-C-1896  
CONTRACTOR: Goodyear Aerospace Corporation  
PROJECT MONITOR: S.A. Marlolo (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738106  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report covers the expanded scope program conducted to obtain additional data to validate and/or supplement the data reported in AFML-TR-74-234. The test program utilized polycarbonate materials exclusively as the structural member, except in test series 5, alternate configuration, where three windshields of stretched acrylic were tested. Polycarbonate in thicknesses from 0.25 inch to 1.00 inch in as-extruded, press-polished and fusion-bonded conditions were tested as well as three different interlayer materials to specifically meet the required parameters of the seven test series.

REPORT NO: AFML-TR-75-42, Volume I AD A021 053  
ACCESS NO: 204,218 September 1975  
TITLE: PROCEEDINGS OF THE 1974 TRISERVICE CORROSION OF MILITARY EQUIPMENT CONFERENCE, 29-31 OCTOBER 1974, VOLUME I: SESSIONS I THROUGH III

AUTHOR(S): F.H. Meyer, Jr.  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MXA  
PROJECT MONITOR: F.H. Meyer (AFML/MXA)  
PROJECT NO: 7381  
TASK NO: 738107  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report is a compilation of papers presented at the 1974 Triservice Corrosion of Military Equipment Conference held in Dayton, Ohio, 29-31 October 1974.

REPORT NO: AFML-TR-75-42, Volume II AD A029 934  
ACCESS NO: 204,110 September 1975  
TITLE: PROCEEDINGS OF THE 1974 TRISERVICE CORROSION OF MILITARY EQUIPMENT CONFERENCE, 29-31 OCTOBER 1974, VOLUME II: SESSION IV THROUGH VII

AUTHOR(S): F.H. Meyer  
CONTRACT NO: Internal  
CONTRACTOR: AFML/MXE  
PROJECT MONITOR: F.H. Meyer (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738107  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report is a compilation of papers presented at the 1974 Triservice Corrosion of Military Equipment Conference held in Dayton, Ohio, 29-31 October 1974. The purpose of the 1974 Conference was to continue inter-service coordination in the areas of corrosion research and corrosion prevention and control. Specifically, the objectives were to make Department of Defense

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personnel, contractors and interested individuals aware of the important corrosion problems in military equipment, to present the status of significant corrosion research projects currently pursued by the military services and to provide a general forum for exchange of corrosion prevention and control information.

REPORT NO: AFML-TR-75-46 AD A020 956  
ACCESS NO: 204,141 March 1975  
TITLE: IMAGE PROCESSING OF INDUSTRIAL RADIOGRAPHS  
AUTHOR(S): J.A. Holloway, W.L. Shelton and J. Mitchell  
CONTRACT NO: Internal, F33615-70-C-1337, F33615-74-C-5043  
CONTRACTOR: AFML/MXA, University of Dayton, Universal Technology  
PROJECT MONITOR: J. Holloway (AFML/MXA)  
PROJECT NO: 7351  
TASK NO: 735109  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The report documents the data accumulated as a result of a survey of various approaches to radiographic image processing conducted by the Air Force Materials Lab. A detailed discussion of each method is presented together with the results of an evaluation of several typical systems using a set of control radiographs. Systems evaluated included electronic or electromechanical, using both analog and digital techniques as well as photographic approaches to image processing.

REPORT NO: AFML-TR-75-134, Volume I AD B009 541L  
ACCESS NO: 204,172 August 1975  
TITLE: MATERIAL PERFORMANCE ASSESSMENT FOR MANEUVERING REENTRY VEHICLES, VOLUME I: ANALYSIS OF NOSETIP SHAPE CHANGE DATA AT ANGLE OF ATTACK  
AUTHOR(S): M.D. Jackson and D. Rafinejad  
CONTRACT NO: F33615-73-C-5132  
CONTRACTOR: Acurex, Aerotherm Division  
PROJECT MONITOR: E. Heinonen (AFML/MXS)  
PROJECT NO: 7381  
TASK NO: 738102  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Critical aspects of ablative material performance relative to maneuvering reentry vehicle applications have been examined. Nosetip ablation at sustained angle-of-attack was studied experimentally and analytically. ATJ-S graphite and Mod III A carbon/carbon nosetip models were ablation tested at angles-of-attack ranging from 0° to 30° and at three pressure levels in the AFFDL 50MW arc. These analyses showed that angle-of-attack does not significantly affect nosetip shape-change when referenced to the flow direction, and that accurate modeling of boundary layer transition and "sharpening" are the most important requirements for predicting nosetip shape-change at both zero and nonzero angles-of-attack. The primary objective was to design an optimum procedure for testing materials for this application using existing ground test facilities.

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REPCRT NO: AFML-TR-75-134, Volume II AD B009 418L  
ACCESS NO: 204,172 November 1975  
TITLE: MATERIAL PERFORMANCE ASSESSMENT FOR MANEUVERING REENTRY  
VEHICLES, VOLUME II: LOW TEMPERATURE ABLATOR NOSETIP  
SHAPE-CHANGE EXPERIMENTS AT ANGLE-OF-ATTACK  
AUTHOR(S): E.V. Nelson and M.D. Jackson  
CONTRACT NO: F33615-73-C-5132  
CONTRACTOR: Acurex, Aerotherm Division  
PROJECT MONITOR: E.W. Heinonen (AFML/MXS)  
PROJECT NO: 7381  
TASK NO: 738102  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Critical aspects of ablative material performance relative  
to maneuvering reentry vehicle applications have been examined. Nosetip abla-  
tion at sustained angle-of-attack was studied experimentally and analytically.  
ATJ-S graphite and Mod-3a carbon/carbon nosetip models were ablation tested at  
angles-of-attack ranging from 0° to 30° and at three pressure levels in the AFFDL  
50 MW arc. These analyses showed that angle-of-attack does not significantly  
affect nosetip shape-change referenced to the flow direction, and that accurate  
modeling of boundary layer transition and "sharpening" are the most important  
requirements for predicting nosetip shape-change at both zero and nonzero  
angles-of-attack. The primary objective was to design an optimum procedure for  
testing materials for this application using existing ground test facilities.

REPORT NO: AFML-TR-75-134, Volume III AD B009 575L  
ACCESS NO: 204,172 November 1975  
TITLE: MATERIAL PERFORMANCE ASSESSMENT FOR MANEUVERING REENTRY  
VEHICLES, VOLUME III: GRAPHITE AND CARBON/CARBON NOSETIP  
SHAPE-CHANGE EXPERIMENTS AT ANGLE-OF-ATTACK  
AUTHOR(S): R.E. Maurer and C.A. Powars  
CONTRACT NO: F33615-73-C-5132  
CONTRACTOR: Acurex, Aerotherm Division  
PROJECT MONITOR: E.W. Heinonen (AFML/MXS)  
PROJECT NO: 7381  
TASK NO: 738103  
DIST. STATEMENT: U.S. Govt. Agenices Only  
ABSTRACT: Critical aspects of ablative material performance relative  
to maneuvering reentry vehicle applications have been examined. Nosetip abla-  
tion at sustained angle-of-attack was studied experimentally and analytically.  
ATJ-S graphite and Mod-3a carbon/carbon nosetip models were ablation tested at  
angles-of-attack ranging from 0° to 30° and at three pressure levels in the  
AFFDL 50 MW arc. These analyses showed that angle-of-attack does not signi-  
ficantly affect nosetip shape-change when referenced to the flow direction, and  
that accurate modeling of boundary layer transition and sharpening are the  
most important requirements for predicting nosetip shape-change at both zero  
and nonzero angles-of-attack. The primary objective was to design an optimum  
procedure for testing materials for this application using existing ground test  
facilities.

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REPORT NO: AFML-TR-75-180 AD A026 138  
ACCESS NO: 204,683 February 1976  
TITLE: IMPROVED ULTRASONIC STANDARD REFERENCE BLOCKS  
AUTHOR(S): D.G. Eitzen, G.F. Sushinsky, D.J. Chwirut, C.J. Bechtoldt,  
and A.W. Ruff  
CONTRACT NO: F33615-74-M-6752  
CONTRACTOR: National Bureau of Standards  
PROJECT MONITOR: L.R. Gulley (AFML/MXA)  
PROJECT NO: 7381  
TASK NO: 738107  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: A program to improve the quality, reproducibility and  
reliability of non-destructive testing through the development of improved  
ASTM-type ultrasonic reference standards is described. Reference blocks of  
aluminum, steel, and titanium alloys are to be considered. Equipment repre-  
senting the state-of-the-art in laboratory and field ultrasonic equipment was  
obtained and evaluated. RF and spectral data on ten sets of ultrasonic refer-  
ence blocks have been taken as part of a task to quantify the variability in  
response from nominally identical blocks. Techniques for residual stress,  
preferred orientation, and microstructural measurements were refined and are  
applied to a reference block rejected by the manufacturer during fabrication  
in order to evaluate the effect of metallurgical condition on block response.  
New fabrication techniques for reference blocks are discussed, and ASTM acti-  
vities are summarized.

REPORT NO: AFML-TR-75-185 AD A033 188  
ACCESS NO: 204,626 May 1976  
TITLE: ACOUSTIC EMISSION STRUCTURE-BORNE NOISE MEASUREMENTS ON  
AIRCRAFT DURING FLIGHT  
AUTHOR(S): W.H. Lewis, C.D. Bailey, and W.M. Pless  
CONTRACT NO: F33657-74-C-0588  
CONTRACTOR: Lockheed-Georgia  
PROJECT MONITOR: G.L. Hardy (AFML/MXA)  
PROJECT NO: 7381  
TASK NO: 738107  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This joint program between the Lockheed-Georgia Co. and  
the AFML was concerned with measuring the structure-borne noise background in  
a large aircraft to determine the feasibility from a signal-to-noise stand-  
point of using acoustic emission techniques to monitor structure during flight.  
Measurements were made in the frequency range from 0.1 MHz to 2.0MHz using  
off-the-shelf acoustic emission transducers and 40-db preamplifiers in con-  
junction with a Lockheed-designed spectrum analyzer and a pulse code modulation  
data system. The results showed that structure-borne noise can vary con-  
siderably over the aircraft structure, and that a suitable acoustic emission  
signal-to-noise ratio can be achieved at most locations within the frequency  
range 0.5 MHz to 0.75 MHz, although the noisiest areas may require operation  
up to 1.0 MHz.

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REPORT NO: AFML-TR-75-186 AD A022 145  
ACCESS NO: 204,212 November 1975  
TITLE: AN INVESTIGATION OF THERMOPLASTICS FOR USE AS 20 mm  
ROTATING BANDS  
AUTHOR(S): D.R. Askins  
CONTRACT NO: F33615-74-C-5024  
CONTRACTOR: University of Dayton  
PROJECT MONITOR: E. Morrissey (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738101  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: An empirical investigation has been conducted to screen  
wide variety of plastic and adhesive candidate materials for use in 20mm  
rotating band systems. The net results of this investigation was the identifi-  
cation of four material combinations which demonstrated substantial promise of  
serving as alternate materials to the nylon 12-253P rotating band system. Three  
of these four employ a domestically produced nylon 6 material (Zytel 211) with  
three different adhesives, P104, P-3, 253P. The fourth is a French produced  
nylon 11 material (BMNO) with the 253P adhesive. Gunfire results are presented  
and discussed, and recommendations for following up the work conducted in  
this program and optimizing the performance of the most promising materials  
are made.

REPORT NO: AFML-TR-75-201 AD B011 378L  
ACCESS NO: 204,299 December 1975  
TITLE: HYPERSONIC TURBULENT HEAT TRANSFER IN REGIONS WITH  
ENTROPY LAYER EFFECTS  
AUTHOR(S): S.S. Sandhu and B. Laub  
CONTRACT NO: F33615-74-C-5038  
CONTRACTOR: Acurex, Aerotherm Division  
PROJECT MONITOR: G.G. Ormbrek (AFML/MXS)  
PROJECT NO: 7381  
TASK NO: 738102  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Progressive melt line free-flight calorimeter models  
were used to study entropy gradient effects on turbulent flow heat transfer  
to blunt bodies. The entropy layer swallowing increased the heat transfer rates  
by more than a factor of two for some conditions. These heat transfer rates  
were compared with analytical predictions obtained using two techniques: an  
"exact" numerical solution of the boundary layer equations (the BLIMP code)  
and an approximate solution using the boundary layer momentum integral equation  
approach (the SAANT code). In general, the momentum integral technique over-  
predicted, and the "exact" numerical solution underpredicted the rate of heat  
transfer increased due to entropy layer swallowing.

REPORT NO: AFML-TR-75-203 AD B014 154  
ACCESS NO: 204,468 December 1975  
TITLE: THERMAL, MECHANICAL AND BRITTLE-TO-DUCTILE BEHAVIOR OF  
THORIATED TUNGSTEN

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AUTHOR(S): F.A. Iannizzi, H.S. Starrett and C.D. Pears  
CONTRACT NO: F33615-74-C-5029  
CONTRACTOR: Southern Research Institute  
PROJECT MONITOR: E.M. Ross (AFML/MXS)  
PROJECT NO: 7381  
TASK NO: 738102  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: An experimental program was carried out to determine the tensile, uniaxial flexural and biaxial flexural strength, the thermostructural response, the thermal expansion and thermal conductivity of Thoriated Tungsten. The variation of the flexural, uniaxial and biaxial strength and proportional limit with temperature, and the thermostructural response were utilized to establish the brittle-to-ductile transition temperature. The brittle-to-ductile transition temperature ranges from 400°F to 600°F depending on the stress-state. The behavior of the thermal expansion and conductivity of Thoriated Tungsten with temperature closely resembles the behavior of pure Tungsten.

REPORT NO: AFML-TR-75-208 AD A021 689  
ACCESS NO: 204,211 December 1975  
TITLE: TEMPERATURE EFFECT ON THE MECHANICAL PROPERTIES OF ALUMINUM ALLOY 2124-T851

AUTHOR(S): R.R. Cervay  
CONTRACT NO: F33615-74-C-5024  
CONTRACTOR: University of Dayton  
PROJECT MONITOR: D. Watson (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738106  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The test material, aluminum alloy/temper 2124-T851, was a 2.5 inch thick plate. The tensile strength, fracture toughness, and cyclic crack growth rate of the material was unaffected over the temperature range of 72°F (22°C) to 200°F (93°C). A 300°F environment is the maximum limit for an extended time service temperature, higher temperatures causing too severe of loss in load carrying capability. The fracture toughness varied very little over the temperature range of -100°F to 400°F. A test temperature of 400°F accelerates the crack growth rate, and the 0°F and -100°F test temperatures reduced the cyclic loading crack growth rate.

REPORT NO: AFML-TR-75-220 AD A023 139  
ACCESS NO: 204,227 December 1975  
TITLE: ALUMINUM ALLOY 7475-T7651 STATIC AND DYNAMIC FRACTURE PROPERTIES

AUTHOR(S): R.R. Cervay  
CONTRACT NO: F33615-74-C-5024  
CONTRACTOR: University of Dayton Research Institute  
PROJECT MONITOR: D. Watson (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738106  
DIST. STATEMENT: Approved for public release; distribution unlimited.

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ABSTRACT: The ultimate strength and yield strength of the material (alloy 7475-T7651) are similar to those of alloy 7475-T651. There was little difference in the tensile strength capability between the two specimen orientations that underwent test. The test alloy is tougher than all other 7000-series alloys currently in service. The long-transverse and short-transverse fracture toughness are lower than the longitudinal oriented toughness test results. The constant amplitude cyclic crack growth rate is similar to crack growth data on the same alloy in the T7351 and T651 tempers. A salt water test solution accelerated the crack growth rate by a factor of approximately three. There is some data scatter associated with the fatigue test results, a problem that seems to be inherent in the test alloy. No distinction can be made between longitudinal and transverse fatigue properties.

REPORT NO: AFML-TR-76-1 AD A022 275  
ACCESS NO: 204,073 February 1976  
TITLE: EVALUATION OF MATERIALS FOR AIR FORCE SYSTEMS AND  
HARDWARE APPLICATIONS  
AUTHOR(S): W.E. Berner and G.J. Petrak  
CONTRACT NO: F33615-74-C-5024  
CONTRACTOR: University of Dayton  
PROJECT MONITOR: A. Olevitch (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738106

DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The first section of this report involves studies of the crack resistance of B-1 materials and the evaluation of a landing gear side brace which were conducted in direct support of Air Force Systems. Other more general studies were conducted on 7475 and X2040 aluminum alloys, Ti-6-4 and Ti-6-6-2 annealed forgings, beta processed titanium and D6ac steel. The second section of the report describes in detail a comprehensive test program to evaluate elastomeric ground water seals for missile silos. High temperature sealants for use in F-111 and C-130 aircraft fuel tanks were also evaluated. Another program discussed involves the evaluation of O-ring packings in a dynamic test made. Two structural adhesives were evaluated to determine their performance in a high temperature high humidity environment. The final program discussed involves the evaluation of thermoplastics for use as rotating bands on 20mm projectiles.

REPORT NO: AFML-TR-76-2, Volume I AD B012 034L  
ACCESS NO: 204,337 February 1976  
TITLE: ABLATION/EROSION EVALUATION OF REENTRY VEHICLE MATERIALS,  
VOLUME I: NOSETIP MATERIALS  
AUTHOR(S): R.B. Dirling, Jr., K.M. Kratsch, J. Jortner, and D.D. Woolley  
CONTRACT NO: F33615-75-C-5186  
CONTRACTOR: McDonnell Douglas Astronautics  
PROJECT MONITOR: E.W. Heinonen (AFML/MXS)  
PROJECT NO: 627A  
TASK NO: 627A00  
DIST. STATEMENT: U.S. Govt. Agencies Only

AFML/MX

ABSTRACT: This report presents the results of a program to characterize the ablation and erosion response of three carbon-carbon materials for reentry vehicle nosetip applications. The response of the materials to ablation and particle impact environments is summarized and correlated with pertinent material microstructural parameters. The role of processing technique during the manufacture of carbon-carbon composites is also discussed. Based on the composite of the data obtained, various analyses of reentry flight performances are presented.

REPORT NO: AFML-TR-76-24 AD A026 412  
ACCESS NO: 204,339 March 1976  
TITLE: ENVIRONMENTAL RESISTANCE OF COATED AND LAMINATED  
POLYCARBONATE TRANSPARENCIES  
AUTHOR(S): R.A. Huyett and G.E. Wintermutte  
CONTRACT NO: F33615-74-C-5005  
CONTRACTOR: Goodyear Aerospace Corporation  
PROJECT MONITOR: S. Marolo (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738106  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report covers a program conducted to assess the environmental resistance characteristics of selected coated polycarbonate and acrylic/interlayer/polycarbonate composite aircraft windshield materials when exposed to aggressive laboratory accelerated and outdoor environmental testing.

REPORT NO: AFML-TR-76-26 AD B014 300L  
ACCESS NO: 204,540 April 1976  
TITLE: THERMOSTRUCTURAL TESTING OF INSTRUMENTED ATJ-A GRAPHITE  
SHELL NOSETIPS IN THE AFFDL 50 MW FACILITY  
AUTHOR(S): D.L. Baker, H.S. Starrett and C.L. Budde  
CONTRACT NO: F33615-74-C-5105  
CONTRACTOR: Acurex, Aerotherm Division  
PROJECT MONITOR: C.L. Budde (AFML/MXS)  
PROJECT NO: 7381  
TASK NO: 738102  
DIST. STATEMENT: U.S. Govt. Agencies Only  
ABSTRACT: Instrumented ATJ-S graphite shell nosetip models were tested in the AFFDL 50 MW RENT facility. These models had a 3/4 inch nose radius, 1 inch overhang, 10° cone half angle and a skirt thickness of 0.15 inch. The inside surface of the models was instrumented with seven thermocouples and three clip-on extensometers. The outside surface temperature of the models was monitored in two locations by optical pyrometers. Finally, the tests were recorded by three high speed motion picture cameras. Pressure and calorimeter models were also tested in order to help define the flowfield condition and heating distribution around the models. A pretest thermostructural analysis was conducted in order to design and locate the instrumentation for the test models. The results of the 50 MW thermostructural test program were highly significant in that this was the first instance in which actual temperature and strain data has been obtained for a nose tip in a simulated reentry environment.

AFML/MX

REPORT NO: AFML-TR-76-41 AD B014 238L  
ACCESS NO: 204,542 March 1976  
TITLE: VAPORIZATION OF GRAPHITIC MATERIALS AT HIGH MASS TRANSFER RATES  
AUTHOR(S): R.E. Maurer, G. Hartman, C.A. Powars, and T.F. Foster  
CONTRACT NO: F33615-74-C-5094  
CONTRACTOR: Acurex, Aerotherm Division  
PROJECT MONITOR: G. Ormbrek (AFML/MXS)  
PROJECT NO: 7381  
TASK NO: 738102  
DIST. STATEMENT: U.S. Govt. Agencies Only

ABSTRACT: The thermochemical sublimation response of ATJ-S graphite in both low and high mass transfer convective environments was studied both experimentally and analytically. Ablation tests were run under both subsonic and supersonic flow conditions at both pressures. High quality recession rate and surface temperature from the ablation tests were correlated with various thermochemical ablation predictions. The conclusion is made that the JANAF equilibrium sublimation model is most appropriate for graphite thermochemical ablation predictions under high pressure reentry conditions.

REPORT NO: AFML-TR-76-42 AD A031 775  
ACCESS NO: 204,686 May 1976  
TITLE: NON-METALLIC ANTENNA-SUPPORT MATERIALS PULTRUDED RODS FOR ANTENNA GUYS, CATENARIES AND COMMUNICATIONS STRUCTURES  
AUTHOR(S): N. Halsey, D.E. Marlowe, R.A. Mitchell, and L. Mordfin  
CONTRACT NO: F33615-72-M-5000  
CONTRACTOR: National Bureau of Standards  
PROJECT MONITOR: J.R. Rhodehamel (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738106  
DIST. STATEMENT: Approved for public release; distribution unlimited.

ABSTRACT: Both E-glass and Kevlar 49 (aramid) fibers were used to reinforce an isophthalic polyester resin. These materials were used, in turn, to form pultruded antenna rod hardware for structural tests. The aramid material exhibited substantially improved strength-retention properties over the glass-reinforced material under prolonged exposure to heat and humidity. The aramid material offers the promise of superior weatherability in antenna-support applications although further testing is warranted. The stress-rupture properties of pultruded rod, under high humidity, possess unusual temperature and time dependencies. These are explained in terms of the mechanisms whereby moisture is transported from the environment to the fiber/matrix interface. The stress-rupture properties, as well as the tensile properties, may be improved by appropriately modifying the pultrusion process.

REPORT NO: AFML-TR-76-50  
ACCESS NO: 204,601 April 1976  
TITLE: DEVELOPMENT OF LARGE SCALE EXTRUSIONS  
AUTHOR(S): J.E. Aker, J.L. Weingarten, L.E. Fielding, and E.J. Morrisey

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CONTRACT NO: F33657-70-C-0884  
CONTRACTOR: Amoco Chemicals Corporation  
PROJECT MONITOR: E.J. Morrissey (AFML/MXE)  
PROJECT NO: 1244  
TASK NO: 124401  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report details the development of an extrusion process and refers to a pallet for background. Utilizing a 3 1/2" extruder, structural shapes 2 1/4" thick by 101" wide by 9' in length were extruded. The material used was Amoco 6004 polypropylene with 30% by weight fiberglass from a blend with Fiberfill G-63/70. The structural shape was developed for use as a HCU-6/E (463L) Air Cargo Pallet. The extrusions were equipped with side rails to complete construction of A/C pallets and are undergoing evaluation tests as A/C cargo pallets. A significant advancement in the state-of-the-art of large scale polymer extrusions was accomplished in this program. Development effort to date has effectively shown that large scale extrusions of thermoplastics can be achieved. While feasibility has been proved, economic utilization of this technology will require further improvements to speed the extrusion process.

REPORT NO: AFML-TR-76-52 AD A030 275  
ACCESS NO: 204,478 May 1976  
TITLE: EXPLORATORY DEVELOPMENT OF DESIGN DATA ON JOINTS USING FATIGUE-IMPROVEMENT FASTENERS  
AUTHOR(S): S.C. Ford  
CONTRACT NO: F33615-73-C-5111  
CONTRACTOR: Battelle's Columbus Laboratories  
PROJECT MONITOR: A. Brisbane (AFML/MXE)  
PROJECT NO: 7381  
TASK NO: 738106  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This report presents fatigue design data on joints using fatigue-improvement fasteners. The major emphasis is placed upon low-load transfer specimens made of 7075-T73 and T7351 aluminum, assembled with PH13-8Mo and Ti-6Al-4V fasteners using TaperLok, HiTigue, and split-sleeve mandrelized hole-fastening systems. The study revealed that the fatigue properties of fastener joints with mandrelized holes were similar to those of fastener joints with the TaperLok and HiTigue fastener systems. A method of condensed data presentation in MIL-HDBK is proposed along with data requirements for future programs.

REPORT NO: AFML-TR-76-54  
ACCESS NO: 204,600 April 1976  
TITLE: CONFERENCE ON AEROSPACE TRANSPARENT MATERIALS AND ENCLOSURES  
AUTHOR(S): S.A. Marolo  
CONTRACT NO: F33615-72-C-2193  
CONTRACTOR: AFFDL/AFML  
PROJECT MONITOR: S.A. Marolo (AFML/MXE)

PROJECT NO: 7381  
 TASK NO: 738106  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: The purpose of this report is to make available the technical papers presented at the Eleventh Conference on "Aerospace Transparent Materials and Enclosures." Thirty-nine technical papers are presented in the seven sessions that address transparency design and performance, characterization, materials and processes, and bird impact resistance. The papers contained herein have been reproduced directly from the original manuscripts.

REPORT NO: AFML-TR-76-63 AD A031 320  
 ACCESS NO: 204,544 June 1976  
 TITLE: PRELIMINARY DEVELOPMENT OF AN INTERFEROMETRIC STRAIN GAGE FOR USE ON NOSETIP MATERIALS SUBJECTED TO THERMAL SHOCK

AUTHOR(S): W.N. Sharpe  
 CONTRACT NO: F33615-75-C-5230  
 CONTRACTOR: Michigan State University  
 PROJECT MONITOR: C.L. Budde (AFML/MXS)  
 PROJECT NO: 627A  
 TASK NO: 627A00  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: This report describes the results of a limited effort to extend the capabilities of the interferometric strain gage (ISG) to high temperatures at high heating rates on graphite and tungsten. The specified temperature limit was 2500°F, which was to be reached in a time of approximately two seconds. ISG is based on the motion of laser-generated interference patterns from the specimen surface. If suitable reflecting surfaces can be made that will withstand the high temperature environment, then the technique has great potential. Tungsten oxidizes very rapidly, and the technique can be used for heating tests only up to about 800°F in air. The temperature limit can be extended by using a less oxidizing atmosphere. Reflecting indentations cannot be formed directly in graphite, so another material must be attached to the specimen surface and the indentations applied to it.

REPORT NO: AFML-TR-76-65  
 ACCESS NO: 204,490 May 1976  
 TITLE: ADHESIVE BONDED AEROSPACE STRUCTURES STANDARDIZED REPAIR HANDBOOK

AUTHOR(S): E. McCarty and R.E. Horton  
 CONTRACT NO: F33615-73-C-5171  
 CONTRACTOR: Boeing  
 PROJECT MONITOR: W.M. Scardino (AFML/MXE)  
 PROJECT NO: 7381  
 TASK NO: 738106  
 DIST. STATEMENT: Approved for public release; distribution unlimited.  
 ABSTRACT: This report covers the third phase of a five-phase program to develop a standardized handbook for the repair of bonded aircraft structure. Tasks include the standardization of small repairs that are now covered by

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the various aircraft technical orders as well as general instructions for large repair work including component rebuilding. Work completed in Phase III included the fabrication and test of small area repair specimens. Repair methods were demonstrated on seven military aircraft components. This work will serve as a base for procedures to be designated in the handbook.

REPORT NO: AFML-TR-76-85 AD A031 008  
ACCESS NO: 204,536 June 1976  
TITLE: POESSY, A COMPUTER PROGRAM FOR THE AUTOMATIC GENERATION OF REENTRY VEHICLE NOSE TIP FINITE ELEMENT MODELS  
AUTHOR(S): F.C. Weiler  
CONTRACT NO: F33615-74-C-0193  
CONTRACTOR: Weiler Research Incorporation  
PROJECT MONITOR: C.L. Budde (AFML/MXS)  
PROJECT NO: 627A  
TASK NO: 627A00  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: The theoretical background of the automatic nosetip finite element model generator, POESSY, is described. The POESSY computer program consists of four basic subprograms which perform different distinct steps in the automatic generation and translation of nose tip models. They are: PGMESH, which automatically generates the structural finite element mesh, PGPRES, which translates the surface pressures and temperatures, PGTEMP, which translates the in-depth 2-dimensional temperature field and PGPLOT, which plots the resultant finite element mesh and temperature contours. The use of the POESSY computer program is demonstrated by sample problems solved for a typical plug and shell nose tip.

REPORT NO: AFML-TR-76-126 AD A032 429  
ACCESS NO: 204,610 July 1976  
TITLE: WATER DROP BREAKUP/IMPACT DAMAGE THRESHOLDS  
AUTHOR(S): J.P. Barber  
CONTRACT NO: F33615-76-C-5038  
CONTRACTOR: University of Dayton Research Institute  
PROJECT MONITOR: G. Ormbrek (AFML/MXS)  
PROJECT NO: 627A  
TASK NO: 627A00  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: An investigation of the breakup criteria for water droplets traversing reentry vehicle bow shocks was conducted. Hemispherical, ATJS graphite tipped, 20mm projectiles were launched at reentry velocities (2.5 km/s to 4.5 km/s) into a single stream of well separated, cloud sized water droplets (20  $\mu$ m to 100  $\mu$ m diameter). The projectile nosetip was observed about 1  $\mu$ s after impact with the droplets. If the droplets survived transit through the shock layer, impact debris plumes were observed. If the droplets broke up in the shock layer, impact debris was not observed. The bow shock layer aerodynamic conditions were systematically varied to investigate the transition (breakup criteria) over a range of Weber numbers (We) from about 20,000 to 160,000. The results showed good agreement with previous indirect measurements of breakup.

TECHNICAL SERVICES DIVISION (AFML/TU)

REPORT NO: AFML-TR-75-35 AD A018 355  
ACCESS NO: 204,684 March 1975  
TITLE: STUDIES IN CHEMICAL IONIZATION MASS SPECTROMETRY  
AUTHOR(S): J. Futrell  
CONTRACT NO: F33615-73-C-5025  
CONTRACTOR: University of Utah  
PROJECT MONITOR: W.R. Powell (AFML/TUA)  
PROJECT NO: 7360  
TASK NO: 736005  
DIST STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: These research efforts have involved studies in chemical ionization mass spectrometry which have led to improved instrumentation, techniques, and methodology for trace analysis. Much of the work has emphasized instrumental developments. These have included the development of high pressure ion sources for chemical ionization studies with a high resolution mass spectrometer, the development of super pressure (20 torr) ion sources for exploring maximum sensitivity of chemical ionization mass spectrometry, and most recently, the development of combined gas chromatography-electron impact-chemical ionization mass spectrometry using a dual source, dual-beam mass spectrometer. This report describes some applications of the latter instrument plus the computer software developed for accumulation of data and data reductions.

PLANS OFFICE (AFML/XR)

REPORT NO: AFML-TR-76-14 AD A025 213  
ACCESS NO: 204,329 March 1976  
TITLE: AIR FORCE TECHNICAL OBJECTIVE DOCUMENT FY 1977  
AUTHOR(S): H. Marcus  
CONTRACT NO: Internal  
CONTRACTOR: AFML/XR  
PROJECT MONITOR: B. Chasman (AFML/XR)  
PROJECT NO: N/A  
TASK NO: N/A  
DIST. STATEMENT: Approved for public release; distribution unlimited.  
ABSTRACT: This Technical Objective Document was prepared by the Air Force Materials Laboratory and describes the Materials Technology Areas for meeting future Air Force Operational needs. The six Technology Areas encompass the full spectrum of materials capabilities required for future aircraft, missile, space and electronic systems - Thermal Protection Materials, Aerospace Structural Materials, Aerospace Propulsion Materials, Fluid, Lubricant and Elastomeric Materials, Protective Coatings and Materials and Electromagnetic Windows and Electronics. Presented for each TA is the general objective, specific goals, technical approaches and a Laboratory TA focal point who can facilitate face-to-face discussions with Laboratory engineers and scientists.

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DOC	7381	03
AFML/LL	7021	01
"	7353	02
"	"	05
"	"	06
"	"	08
LLM	2387	00
"	7021	01
"	"	02
"	"	03
"	7312	01
"	7351	02
"	"	05
"	"	06
"	"	08
"	7353	06
LLN	7351	02
"	"	06
"	"	07
"	7353	03
LLP	2279	01
"	7351	09
"	7353	08
LLS	7351	05
"	"	08
"	7353	02
AFML/LPJ	1470	03
"	2071	00
"	7360	01
"	7367	04
"	7371	01
"	"	03
LPO	317J	00
"	7367	03
"	7371	01
"	"	02
AFML/LTE	500-1	
"	505-1	
"	505-3	
"	506-2	
"	519-2	

PROJECT AND TASK NUMBERS (continued)

<u>Division and Branch</u>	<u>Project Number</u>	<u>Task Number</u>
AFML/LTE	521-5	
"	523-3	
"	538-4	
"	610-3	
"	7371	01
LTM	107-2	
"	109-2	
"	120-2	
"	752-4	
"	753-4A	
"	755-4	
"	817-5	
"	846-3	
"	7381	02
"	7801F	
LTN	304-4	
"	316-4	
"	402-3	
"	408-4	
"	410-2	
"	419-4	
AFML/MBC	ILIR	00
"	2914	03
"	7320	01
"	"	02
"	7340	01
"	"	02
"	"	03
"	"	04
"	7342	02
MBE	ILIR	00
"	7340	01
"	"	02
"	"	05
"	"	07
MBM	ILIR	00
"	2279	01
"	7340	02
"	"	03
"	7342	02
MBP	7340	04
"	7342	01
"	"	03
"	7360	05
MBT	ILIR	00
"	7340	08

PROJECT AND TASK NUMBERS (continued)

<u>Division and Branch</u>	<u>Project Number</u>	<u>Task Number</u>
AFML/MBT	7342	01
"	7343	01
"	"	02
"	"	03
AFML/MXA	7351	09
"	7381	07
MXE	1244	01
"	7381	01
"	"	06
"	"	07
MXS	627A	00
"	7381	02
"	"	03
AFML/TUA	7360	05
AFML/XR	N/A	