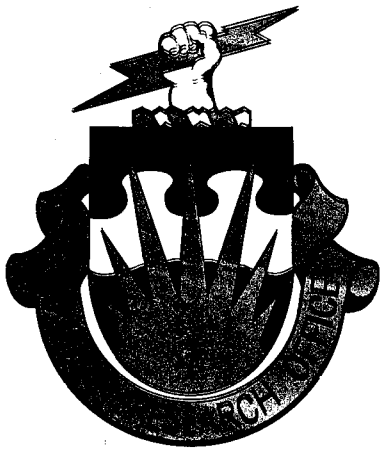
US ARMY
EUROPEAN RESEARCH OFFICE



SCIENTIFIC HIGHLIGHTS.

1st Quarter
1990

US Army Research Development and Standardization Group (United Kingdom)

BOX 65 - FPO NEW YORK 09510 - 1500

FOREWORD

The major functions of the Research Division of U.S. Army Research, Development and Standardization Group (USARDSG-UK) are to identify and cultivate unique offshore technology and to transfer it to the U.S. Army's research laboratories and agencies. In order to make that transfer of technology more timely and effective, we provide, in the Scientific Highlights, information on the significant activities and accomplishments of the Research Division on a quarterly basis.

Further information on the activities and accomplishments of the Research Division is available in the USARDSG-UK Research Activities Report and the U.S. Army Research Office Annual Report. If you are not now receiving these publications, but would like to, please contact the undersigned. Comments or questions regarding items appearing in any of these publications may be addressed to the point of contact given in code at the end of each article and defined in the following pages.

Every year USARDSG-UK sponsors select international conferences relevant to the U.S. Army's Research and Development program objectives. In return, waivers of registration fees for a few scientists who participate from the U.S. Army Labs are allowed. A list of conferences to be held in FY90 is included in this issue. To avail this concession, the incumbent participant should contact the relevant responsible scientist at the USARDSG-UK as early as possible. Similarly, information about the planned workshops is included. These workshops are an excellent forum to discuss ongoing work and to transfer information between foreign and U.S. Army scientists. Researchers, active in the area covered by these workshops, are encouraged to take steps to participate in them. Usually one or two scientists from the U.S. Army laboratories participate by presenting papers or discussions at each workshop. USARDSG-UK will help as much as possible in facilitating participation in these conferences and workshops.

So that we may make this publication more effective in the future, we would appreciate feedback from you, the readers. We welcome your comments and suggestions.

C.C. SMITH
Colonel, CM
Commanding

SCIENTIFIC HIGHLIGHTS

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EXECUTIVE SUMMARY

This publication is arranged so that the significant activities of our organization can be gleaned by the busy executive by reading the Introduction of this report, and the underscored portions of the subsequent sections.

INTRODUCTION

The United States Army Research, Development and Standardization Group - United Kingdom (USARDSG-UK) has both research and standardization missions. The research mission is carried out by the USARDSG-UK's Research Division, historically known as the U.S. Army European Research Office (ERO). It is with the activities of the Research Division that this brochure is concerned.

The Research Division is basically an extension of the U.S. Army scientific community into Europe, Africa, the Middle East, and South West Asia. The technical staff consists of senior scientists and engineers who collectively represent a very broad range of disciplines: chemistry, biology, physics, mathematics, material sciences, aeronautics, mechanics, electronics, and computer sciences. Each of these groupings of disciplines is covered by a staff scientist from the U.S. Army Research Office (ARO). Additionally, staff scientists from the U.S. Army Corps of Engineers and the Army Research Institute (ARI) are administratively attached to USARDSG-UK; they cover: respectively, environmental sciences and behavioural and social sciences. Names and telephone numbers of these scientists are given in a subsequent section.

The research mission is implemented by:

1. Acting to encourage the most effective possible exchange between the scientific and engineering communities of Europe, Africa, the Middle East, and South West Asia, and the scientists and engineers in the U.S. Army research laboratories and agencies; and

2. Encouraging and supporting basic (or fundamental) research which is unique in character and highly relevant to the interests of the U.S. Army.

The former aspect of the mission is accomplished chiefly in four ways: a) technical staff visits to universities and other research activities with resident personnel; b) technical staff attendance at international conferences, symposia, and workshops covering technical subjects of interest to the U.S. Army; c) under certain circumstances, by assisting European, African, Middle Eastern, and South West Asian scientists and engineers to visit appropriate U.S. Army research and development laboratories and agencies; and d) provide, on occasion, travel support for Army scientists.

The latter aspect of the mission is accomplished largely in two ways: a) by support of international conferences, symposia, and workshops, the workshops typically being highly focused on U.S. Army problems; and b) by support of unique research projects. Support of research projects may be accomplished using in-house funds provided by ARO or funds

provided by U.S. Army laboratories and other DOD agencies.

In the sections that follow entitled HIGHLIGHTS OF THE RESEARCH PROGRAM and TECHNOLOGY TRANSFERS, we will present selected activities and progress during this period on projects, liaison travel, symposia, conferences and workshops. Selected technical and administrative items will often be presented in some detail. A listing of the board-approved contracts, as well as planned conferences and workshops sponsored by Research Division will be provided.

POINTS OF CONTACT

Listed below are points of contact for inquiries about items appearing in this publication or about other technical/-scientific matters regarding this office. (FAX: 44-1-724-1433)

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* PLEASE NOTE, AFTER 6 MAY 1990, THE LONDON AREA CODE CHANGES FROM 1 TO 71

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II. HIGHLIGHTS OF THE RESEARCH PROGRAM

FLUORESCENCE DECAY OF MOLECULES ADSORBED ON SURFACES

A Final report on the subject topic has been received from Professor F.C. De Schryver of the Katholieke Universiteit, Leuven, Belgium. He summarizes his interesting latest research results in the following paragraphs.

In general the interpretation of the fluorescence decays of molecules adsorbed on various surfaces (silica, alumina, zeolites, monolayers, clays) is not unambiguous. The time-dependent fluorescence of the organo-clay systems, has also been studied. Several functions have been used to describe the fluorescence decays of adsorbed probe molecules on a clay surface: one-exponential, two-exponential, Poisson distribution of lifetimes, three-exponential. Adsorbed molecules aggregate on the clay surface. This means that besides monomers, several aggregates (dimer, trimer, ...) are present on the surface. Energy transfer from a single monomeric molecule to the aggregates can thus occur. In addition, these aggregates can form excimers upon excitation. Therefore a very complicated fluorescence decay can be expected. The distribution of the adsorbed molecules can be changed by co-adsorbing detergent molecules with a sufficient chain length. As reported previously, the aggregation of the probe molecules decreases with increasing detergent concentration.

The fluorescence decay of the pyrene probe becomes less complex when detergent molecules are co-adsorbed. One possible approach is to use a two-exponential function to fit the fluorescence decay. Besides the monomer lifetime, a short decay time is observed. The contribution of the short decay time decreases with increasing detergent concentration. The fluorescence decay becomes thus more and more one-exponential with increasing detergent concentration but, even at the highest detergent concentration, a multi-exponential function is needed to describe the fluorescence decay. In a certain region of concentration one can successfully apply micellar kinetics to describe the fluorescence decay, as is shown in a previous report.

When there is no detergent co-adsorbed the fluorescence decay of the adsorbed probe is very complicated. Here a three-exponential function is sometimes used to fit the decay. Short decay components are found besides the monomer fluorescence lifetime. These short decay components are usually ascribed to the aggregates. However, there is no underlying model to explain this three-exponential behaviour.

A new approach to the problem of the fluorescence decay of molecules adsorbed on surfaces is offered by the use of the expression developed by Klafter and Blumen which describes the

Förster energy transfer in a fractal environment. The notion "fractal" was first used by Mandelbrot to describe geometrical structures whose dimensions have non-integer values. Fractals have the potential to describe a multitude of irregular structures. All of these structures are then characterized by a fractal dimension D. With the aid of this fractal dimension, it is possible to distinguish between different irregular structures in a more or less quantitative manner.

Different sets of experiments were simulated utilizing the expression derived by Klafer and Blumen. Afterwards, these experiments are analyzed in different ways: as a mono-exponential, a two exponential or a three exponential decay. Both with single curve analysis and with global analysis, it turns out to be impossible to fit a fractal decay to a mono exponential or a two exponential decay.

A three exponential fit to the fractal data gave good fits with single curve analysis and this over the whole of the concentration region studied. A global analysis, which makes use of model dependent relations between the parameters, can help to distinguish between the models.

Micellar kinetics, which is another often used approach for the analysis of the fluorescence decays of adsorbed dyes can easily be distinguished from a fractal decay both with single curve analysis and with the global analysis approach.

Finally, an expression used in the analysis of energy transfer between dyes in monolayers was tested against the fractal analysis.

$$\phi(t) = A_1 \exp[-t/\tau_D - q_A(t/\tau_D)^{1/3}] + A_2 \exp(-t/\tau_D)$$

The expression consists out of two parts: one is the generally known expression for Förster energy transfer in two dimensions, the other part is a mono-exponential decay. This expression is used to analyze energy transfer in monolayers and is explained by the content of domain formation in the monolayers. The mono-exponential part is then ascribed to the decay of isolated donors far from the acceptors which reside in another domain of the monolayer. The simulation study clearly showed that this expression could not be fitted to a fractal decay and this for a set of experiments where the ratio of the pre-exponential factors ranged from 0.1% to 1%.

A simulation study was also started to find out how one can at best analyse an anisotropic decay. In this simulation study a program was used which allows for different analyser angles to be included in the analysis. This approach was then compared with other methodologies e.g. a global analysis in function of excitation wavelength, emission wavelength or a higher number of counts in the peak channel.

Contradictory to the recent results Fendler presented, it was found that the inclusion of more than two analyser angles did not improve the analysis dramatically. An analysis in function of temperature, emission wavelength or excitation wavelength (dependent on the problem) does have a much more pronounced effect on the quality of the analysis). (Chemistry and Biological Sciences Branch)

PROTECTION OF GRAIN AGAINST INSECTS AND DETERIORATION

A biological sciences research contract by Professor Y. Birk and S. Applebaum of the Hebrew University of Jerusalem has been completed this quarter. It is entitled "Proteases of Stored Product Insects and Their Inhibition by Specific Protease Inhibitors from Soybeans and Wheat Grain". A brief description of the methodology, and a summary of the most important results are presented below:

A balanced co-evolution is assumed to have developed between herbivorous insects and their hosts, with each type of insect adapting its physiology to best cope with the vagarities of its specific host(s) and the host plant concurrently elaborating methods of defence in order to decrease its suitability for the development of the insect. Stored product insects have evolved a complex relationship with seeds and grains which is conceptually similar to the host-plant relation encountered in herbivorous insects.

Specific protein protease inhibitors, which inhibit digestive protease of insects have evolved in plants. It is often declared that the physiological function of the seed embryo and endosperm protein protease inhibitors is to protect grain against attack by insects and against deterioration by microorganisms. The hypothesis that these protease inhibitors are of potential use in protection of valuable crops from damage as a consequence of attack by insects served as a guideline throughout these studies. The investigation of the digestive proteases of several model insects is a pre-requisite for understanding the complex relationships that the insects have evolved with the plant. The information on insect proteolytic enzymes and more specifically, on insect trypsins and chymotrypsins, in comparison to the corresponding proteases from higher organisms, is essential for studying the selective, species specific, interactions of the naturally-occurring protease inhibitors with the insect proteases.

SUMMARY OF MOST IMPORTANT RESULTS

Trypsin- and chymotrypsin-like enzymes have been isolated from the digestive tracts of three model insects: Tenebrio molitor, Tribolium castaneum and Locusta migratoria and characterized. The inhibitability of these enzymes by proteinaceous trypsin-chymotrypsin inhibitors from soybeans

and chick peas suggest that these insects may be affected by the inhibitors in vivo.

The lack of disulfide bridges in the insects' proteases suggest different conformation and assembly from those known for the respective mammalian enzymes. Further investigation of the structure of insect proteases may lead to better understanding of their susceptibility to inhibitors in vivo.

The Bowman-Birk trypsin-chymotrypsin inhibitor from soybeans (BBI) strongly inhibits the trypsin- and chymotrypsin-like enzymes from the digestive tract of the three model insects (Tenebrio, Tribolium and Locusta) when assayed on protein substrates. The affinity of the proteinases for the inhibitors has been increased in immobilized systems, when compared to their effect in solution. This potentiated effect seems to result from better mutual accessibility of enzyme to inhibitor. It thus may resemble the in vivo interaction between the insect and the raw soybean.

The potential inhibitory effect of soybean protein components on insect proteases has been exemplified by the inhibitability of locust chymotrypsin by the Kunitz soybean trypsin inhibitor (STI) which does not inhibit bovine chymotrypsin.

The Tribolium protease inhibitor from soybeans, which does not inhibit bovine, Tenebrio and locust trypsins, fully inhibits P1, one of the major Tribolium proteases. The proteolytic activity of P1 can also be inhibited by the specific trypsin inhibitors "Kunitz" (STI) and "Bowman-Birk" (BBI) from soybeans. None of these inhibitors affects the Tribolium thiol proteases which have been separated by gel electrophoresis and by affinity chromatography on thio-propylsepharose.

A revised method with high yield has been developed for the isolation of Tenebrio trypsin and chymotrypsin using affinity chromatography on immobilized, synthetic specific inhibitors of trypsin and chymotrypsin, respectively, with very low affinity for the Tenebrio enzymes when assayed in solution. This emphasizes once again the significance of the environment in which the protease "encounters" its inhibitor.

A highly sensitive, specific radioimmunoassay has been developed for the detection and quantitation of trypsin-like ensymes in tissues and insect body fluids using locust trypsin as a model. The specificity of the antibodies was demonstrated by immunoblot technique and cross-reactivity experiments. Positive blot reaction with the antiserum was observed only with the locust trypsin. Bovine porcine, Tenebrio and Tribolium trypsins and locust chymotrypsin did not inhibit the binding of locust trypsin to the antiserum even at 1000-fold concentration. (Chemistry and Biological Sciences Branch)

ENHANCING PERFORMANCE UNDER STRESS

Professor Shlomo Breznitz of the University of Haifa, Israel, reports on results of his research on "Enhancing Performance under Stress by Information about its Expected Duration", Contract No. DAJA45-86-C-0048. This work is supported by the U.S. Army Research Institute.

In the first field study, several hundred Israeli soldiers participated in a 20km march at a very fast pace carrying full field gear. They were randomly divided into four experimental conditions:

a. Full information: soldiers were told the actual distance.

b. No information: told only that the march would be difficult.

c. Too short: told that the distance was less than actual (e.g. 15km for a 20km march), and then, just before the end, told that they would have to do more (e.g. 5km more).

d. Too long: told that distance would be 25km, but at 14th km, told that it would be reduced to 20km.

All marched the same distance on the same day. Only information and timing of information differed among groups.

RESULTS

The number of soldiers successfully completing the march differed significantly between groups - Group A best, Group B worst, with Group C somewhat better than Group D. Both cortisol and prolactin levels were significantly higher in Group B than in A. (Knowing when the ordeal will end seems to help soldiers physically as well as mentally).

Current laboratory experiments are underway to investigate the effects of different kinds and timing of information on the endurance of prolonged painful stimuli. (U.S. Army Research Institute European Science Coordination Office)

LASER SPECTROSCOPY OF QUANTUM WELL AND SUPERLATTICE STRUCTURES

Professor B. Henderson at the University of Strathclyde, Glasgow, Scotland, has been conducting a research program that involves the application of optical and magneto-optical techniques to the study of recombination centers in quantum well structures (QWS) and strained layer superlattices (SLSs). In the square well model of the confining layer of thickness L the excitonic energies scale as L^{-2}: a small variance in thickness, ΔL, of the individual wells results in a broadening of $2\Delta L$ about the mid-point of the exciton peak. Such broadening may be probed by high resolution optical

techniques. In epilayer structures involving mixed alloy semiconductors, however, there is additional broadening due to non-uniformity in composition (i.e. non-stoichiometry). In general, strain and compositional disorder do not affect the exciton peak except through its second moment (i.e. width) and decay time. His group have grown type I and type II SLSs based on the system $Zn_xCd_{1-x}S_ySe_{1-y}$ and carried out photoluminescence (PL) and photoluminescence decay (PLD) measurements on these materials.

The II-VI compound SLSs were grown using atmospheric pressure MOCVD on (100) GaAs substrates in the temperature range 650-750K in a horizontal reactor. The well and barrier layer thicknesses were measured by means of X-ray diffraction. Typically the SLSs consisted of 100 periods of 5nm thick ZnS with 0.5nm ZnSe with or without buffer layer to minimise growth strain.

PL spectra were obtained conventionally using a UV Ar^+ laser and ND filters to provide excitation densities in the range $10mw/cm^2$ to $1kW/cm^2$. Samples were maintained at constant temperature between 10K and 300K using a closed-cycle cryorefrigerator equipped with 4-port optical access. A fast photodetector and time-correlated single photon counting electronics were used to build up an histogram of decay times for individual fluorescence events. Lifetimes down to $300x10^{-12}$s can be measured. The technique measures the duration of events which begin with the generation of an electron-hole pair and end with the radiative recombination of the minority carrier in a selected radiation channel.

Typical PL spectra were obtained indicating how the band gap of the confinement region affects the exciton emission wavelength.For allowed transmissions, the exciton lines in SLSs are shifted to shorter wavelengths (i.e. blue-shifted) compared to bulk samples. In the case of a single, thick ZnSe epilayer (t = 1.5um) the luminescence peak is observed at 443.5nm. A sample consisting of 100 periods of 0.6nm ZnSe/ 5.4nm ZnS excited under weak beam conditions showed a single peak at 406nm. The shift from 443.5nm to 406nm is due to quantum confinement in the ZnSe layers.

A single ZnSe epilayer shows excellent single exponential decay with characteristic decay time at 10K of 300ps: such single exponential decay is expected for exciton fluorescence. However, for ZnS/ZnSe SLSs the decay is multiexponential: up to 50% of the intensity decays via a rather fast decay process (less than 1ns) after which there is a persistent long-lived decay, the rate of which decays with increasing time delays. The decay curves are not very different in the temperature range 10-110K. At higher temperatures the decay becomes progressively faster. The non-exponential behaviour seems likely to be due to impurities and trap saturation. The rather fast decay follows from ZnS/ZnSe SLSs

being type I superlattices i.e. both electrons and holes are localised in the narrow gap material (i.e. ZnSe). Carrier separation, such that electrons in the conduction band of one material recombine with a hole in the valence band of a neighbouring layer, occurs in type II superlattices. The recombination in type II superlattices is expected to have much longer lifetimes than type I systems. Preliminary experiments have been carried out on ZnS/CdS, ZnSe/CdSe and CdS/CdSe to determine which, if any, of these materials are of type II character. Initial CW photoluminescence decays are consistent with the "common anion" rule for the band offsets in these II-VI materials. This leads to the general band effect diagram in which the conduction band offset between ZnSe and ZnS is very small, with a single alignment of bands across the mixed cation system CdS/ZnS or CdSe/ZnSe. This implies ZnS/CdSe to be type I but ZnSe/CdS is type II, just as CdS/-CdSe is.

These experiments are important not only for improving the basic understanding of the physics of superlattice structures, but also for developing solid state, visible lasers that can be used in Army display systems. (Electronics and Computer Sciences Branch)

PARTICLE DYNAMICS AND GRAVEL STREAM-BED ADJUSTMENTS

A multiplicity of novel techniques are employed to elucidate the nature of intermittent coarse particle initiation and unsteady motion in a steep gradient gravel bed stream. The objective of this research is to better understand the initial motion processes of particles in coarse mixtures in gradually varied (unsteady) natural flows, the nature of particle motion (i.e. rolling, sliding, intermittent motion as single particles or as kinematic waves), the relationship between local sediment sources and sinks, kinematic waves of particles and rapid changes in bed levels.

Incomplete theoretical derivations of all these processes are available in the literature. Detailed comprehensive test data from natural rivers are required to rigorously test these and refine predictive models.

The process of bedload transport in gravel-bed streams is of interest to scientists the world over from both a practical and theoretical standpoint (e.g. Hey and others, 1982). An important focal point for research has been the nature of transport in gravel bed streams. Answers to a variety of questions are being sought, as the hydraulic conditions necessary to initiate transport, the nature of transport as an event begins and ends and during transport, verification that gravel particles move in kinematic waves such as those described by Langbein and Leopold (1968), or do they move continuously past a point, and does transport take

place on a stream bottom.

Rather than investigate initial motion, particle transport or bed level fluctuations in isolation in a natural stream, the present objective is to monitor the phenomena and associated processes intensively over a defined reach where inputs and outputs of sediment are known. Linkages between hydraulics, initial motion criteria, transport mechanisms and bedlevel fluctuations will be established. A better understanding of the complex processes of sediment transport and river channel adjustment mechanism will ensue. Findings will have immediate relevance to defining theoretical bedload transport relationships and models of sediment sorting (including the armouring process) which have practical application to fluvial hydraulics.

The research will be conducted by Dr. P.D. Carling et al of Freshwater Biological Association Windermere Laboratory, Cumbria, UK. (Environmental Sciences Branch)

HIGH TEMPERATURE THERMAL ANNEALS AND SILICON GERMANIUM ALLOYS

Professor M. Rowe (University of Wales, Cardiff) has recently completed an ERO research contract funded by the Electronic Technology and Devices Laboratory (ETDL). Professor Rowe carried out a preliminary theoretical and experimental investigation into the effect of high temperature thermal anneals on the thermoelectric figure of merit of silicon germanium-gallium phosphide material. A realistic theoretical model for the silicon germanium alloy system was employed to investigate the effect of an increase in the doping level on the electrical power factor; the electrical power factor is a function of the Seebeck coefficient and the electrical conductivity. The theoretical analysis indicated that the reported factor of 1.6 increase in the carrier concentration of heat treated silicon germanium-gallium phosphide material compared to conventional silicon germanium alloy would result in an increase in the electrical power factor of between 12 to 14% at room temperature, rising to 18-22% at 100K.

Comparison of measured transport data on silicon germanium-gallium phosphide material and a zone leveled silicon germanium alloy confirms that substantial improvements in the electrical power factor can be obtained by subjecting the silicon germanium-gallium phosphide material to high temperature thermal anneals, while the total thermal conductivity remains relatively unchanged. Although there are differences in the increases in the power factor obtained by different researchers, Professor Rowe's findings support the conclusion that the electrical power factor, and hence the figure of merit of silicon germanium-gallium phosphide, can be

significantly improved by high temperature thermal anneals. (Mathematics and Physics Branch)

MODELLING A BATTLE BY DECOMPOSING IT INTO A SET OF MINI-BATTLES

Professor M. Bathe (Royal Military College of Science) recently completed a one year research project concerned with the development of a prototype combat model based on the concept of battle decomposition. The main source of data were armor/anti-armor combat field trials held in Europe and the U.S. The final report of Bathe's research contains a review of some relevant results obtained by the authors in a related study, along with the results of some new data analysis concerning force activity levels and the distribution of firing activity among individual weapon systems. Attrition methodologies appropriate to the resolution of few-on-few combat are discussed, and two such methods which have been incorporated into the model are examined in detail. (Mathematics and Physics Branch)

SPALLATION AND DYNAMIC FRACTURE AS AN EFFECT OF LASER INDUCED SHOCK WAVES IN CARBON COMPOSITES.

In their final report, Drs S. Eliezer and I Gilath of the Soreq Nuclear Research Center, Israel (DAJA-87-C-0032) describe damage thresholds for aluminum, iron and carbon composites under short pulsed high power Nd:glass laser irradiation. Dynamic brittle fracture at hypervelocity impact conditions was observed as a result of reflected shock waves as tensile waves from the back surface of samples. Successive stages of damage from incipient spallation to complete sample perforation were obtained by increasing gradually the laser energy. The thermo-mechanical damage on the front surface as a result of laser interaction with the target material, and the mechanical damage at the back surface as a result of shock wave reflection were characterized by optical and scanning electron microscopy. The failure properties of the carbon-carbon composites were related to the processing of densification and graphitization mode; while the failure properties for carbon epoxy composites were related to impact direction versus fiber direction. A comparison was made between spall properties of carbon epoxy composites with aluminum and iron. A new experimental method was developed to calculate the attenuation of laser generated shock waves. This technique enables also the evaluation of the laser induced spall pressure in different materials and was compared to large laser-matter hydrodynamic codes.

The experimental work consisted of determining the irradiance and energy density conditions required to produce spall in one dimensional shock wave geometry threshold cond-

itions. The threshold pressure necessary to obtain incipient spallation of the samples was calculated from the plasma ablation pressure. A linear dependence was obtained experimentally for the pressure as a function of target thickness for isotropic materials such as aluminum and iron. Similar experiments were performed on carbon fiber epoxy unidirectional composites for two impact geometries, one for perpendicular impact vs fiber direction and the other along the fiber direction, see Fig. 1.

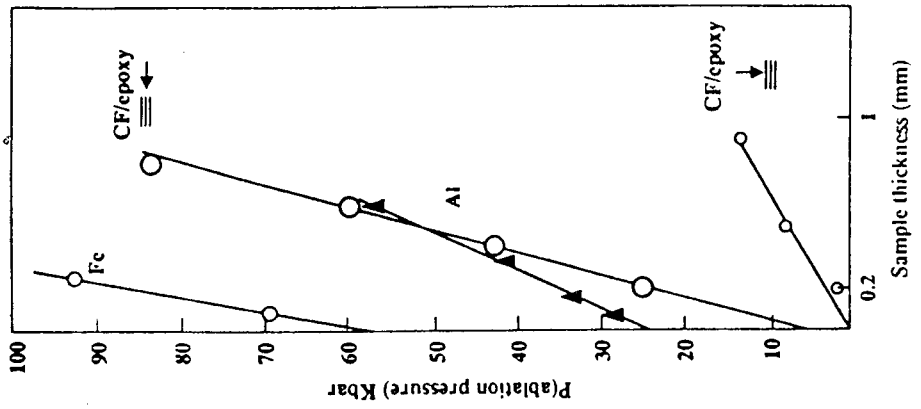

Fig.1

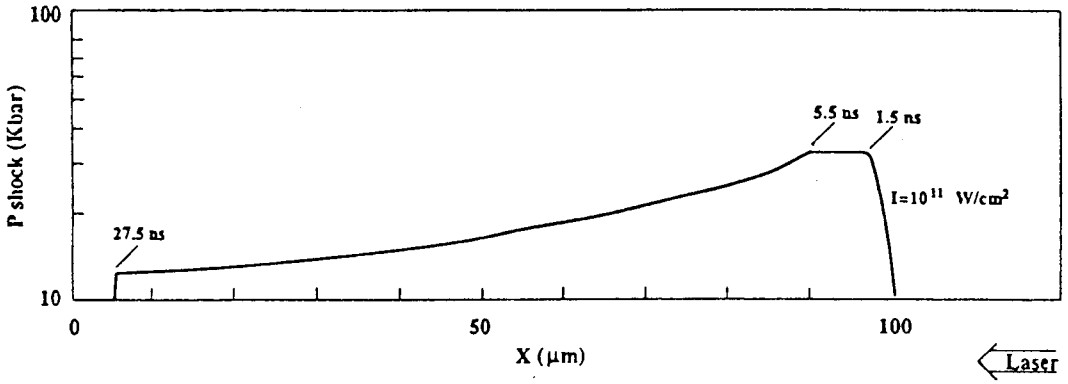

Fig.2

Experiments yield directly the pressure gradient values. The values of Pspall were obtained by extrapolating to zero foil thickness. In Fig 2 simulation results are presented for shock wave pressure attenuation in a 100 um aluminum slab target for an irradiance of 10^{11} W/cm^2. It is interesting to point out the ablation pressure calculated for aluminum for a laser irradiance of 1 x 10^{11} W/cm^2 is the same as the value obtained from the simulation, which is 34 Kbar (see Fig. 2). The pressure gradient from (simulation) is 0.135 (Kb/um) while the experimental value for aluminum pressure gradient is 0.057 (Kb/um) because the simulation is a fluid code and therefore does not take into account material strength. It is therefore probable that experimental results are more reliable than simulation results in the domain of low pressure. Final Report is available from DTIC. (Materials Science Branch).

WAVE AND FRACTURE PHENOMENA IN IMPACTED CERAMICS.

In the final report (DAJA45-88-C-0011) Dr. S. Winkler, FRG-IWM Freiburg, FRG, describes experiments performed to investigate the fracture behaviour of pressure wave loaded alumina tiles. The pressure waves were produced by impacting steel projectiles at a speed range between 100 and 1200m/s. The investigation of the damage generation phase was made possible by a newly developed special loading and observation arrangement. The tiles were impacted edge on and observation was made of one of the large surfaces by a photographic high speed technique in combination with the shadow optical method.

The aim was to observe the fracture appearance and, based on this, to understand energy absorbing processes. The results were compared with those of earlier experiments with glass slabs (Fig 1). It was found that alumina behaves quite different than glass. From a fracture mechanics point of view it was most surprising that no distinct terminal crack velocity could be found as expected and was experienced with glass (Fig 2).

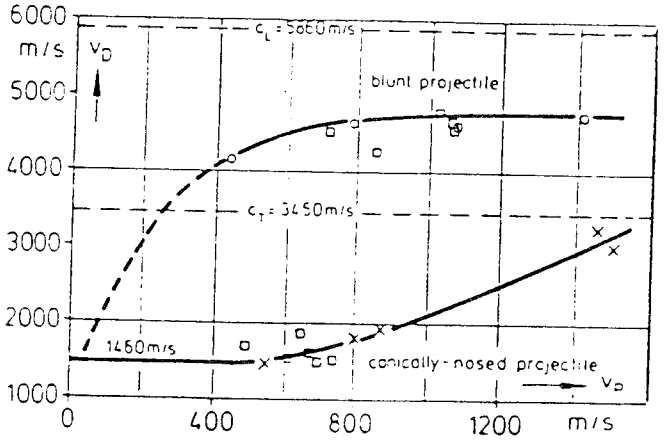

Fig.1

Crack and damage velocities in glass

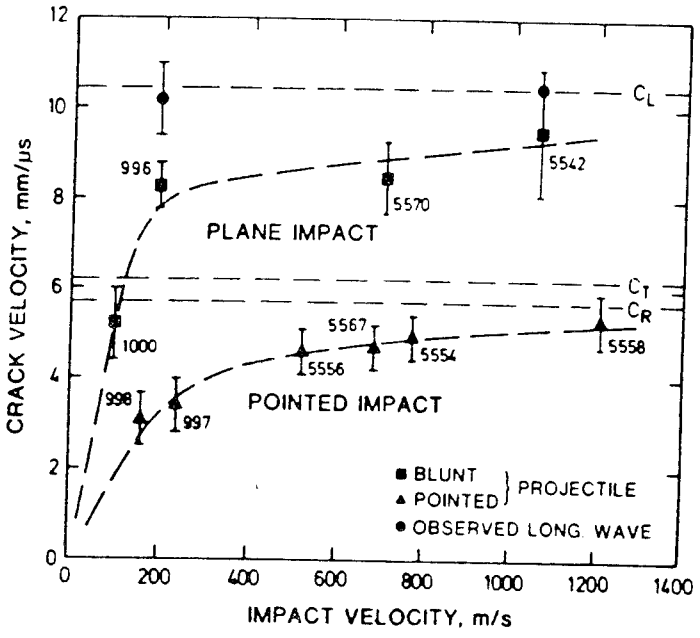

Fig.2

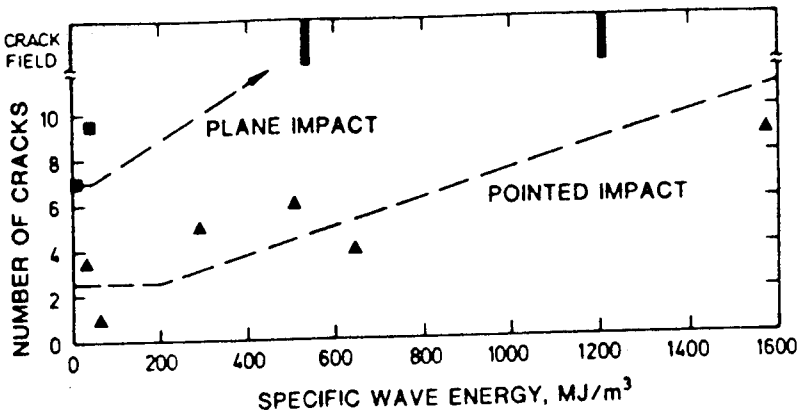

Fig.3

Number of cracks vs. energy density of the wave

Although for certain loading condition the crack velocity seemed to be terminated, different terminal crack velocities were measured for different situations. The responsible input parameter is assumed to be the specific energy of the pressure wave (Fig 3). Two energy absorption mechanisms were observed: In the regime of a low specific energy, an energy augmentation causes the crack speed to increase while the number of produced cracks remains small and essentially constant. This changes rather abruptly into the opposite when the crack speed exceeds a threshold at about 80% of the correlated wave speed. The number of cracks becomes large, their velocity, however, increases only slightly and seems to approach the wave speed asymptotically. This project is closely monitored by MTL and BRL. The work was funded by MTL (SLCMT-EM). Final report is available from DTIC. (Materials Science Branch)

III. TECHNOLOGY TRANSFERS

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III. TECHNOLOGY TRANSFERS

LIAISON SCIENTIST VISIT TO BALLISTIC RESEARCH LABORATORY

A visit by Dr. G.A. Leiper of ICI Explosives, Nobel's Explosives Company Ltd., UK, was made to the Ballistic Research Laboratory under sponsorship of the U.S. Army European Research Office (R&D 6333-CH-06) and hosted by Dr. George Adams. The visit covered many of the current research topics at BRL, and several areas of common interest were identified.

Discussions with Dr. George Adams : Quantum Mechanics

The calculations being performed at BRL for the design of explosive binders from first principles were very impressive. The ability of CADPAK to model the molecular interaction of the polymer molecules and thus derive estimates of their mechanical and thermal properties is a significant advance. Similarly, the use of quantum chemistry to visualise the molecular structures, and thus identify good synthetic pathways will speed the development process. In terms of the relevance to ICI, the development of new polymer binders is of interest. ICI has a quantum chemical capability in the pharmacological field. Dr. Adams would be welcome to visit ICI, if he were in the UK, and thus strengthen work in this area.

Discussions with Dr. Joe Heimerl : LOVA

Discussions ranged over the areas of DDT and shaped charge attack on cased propellant charges. The key issue is the need to understand whether the propellant bed undergoing shaped charge attack behaved as a continuum explosive or a discrete bed of explosive granules, each of which detonates independently. The similarity between detonation in propellant beds and in some highly heterogeneous explosives was highlighted. The use of Reactive Flow techniques to model the Shock to Detonation Transition were described by Dr. Leiper.

Discussions with Dr. Lang Mann Chang : Internal Ballistics

Dr. Chang gave an overview of the research in progress at BRL on understanding the internal ballistics of large diameter guns. Results of ignition visualisation experiments using transparent breech techniques were shown, and the efforts made to correlate the observations with theoretical predictions described. The behaviour of the NOVA code was discussed in some detail, and Dr. Chang explained the inherent assumptions in the analysis, and the variants of the code available to contractors. (Chemical and Biological Sciences Branch)

ISRAELI SCIENTIST VISITS BRL AND CRDEC

Professor Aviv Amirav of Tel Aviv University, Israel, visited Aberdeen Proving Ground for three days, where he presented two seminars at BRL and CRDEC. One seminar entitled "Mass Spectroscopy in Supersonic Molecular Beams" was presented at both places, and the other one entitled "Intermolecular Radiationless Transitions" was presented at BRL only. Each seminar elicited several questions and lively discussion with Army personnel.

The highlight of Professor Amirav's visit was the successful operation and demonstration of a new type of a flame burner called "Pulsed Flame Detector". This unique device was designed and built in Israel, and was bought to BRL by the visitor. Drs. Forch and Locke of BRL worked with the visitor in an attempt to implement several ideas concerning laser ignition of this pulsed flame. They succeeded in the laser flame ignition in three different ways. They also started to explore the desirable idea of laser selective flame ignition in which much research remains to be done.

Finally, the visitor had extensive series of discussions with Dr. Forch and Dr. Miziolek about the analytical and combustion related aspects of the "Pulsed Flame Detector", as well as aspects of "Hyperthermal Surface Ionization". This latter topic is the subject of a research contract that was awarded to Professor Amirav by ERO in FY89. (Chemistry and Biological Sciences Branch)

OPTICAL CHARACTERIZATION OF UK SAMPLES AT CREOL

Dr. J. Zavada, Chief of the Electronics and Computer Sciences Branch at ERO, visited the Center for Research in Electro-Optics and Lasers (CREOL) at the University of Central Florida in Orlando. CREOL is a new laboratory that was formed about two years ago, and is in a very fine condition for such a new lab. In general, its facilities are excellent, and the lab is undergoing expansion in terms of personnel, as well as equipment. Dr. Zavada met with Professor E. Van Stryland, who gave him a tour of the nanosecond and picosecond laser labs. Professor Van Stryland has received thin film samples prepared by OCLI Ltd., UK, under ERO contract 6060-EE-01 under DARPA/-Army support, and delivered to U.S. Army CNVEO in FY89. These samples had undergone initial measurements at CNVEO and were then forwarded to CREOL. Professor Van Stryland reviewed data taken at CREOL and discussed further tests that would be made on the non-linear optical properties of these samples. Professor Van Stryland also discussed laser experiments that would be performed on a different set of samples produced by Cambridge University under ERO contract 6406-EE-01. U.S. Army VAL is supporting the research work at Cambridge and the sample characterization at CREOL. Arrangements to coordinate

the exchange of samples and the flow of information on this project were also discussed.

The meeting at CREOL was very helpful in assessing their laser capabilities, and in understanding their overall involvement with the ERO contracts being supported by DARPA, CNVEO and VAL. (Electronics and Computer Sciences Branch)

WORKSHOP ON INDIUM PHOSPHIDE SEMICONDUCTORS

The Electronics and Computer Sciences Branch of ERO sponsored an international workshop dealing with the effects of hydrogen on the opto-electronic properties of indium phosphide (InP) semiconductor devices. The workshop was organized by Dr. J.M. Dumas of the Centre National d'Etudes des Telecommunications (CNET), and was held in Lannion, France, at the end of October. A number of important results were presented at this meeting, which was attended by 31 experts from Europe and the USA, including Dr. J.M. Zavada from ERO, and Dr. E. Davies from EOARD. Researchers at CNET-Bagneux reported on a new fabrication process for solid state InP-based lasers. These lasers have lower capacitances and threshold currents than lasers produced by present methods. In papers from AT&T and British Telecommunication research labs, data was presented that hydrogen can enter InP semiconductor components either through growth procedures or etching techniques causing deleterious results in opto-electronic devices. Other papers contained state-of-the-art information concerning characterization of hydrogen at InP surfaces and in bulk samples. The discussions after each paper clarified many topics and generated suggestions for future work. Such interactions do not normally occur at large meetings with rigid time schedules. Results from this meeting are expected to benefit programs at U.S. Army labs, including ETDL, HDL and CNVEO. (Electronics and Computer Sciences Branch)

VISIT TO RISC (RESEARCH INSTITUTE FOR SYMBOLIC COMPUTING), JOHANNES KEPPLER UNIVERSITY, LINZ, AUSTRIA

Dr. J. Wu, Mathematics and Physics Branch, visited RISC-LINZ on 24 October 1989. RISC-LINZ was founded by the Austrian Government in 1987, and is part of the Johannes Keppler University in Linz, Austria. Organizationally, RISC-LINZ is an independent unit but operates in close contact with the Department of Mathematics and the Department of Computer Science of the Johannes Keppler University. RISC-LINZ is directed by Professor B. Buchberger. The faculty of the Institute consider symbolic computation to cover all aspects of algorithmic solutions of problems dealing with symbolic (i.e. non-numeric) objects. Their research addresses the following areas:

1. Computer algebra
2. Computational geometry
3. Computational logic
4. Automated programming

The application areas include: automated mathematics, logic programming, very high level programming languages, computer-aided software development, robot programming, expert systems, analytic computation software, computer-aided design, geometry software, automation software and artificial intelligence software. The primary goals of RISC-LINZ are:

1. Research
2. Graduate teaching
3. Industrial projects and training

These goals are based on the conviction that, in computer science, symbolic computation is one of the most important theoretical areas needing formal mathematical and practical systems training, and opens some of the most promising directions for future software development. Their list of visitors includes George E. Collins (Ohio State Uni.), Marc Gaetano (INRIA Sophia Antipolis), Dima Grigoriev (Uni. of Leningrad), Tim Havel (Uni. of New Zealand), Zohar Mann (Stanford Uni.) Scott McCullum (Australian National Uni.), Michael Rothstein (Kent State Uni.), Victor Rudenko (Uni. of Moscow), Shojiro Sakata (Toyohashi Uni.), Michael Singer (Uni. of North Carolina), Bernd Sturmfels (Cornell Uni.), Niel L. White (Uni. of Florida), Chee Yap (Courant Institute, NY).

The students of RISC-LINZ are grouped together in the following laboratories:

1. Computer Algebra Lab (Head: Franz Winkler)
2. Softautomation Lab (Head: Sabine Stifter)
3. Parallel Computation Lab (Head: Bruno Buchberger)
4. Expert Systems Lab (Head: Thomas Weigert)
5. Chemical Synthesis Lab (Head: Edward Blurock)
6. Algorithmic Combinatories (Head: Peter Paule)
7. Symbolic Computation in Education Lab (Head: Bernhard Kutzler)

The Institute emphasizes both basic research and industrial applications. Currently, the following basic research projects are being pursued:

a. Computer algebra
b. LL-Language (for "parallel" symbolic computing)
c. Symbolic methods in CAD/CAM
d. Path finding algorithms (for robotics)
e. MEDLAR (a ESPRIT sponsored program in machine logic and reasoning)
6. Geometric modelling

In addition to foundational research projects, industrial projects are pursued at RISC-LINZ. Significant research motivation and funding for RISC-LINZ comes from this source. At present, work on the following projects is being carried out in cooperation with industrial partners:

1. SMART/NC - Offline Robot Programming (ATS GmbH Linz, Austria)
2. Eurotunnel (Mayreder GmbH Linz, Austria; Eureka project EU-360)
3. Expert Systems for plant control (VDEST ALPINE AG Linz, Austria)
4. CADS - Molecular synthesis systems (UNIWARE GmbH Hagenberg, Austria)
5. Algebraic methods for neural networks (SIEMENS AG, Munich, FRG)
6. Parallel surface rendering (DIS Linz, Austria)

Owing to the research accomplishments and world reputation of RISC's Director, Dr. Bruno Buchberger, the U.S. Army Research Office has extended him an invitation to give a one hour lecture at the 1990 Army Conference on Applied Mathematics and Computing, to be held at the Mathematical Research Institute, Cornell University, next June. (Mathematics and Physics Branch)

VISITS WITH MATHEMATICS GROUPS AT OXFORD, HERIOT-WATT AND STRATHCLYDE UNIVERSITIES

Dr. Chandra visited Oxford University, Heriot-Watt University and the University of Strathclyde during October 1990. The visit to Oxford was in two parts: in the first part, Dr. Chandra met with Professor B. Benjamin, FRS, a distinguished Professor of Mathematics. He is a very eminent scientist and a strong advocate for close interaction between mathematicians and experimental physical scientists. For instance, his pioneering work on stability and bifurcation studies of fluid flows was carried out in collaboration with the experimentalists working on physics of fluids. His ultimate goal is to develop a comprehensive and rigorous understanding about the turbulence phenomena.

The second part of the visit to Oxford consisted of presentations by several members of the applied mathematics group under Dr. John Ockendon. Dr. Ockendon has been leading a very commendable effort in fostering University-industry interactions. The experience of this group could be of considerable benefit to the Army in its technology transfer activities. Many groups in the U.S. are already emulating this model of University-industry liaison. These include programs at RPI, University of Delaware and Claremont College. Several topics being studied are of considerable interest to the Army. These include modelling of shear band formation,

models for hazardous waste disposal, frost heave and mobility in cold regions, and powering of rail gun accelerators.

Professor John Ball, FRS, of Heriot-Watt University, is one of the most promising applied mathematicians in the UK. He is developing new theoretical models for the description of phase transitions and phase stability in solids. Ball works in close collaboration with the experimental group in Antwerp, Belgium, and the group at the University of Minnesota. The novelty of his theory is two-fold: first, in contrast to most other theoretical work, his models are based on the theory of nonlinear elasticity, which incorporates nonlinearities due both to large rotations and to nonlinear material response. Secondly, it employs tools from variational methods to handle unconventional situations arising in microstructural studies. He has been successful in predicting microstructure based solely on the minimization of strain energy function. Experimental work at Minnesota under Professor R. James has been able to corroborate some of the theoretical predictions. Ball is also involved in bidding for an International Mathematics Institute in Edinburgh. This will be the first of its kind in the UK, and will have major implications to mathematical research in this country. Other contenders include Cambridge, Oxford, Warwick and the University of London. The imminent establishment of an International Institute of Mathematics will have tremendous impact on mathematical sciences research in the UK and Europe. We should watch this development with great care, and explore opportunities to leverage the activities of the proposed institute.

At the University of Strathclyde, Professor G. Roach described his work on reaction-diffusion equations and scattering theory. His basic approach utilizes appropriate Green's functions and the study of integral equations that result from this process. He has been in touch with the relevant work on combustion at BRL and has also been in contact with scientists at MICOM. He plans to organize a workshop on nonlinear waveguides in 1991. This topic is of particular interest to scientists at MICOM. (Mathematics and Physics Branch)

PARALLEL METHODS FOR LARGE-SCALE OPTIMIZATION PROBLEMS

Dr. Chandra visited Professor Dixon (Hatfield Polytechnic) to review his work on parallel methods for large-scale optimization problems. This work is supported by IST/SDIO through ERO Mathematics program. Large-scale optimization problems are at the core of a variety of Army and Space defense applications. Efficient and, in most cases, real-time solution of these problems is very critical. The principal thrust of Dixon's work is on the development of efficient-optimization algorithms for highly parallel computer architectures. These include DAP (distributed array proces-

sors) and transputer based medium size parallel systems. Ultimate aim is to push these methods towards massively parallel systems to achieve high speeds for real-time implementation of optimization problems involving thousands of variables and constraints. Dixon's work is primarily aimed at nonlinear problems. He has successfully implemented his truncated Newton algorithms in ADA language, which appears to be quite suitable for numerical differentiation of functions involved. He has designed an automatic differentiation package in ADA for the full Hessian matrices, particularly for sparse matrices. He has also successfully demonstrated the effectiveness and limitations of these methods on the concurrent computing systems. One of the annoying problems is the design of pre-conditioner in parallel implementation. He has been able to develop a sparse approximate inverse pre-conditioner for use on a parallel computer system. Professor Dixon is very productive with several publications in the past two years of support. He has also been successful in attracting very good research students.

Dr. Chandra also met with Dr. Paul Kaye, the research coordinator for the Division of Electrical Engineering at Hatfield. Dr. Kaye described several activities in his division that relate to image and signal processing and high performance computing. The work on medical systems research under the leadership of Dr. D. Maynard was particularly impressive. This work is largely concerned with the application of modern signal processing and analysis techniques to physiological signals with the aim of developing systems capable of assisting and improving diagnosis and treatment of patients. A particular and very impressive (but depressing) area of investigation is the analysis of electro-encephalographic (EEG) waveforms emitted by the brain using novel digital signal processing techniques, with a view to developing theoretical models and instrumentation for a variety of applications including, for example, the servo-assisted control of general anaesthesia, or the monitoring of fetal brain activity during labor. The statistics of likelihood of brain damage during general surgery, such as open heat, are very alarming. Insurance companies are very much interested in these investigations because they can use this information in mal-practice suits. Another area of interest was VLSI design of microchips, primarily for British Aerospace. The other activities worth monitoring were work on laser systems for particle analysis. The work is based upon extensive theoretical studies and mathematical modelling. Applications include laser-based pollution control devices and detectors for chemical and biological agents in the atmosphere.

The work on artificial speech recognition under the leadership of Mrs. J. Hewitt was also noteworthy. Their principal aim is to develop automated systems that can be used by the physically disabled. The work is moving towards implementation on transputer-based systems, making it almost

real-time. There appears to be good synergism between various research programs within mathematics and computer science. For instance, Dixon and his associates collaborate rather closely with the numerical analysis and applied mathematicians working on fluid flow problems or finite element analysis in various applications. In terms of hardware and computer architecture, clearly there is considerable slant towards transputer-based systems. (Mathematics and Physics Branch)

VISIT TO THE TECHNOLOGICAL UNIVERSITY OF DELFT AND THE UNIVERSITY OF PARIS (DAUPHINE)

Professor Dewilde heads the network and systems group in the Department of Electrical Engineering of the Network Theory Laboratory, University of Delft. Other areas of research thrusts in the department include control engineering, electronic materials, electromagnetic research and information theory. Dewilde's work is a nice integration of basic and applied research. Specifically, it is concentrated in the areas of fast and robust algorithms for analysis and modelling of signals, as well as the mapping of algorithms on VSLI structures, the development of VLSI design system tools centered around a central data base, and the VLSI design of carefully chosen signal processing chips. This total integration of activities makes it very attractive in many military applications. For instance, several candidate algorithms for signal processing are being investigated to be embedded in weapon systems. The strategic defense systems will, for example, comprise of complex set of weapons, sensors and command systems. Development, evaluation and integration activities, like those of Professor Dewilde, will be of considerable importance in this context. He is in contact with researchers at Stanford (particularly Professor T. Kailath's group). We should encourage and facilitate this interaction even further, as the payoffs of this collaboration could be very immense and directed at weapon system design. His colleague, Deprettere, is working on estimation of direction of arrival (DOA) and implementation of these algorithms on array processors. DOA algorithms are relevant to many applications including biomedical research, detection, acquisition and tracking, and seismological research.

CWI-Centrum Voor Wiskunde en Informatical (Center for Mathematics and Computer Science) was established in 1946 by the Netherland Organization for the Advancement of Research, which is its primary source of funding. The Center, however, seeks funds from other sources including industries. The Center involves more than 100 researchers and several short and long term visitors. Organizationally, the Center is divided into six departments representing various sub-areas of mathematical and computer sciences. There is a close working arrangement between the Center and two other premier research activities in Europe, namely INRIA (France) and GMD (Germany).

Among them they have many common projects in areas such as parallel computing, system engineering, scientific computing, and human computer interaction. A fellowship program is being implemented to attract promising young European researchers to spend time at these Centers. This consortium is interested in partial external support for this fellowship program. There can also be exchange programs developed between these Centers and those in the US, such as the Mathematics Sciences Institute at Cornell, Center for Intelligent Control Systems (MIT, Harvard and Brown), and the recently established Army High Performance Computing Research Center. Other areas of potential interest are sponsorship of workshops on topics such as stochastic geometry, and adaptive methods for partial differential equations.

The PI, Professor Ekeland, who until recently was the leader of CEREMADE, has been elected President of the University of Paris (Dauphine). However, this group remains very productive with very high quality work. For instance, Professor Lions continues to extend the applicability of viscosity-solutions to a variety of applications. A primary domain of application concerns the theory of optimal control and differential games for deterministic and stochastic evolutions. Other important applications include large deviations and homogenization problems. The other area of major concentration of this group relates to mathematical approaches to machine vision and image analysis. A particular and very promising approach is through wavelet transforms as developed by Professor Meyers and several of his students and associates. This is one of the strongest groups of applied mathematics in Europe, perhaps the strongest in the ERO's Mathematical Sciences program. (Mathematics and Physics Branch)

SOME RESEARCH GROUPS IN INDIA AND THE IEEE TENCON CONFERENCE IN BOMBAY

Dr. J. Chandra, Mathematics and Physics Branch, travelled to Bombay, Hyderabad and Bangalore, India, during 19-25 November 1989. The purpose of the trip was to visit research groups at Osmania University, Hyderabad, participate and chair sessions at the IEEE TENCON '89 Conference, Bombay, and to visit the Indian Institute of Science, Bharat Electronics and Center for Computing, Bangalore. The following paragraphs give a brief overview of his observations:

At Osmania University, the Research and Training Unit for Navigational Electronics is the focal point for research and training in the area of land, air and sea navigation in India. Specifically, the Center is funded by the Department of Electronics and the Indian Air Force. Areas of active research include array signal processing, antenna design and electromagnetic modeling, and terrain modelling. Computational facilities available to this group are quite meagre.

However, there is considerable interest in parallel processing to meet needs of these applications. Another area of significant interest is system identification, modelling and control. Some recent publications from this group cover topics such as modified linear prediction method for direction of arrival estimation of multiple plane waves, and a generalized technique for tracking manoeuvring targets.

The IEEE Region 10 (TENCON '89) Conference was held in Bombay, India. The theme of the conference was centered on information techniques with papers from Australia, Brazil, China, India, Japan, Singapore, Sweden, Taiwan, USA and USSR. The disciplines represented included computer science, computer and electrical engineering, and electronics. During the three-day conference, more than 200 papers were presented in about sixty technical sessions. The proceedings of the conference consisting of extended summaries of the presentation were distributed to the participants. Dr. Chandra was invited to organize and chair two of these sessions on the theory and applications of high performance computing. Other topics covered at the conference included AI and expert systems, image processing, optimization and neural networks, theoretical computer science, data communication networks, fault-tolerant computing, high speed LAN/WAN networking, robotic and automation, pattern recognition and database systems. The conference was preceded by a series of tutorials on topics such as expert systems, neural networks, object oriented programming and computer graphics.

By far the most fruitful technical interactions were in Bangalore. The Indian Institute of Science (ISS) is one of the premiere institutions of graduate studies and research in India. This is probably the oldest and finest centers for research and higher education in science and engineering in India. It has fine academic traditions and has always pursued excellence. The most distinguished feature of this Institute is that the research forms the main activity of the faculty (which is mostly resident on the campus) and the graduate courses are offered by the departments in an atmosphere of research and development. It has more than 40 departments and research centers. The student/faculty ratio is enviable; there are more than 450 faculty for just 1500 students. My interactions were mostly with the Department of Electrical and Communication Engineering. The areas of research of considerable interest were on parallel processing covering algorithms, architectures, languages and performance evaluation; system science covering adaptive and learning systems, stability-theory; computer vision covering computational study of both low and high level vision, automatic target recognition, medical imaging and computer aided tomography; communication theory and systems covering digital communication, spread spectrum and statistical theory of communication; and signal processing covering digital array processing, super resolution algorithms, spectral estimation algorithms and adaptive

filtering.

Bharat Electronics Limited (BEL) is a public sector activity whose interests range from fundamental research to system developments. It has two locations, one in Delhi and the other in Bangalore. The emphasis in Bamgalore is on information sciences. It employs more than 2,000 scientists and engineers, and has substantial interactions with Japan, Europe and USA. Briefings to Mr. Chandra by several scientists included examples of both short and medium (2-5 years) and long range (more than 5 years) projects in device modelling, signal processing and system theory.

The Center for Development of Advanced Computing (CDAC) is one of the few places where some serious work is going on in the area of high performance computing. The Center is under the able leadership of Dr. Paulraj, who is an active Navy Officer on loan to this organization. He has been able to attract a very young and first rate scientific staff which is dedicated to build this place into a premiere computing center in the country. He expressed considerable interest in developing close working relations with the Army High Performance Computing Center at the University of Minnesota. This interaction could be mutually beneficial. (Mathematics and Physics Branch)

BRITISH SCIENTIST VISITS BALLISTICS RESEARCH LABORATORY TO DISCUSS LIQUID PROPELLANTS

Professor F. J. Weinberg from the Department of Chemical Engineering, Imperial College, London, visited the Ballistics Research Laboratory (BRL) to present a seminar entitled "Centrifugal Force-Induced Flow Fields in Plasma Jets and Flames", and to discuss possible future avenues of research into liquid propellant ignition, based on opportunities arising from methods recently developed on research funds provided jointly by USARDSG-UK and BRL. A dilatometer has been constructed at Imperial College to allow measurement of the amount of decomposition (by the increase in gas volume) of a drop of propellant after ignition by a laser. The cavity may be filled with various gases to investigate their effect on the reaction, and also to coat a holder in the vicinity of the laser focus with parent substances which will release relevant decomposition products into the plasma. This should provide useful information for the study of recently proposed reaction mechanisms. (Aeronautics and Mechanics Branch)

BRITISH SCIENTIST VISITS THE BALLISTIC RESEARCH LABORATORY TO DISCUSS INSENSITIVE MUNITIONS RESEARCH

Drs. J.E. Field and P.M. Dickson of the Cavendish Laboratory, Cambridge University, visited BRL to discuss

recent progress on the BRL funded USARDSG-UK research effort entitled "Fracture and Explosive Properties of Reactive Materials" underway at their laboratory. Areas discussed included a) ignition mechanisms, b) drop-weight impact, c) fragment attack and d) techniques for measuring the mechanical properties of energetic materials over a wide range of strain rates. In addition, the scientists presented three papers (on research that had been supported by BRL/USARDSG-UK) at the Ninth Symposium on Detonation, Portland, Oregon. (Aeronautics and Mechanics Branch)

OPTICAL GRATINGS FOR LASER DEFLECTION.

The final report form Cambridge Consultants Ltd., on Contract DAJA45-88-C-0014 describes the design, development and manufacture of a custom transmission diffraction grating with specific optical characteristics. The prime requirement was that the grating should exhibit a low zero-order optical transmission near-infrared waveband. It was also desirable that the grating should have a high laser damage threshold.

The development work showed first that it was impractical to attempt to meet the requirement with a conventional blazed grating because of major fabrication problems associated with the very large groove angle which would be needed. Next, it was established that a transmission grating with a sinusoidal groove profile could in principle achieve the desired performance. Such gratings are normally fabricated in photoresist using an interferometric technique, but such gratings generally have low laser damage thresholds. Moreover, the required groove amplitude was somewhat larger than can be easily achieved using the interferometric technique. For these reasons, the preferred grating fabrication approach which was finally adopted was to use reactive ion etching to transfer a quasi-sinusoidal groove profile into the surface of a "hard" substrate such as fused silica. Differential etch rates were exploited to achieve a larger groove amplitude in the etched grating than in the photoresist "mask". The best of the custom gratings exhibited a zero-order transmission which did not exceed 6% over the wavelength range 543nm-875nm. This result was in reasonably good agreement with a theoretical analysis of the zero-order transmission characteristics of surface relief gratings.

The main conclusion of the work was that a deep-grooved surface relief transmission diffraction grating can provide a broad-band optical attenuation of around 95% across visible and near-infrared waveband. The use of reactive ion etching techniques can enable the production of such gratings with high laser thresholds. These gratings were evaluated by another ERO contractor, Prof. D. DasGupta at the University College, North Wales, and Dr. R. Shuford at US Army Materials Technology Laboratory. Final report is available from DTIC. (Materials Science Branch).

IV. BOARD APPROVED RESEARCH CONTRACTS - FY90

P.I. NAME	INSTITUTION	TITLE	R&D NUMBER
PROF. M. GRATZEL	EPFL, LAUSANNE, SWITZERLAND	CATALYTIC AGENT DEGRADATION	6305-CH
DR. B. WEISS	UNIVERSITY OF SURREY, UK	ION BEAM MIXING IN MQW STRUCTURES	6170-EE
DR. W. JONES	UNIVERSITY OF CAMBRIDGE, UK	SYNTHESIS AND CHARACTERIZATION OF SUPPORTED ELECTRO-OPTICALLY ACTIVE MATERIALS	6404-EE
DR. P.A. CARLING	FRESHWATER BIOLOGICAL ASSOC.	PARTICLE DYNAMICS AND GRAVEL STREAM-BED ADJUSTMENTS	6185-EN
PROF. R. PEARCE	UNIVERSITY OF READING, UK	COORDINATION OF MESOSCALE METEROLOGICAL RESEARCH	6323-EN
PROF. J. WHITEMAN	BRUNEL UNIVERSITY, UK	FINITE ELEMENT METHODS FOR SOLID MECHANICS	6078-MA
PROF. E. PARDOUX	INRIA, FRANCE	NONLINEAR FILTERING AND APPROXIMATION TECHNIQUES	6271-MA
DR. D. AVNIR	HEBREW UNIVERSITY OF JERUSALEM, ISRAEL	NOVEL ORGANIC/INORGANIC PHOTOACTIVE MATERIALS	5548-MS
PROF. R. REISFELD	HEBREW UNIVERSITY OF JERUSALEM, ISRAEL	TUNABLE LASER MATERIAL	5884-MS
PROF. A. KELLER AND DR. J. ODELL	UNIVERSITY OF BRISTOL, UK	HIERARCHIAL STRUCTURE IN ADVANCED POLYMERS	6011-MS
DR. P. ROGL	UNIVERSITY OF VIENNA, AUSTRIA	COMPENDIUM OF TERNARY PHASE DIAGRAMS OF METAL-B-NI AND METAL-SI-NI	6092-MS

V. FY90 CONFERENCES

DATE	P.I. NAME	INSTITUTION	CONFERENCE TITLE	LOCATION	R&D NUMBER
4-6 JAN '90	DR. K. KUNC	UNIVERSITE P.& M. CURIE	TOTAL ENERGY METHODS AND PHYSICS OF III-V SEMICONDUCTORS	PARIS, FRANCE	6230-EE
29 JAN-2 FEB '90	DR. T. BRICHETEAU	INRIA	9TH INTERNATIONAL CONFERENCE ON COMPUTING METHODS IN APPLIED SCIENCES AND ENGINEERING	PARIS, FRANCE	6371-MA
16-23 MAR '90	DR. D. CAILLARD	CENTRE D'ELABORATION de MATERIAUX	MECHANISM OF DEFORMATION AND THE STRENGTH OF ADVANCED MATERIALS	AUSSOIS, FRANCE	6321-MS
2-4 APR '90	DR. K. HENRIKSEN	UNIVERSITY OF TROMSO	INTERNATIONAL SYMPOSIUM ON CLIMATES OF THE NORTHERN LATITUDES: PAST, PRESENT, FUTURE	TROMSO, NORWAY	6373-EN
16-27 APR '90	PROF. M.V. HEITOR	INSTITUTO SUPERIOR TECNICO	NATO ASI ON COMBUSTING-FLOW DIAGNOSTICS	ALGARVE PORTUGAL	6416-AN
24-27 APR '90	PROF. J. WHITEMAN	BRUNEL UNIVERSITY	7TH CONFERENCE OF FINITE ELEMENTS AND APPLICATIONS	UXBRIDGE, UK	6258-MA
12-19 MAY '90	PROF. J. HOSCHEK	TECHNISCHE HOCHSCHULE DARMSTADT	TOPICS IN CAGD 1990	ERICE TRAPANI SICILY	6388-MA

V. FY90 CONFERENCES CONT/....

DATE	P.I. NAME	INSTITUTION	CONFERENCE TITLE	LOCATION	R&D NUMBER
28-30 MAY '90	DR. A. DANCER	INSTITUTE FRANCO-ALLE MAND de RECHERCHES	SYMPOSIUM ON NOISE-INDUCED HEARING LOSS	BEAUNE, FRANCE	6377-BC
21-27 JUN '90	PROF. A. LE MEHAUTE	UNIVERSITE DES SCIENCES ET TECHNIQUES de LILLE	INTERNATIONAL CONFERENCE ON CURVES AND SURFACES	CHAMONIX, FRANCE	6367-MA
25 JUN-7 JUL '90	DR. L. PARETTI	INSTITUTE MASPEC del CNR	NANOSTRUCTURED MAGNETIC MATERIALS	CRETE, GREECE	6418-MS
2-6 JUL '90	PROF. B.D. SLEEMAN	UNIVERSITY OF DUNDEE	10TH CONFERENCE ON THEORY OF ORDINARY AND PART-IAL DIFFERENTIAL EQUATIONS	DUNDEE, SCOTLAND, UK	6411-MA
8-14 JUL '90	PROF. J. JIMINEZ	UNIVERSIDAD POLITECNICA MADRID	THE GLOBAL GEOMETRY OF TURBULANCE	ROTA, SPAIN	6417-AN
8-14 JUL '90	DR. F. KAPPEL	UNIVERSITY OF GRAZ	CONTROL AND ESTI-MATION OF DISTRIB-UTED PARAMETER SYSTEMS	STYRIA, AUSTRIA	6425-AN
9-12 JUL '90	PROF. D.F.G. DURAO	INSTITUTO SUPERIOR TECHNICO	5TH INTERNATIONAL SYMPOSIUM ON APP-LICATIONS OF LASER ANEMOMETRY TO FLUID MECHANICS	LISBON, PORTUGAL	6426-AN

V. FY90 CONFERENCES CONT/....

DATE	P.I. NAME	INSTITUTION	CONFERENCE TITLE	LOCATION	R&D NUMBER
30 JUL-10 AUG '90	PROF. J. MARSH	UNIVERSITY OF GLASGOW	NATO ASI IN WAVE-GUIDE OPTOELEC-TRONICS	GLASGOW, SCOTLAND, UK	6414-EE
28-31 AUG '90	PROF. A.H. CARDON	VRIJE UNIVERSITY BRUSSELS	DURABILITY OF POLY-MER BASED COMPOSITE SYSTEMS FOR STRUC-TURAL APPLICATIONS	BRUSSELS, BELGIUM	6183-MS
4-7 SEP '90	PROF. D. DOWSON & DR. C.M. TAYLOR	UNIVERSITY OF LEEDS	17TH LEEDS-LYON SYMPOSIUM ON TRIBOLOGY	LEEDS, UK	6415-AN

VI. FY90 WORKSHOPS

DATE	P.I. NAME	INSTITUTION	TITLE	LOCATION	R&D NUMBER
26-28 MAR '90	PROF. D. BLOOR	UNIVERSITY OF DURHAM	PROGRESS TOWARDS MOLECULAR SCALE ELECTRONICS	DURHAM, UK	6332-CH
2-3 JUL '90	PROF. J.H. WHITELAW	IMPERIAL COLLEGE	UNSTEADY FLOWS	LONDON, UK	6314-AN
2-4 JUL '90	PROF. B.L. WEISS	UNIVERSITY OF SURREY	MULTIQUANTUM WELL MIXING FOR OPTICAL DEVICES	COMO, ITALY	6343-EE
6-8 SEP '90	PROF. D. MAYSTRE	UNIVERSITY OF MARSEILLE	MODERN ANALYSIS OF SCATTERING PHENOMENA	MARSEILLE,	6236-EE

VII. CONTRACT REPORTS RECEIVED

AUTHOR(S)	TITLE	TYPE OF REPORT
G. BINDER	EXPERIMENTAL INVESTIGATION OF RETARDED UNSTEADY TURBULENT BOUNDARY LAYERS	FIFTH INTERIM (4922-AN-01)
J.E. FIELD	DEFORMATION, FRACTURE AND EXPLOSIVE PROPERTIES OF REACTIVE MATERIALS	SECOND INTERIM (6112-AN-01)
A.F. ALLISTON-GREINDER & J.A. GREENWOOD	BASIC MECHANICS OF DIESEL LUBRICATION CORRELATION OF BENCH AND ENGINE TESTS	THIRD IMTERIM (5305-AN-01)
G. KLINGENBERG & H. ROCKSTROK	INVESTIGATION OF HIGHLY PRESSURIZED TWO-PHASE REACTING FLOW	FOURTH INTERIM (5708-AN-01)
A.F. ALLISTON-GREINER, J.A. GREENWOOD, D. CAMERON & A. CAMERON	BASIC MECHANICS OF DIELSEL LUBRICATION CORRELATION TO BENCH AND ENGINE TESTS	SECOND INTERIM (5003-AN-01)
C.N. MARCH	4TH U.S. ARMY WORKSHOP ON LOW HEAT REJECTION ENGINES (29-31 Mar 88, Leeds, UK)	INF CONF PROC (6149-AN-03)
H. REICHENBACH & K. OPALKA	AN OPTICAL STUDY OF FLOW START UP IN A CONVERGENT - DIVERGENT NOZZLE	FIRST INTERIM (6229-AN-01)
F.B. CARLETON, K. KRALLIS & F.J. WEINBERG	LASER INITIATED IGNITION OF LIQUID PROPELLANT	FIFTH INTERIM (5462-AN-01)
R. HANSEN, E. BACKOF & H.E. de GREIFF	PROCESS FOR ASSESSING THE STABILITY OF HAN-BASED LIQUID PROPELLANTS	FINAL REPORT (5554-AN-01)
A. CAMERON	BASIC MECHANICS OF DIESEL LUBRICATION CORRELATION OF ENGINE TESTS	DRAFT FINAL (5305-AN-01)

F.B. CARLETON, K. KRALLIS & F.J.	LASER INITIATED IGNITION OF LIQUID PROPELLANT	FIFTH INTERIM (5462-AN-01)
G.E.A. MEIER, H.H. BARTELS, H.M. LENT & K.F. LOHR	NOISE GENERATION AND BOUNDARY LAYER EFFECTS IN VORTEX-AIR FOIL INTERACTION AND METHODS OF DIGITAL HOLOGRAM ANALYSIS FOR THESE FLOW FIELDS	FIFTH INTERIM (5749-AN-01)
P.N.R. USHERWOOD & E.A. BARNARD	STRUCTURAL AND BIOPHYSICAL CHARACTERIZATION OF A GLUTAMATE RECEPTOR	SECOND INTERIM (5937-BC-01_
D. LANCET	IDENTIFICATION AND MOLECULAR CLONING OF OLFACTORY RECEPTOR PROTEINS	FOURTH INTERIM (5926-BC-01)
I. SA CORREIA	BIOTECHNOLOGY AND BIODEGRADATION WORKSHOP (19-23 Jun 89, Sabugo, Portugal)	INF CONF PROC
M. SHOHAN & J. SUSMAN	STRUCTURAL ANALYSIS OF PROTEINS IN EXTREME SALINE ENVIRONMENTS	FINAL REPORT
R. KASINATHAN	ISOLATION, PURIFICATION AND CHARACTERIZATION OF TOXIN FROM SNAIL CONUS	FIRST INTERIM
Y. BIRK & S.W. APPLEBAUM	PROTEASES OF STORED PRODUCT INSECTS AND THEIR INHIBITION BY SPECIFIC PROTEASE INHIBITORS FROM SOYBEANS AND WHEAT GRAIN	SIXTH INTERIM (5383-BC-01)
M.H. ABRAHAMS & G.S. WHITING	A NEW METHOD FOR THE CHARACTERIZATION OF SOLUTES AND SOLVENTS PHASES USING SOLVATOCHROMIC PARAMETERS	FIFTH INTERIM (5390-CH-01)
D. PHILLIPS	ENERGY MIGRATION, MOTION AND ORDER IN SYNTHETIC POLYMERS	FIFTH INTERIM (5718-CH-01)
A. LATTES & M.T. MAURETTE	CHEMICAL AND PHOTOCHEMICAL REACTIVITY IN MICROEMULSIONS AND WATERLESS MICROEMULSIONS	FINAL REPORT (5037-CH-01)

E. PELED	ADVANCED CALCIUM-THIONYL CHLORIDE HIGH-POWER BATTERY	FIRST INTERIM (5899A-CH-01)
E. ENGEL	INVESTIGATION OF THE PHASE STABILIZING EFFECT OF POTASSIUM FLUORIDE ON AMMONIUM NITRATE	FINAL REPORT (5955-CH-01)
G. CECCARELLI	NATO ADVANCED STUDY INSTITUTE ON CHEMISTRY AND PHYSICS OF THE MOLECULAR PROCESS IN ENERGETIC MATERIALS	PRE CONF LIT (6174-CH-02)
C. GABRIELLI	INTERNATIONAL SYMPOSIUM ON ELECTROCHEMICAL IMPEDANCE SPECTROSCOPY (22-26 May 89, Bambannes, France)	INF CONF PROC (6204-CH-02)
F. VOLK	3RD INTERNATIONAL SYMPOSIUM ON ANALYSIS AND DETECTION OF EXPLOSIVES	INF CONF PROC (6274-CH-02)
N.N. GREENWOOD	KINETICS OF BORON HYDRIDE INTERCONVERSION REACTIONS	FINAL REPORT (5004-CH-01)
M. GRATZEL	AGENT DEGRADATION VIA CATALYTIC AND PHOTOCATALYTIC REACTIONS ON SURFACES AND IN ORGANIZED ASSEMBLIES	FINAL REPORT (5504-CH-01)
A. HOLMES-SEIDLE	THE USE OF RADFETS IN RADIATION DOSE MEASUREMENT	FINAL ERPORT (5764-CH-01)
E. PELED	ADVANCED CALCIUM-THIONYL CHLORIDE HIGH-POWER BATTERY	SECOND INTERIM (5899A-CH-01)
W. ENGEL	INVESTIGATION OF THE PHASE STABLIZING EFFECT OF 4% POTASSIUM FLUORIDE ON AMMONIUM NITRATE	FINAL REPORT (5955A-CH-01)
C. TROYANOWSKY	WORKSHOP - MODELING OF MOLECULAR STRUCTURES AND PROPERTIES IN PHYSICAL CHEMISTRY AND BIOPHYSICS	INF CONF PROC (6178-CH-01)

P. VON RAGUE SCHLEYER	POLYHALOGENATED CAGE MOLECULES	FIRST INTERIM (6190-CH-01)
M.F.A. DOVE, N. LOGAN & J.P. MAUGER	CORROSION OF ALLUMINIUM ALLOYS BY IRFNA	FIRST INTERIM (6286-CH-01)
B. HENDERSON	LASER SPECTROSCOPY OF QUANTUM WELL AND SUPER-LATTICE STRUCTURES	FOURTH INTERIM (5782-EE-01)
J.S. ORR, H. GORDON & H. ORR	VANADIUM DIOXIDE PROTECTIVE DEVICES	FINAL REPORT (6060-EE-01)
A.K. JONSCHER, M.A. BARI & N. SIDDIQUE	DIELECTRIC SPECTROSCOPY OF SEMICONDUCTORS	FIFTH INTERIM (5119-EE-01)
R.A. LEE	2ND INTERNATIONAL CONFERENCE ON VACUUM MICRO-ELECTRONICS (24-26 Jul '89, Bath, UK)	INF CONF PROC (6158-EE-02)
J. MAGARSHACK	13TH WORKSHOP ON COMPOUND SEMICONDUCTOR DEVICES AND INTEGRATED CIRCUITS (10-12 May '89, Cabourg, France)	INF CONF PROC (6132-EE-02)
J.C. DAINTY	ENHANCED BACKSCATTERING FROM ROUGH SURFACES	FIFTH INTERIM (5830-EE-01)
J.R. BIRCH	WORKSHOP ON NEAR MILLIMETER WAVELENGTH MEASUREMENT TECHNIQUES	INF CONF PROC (5342-EE-03)
A. VECHT	THE PREPARATION OF ACEL THIN FILMS	FIFTH INTERIM (5910B-EE-01)
G.E.A. MEIER & P.A. THOMPSON	INTERNATIONAL UNION OF THEORETICAL AND APPLIED MECHANICS - SYMPOSIUM ON ADIABATIC WAVES IN LIQUID-VAPOR SYSTEM (28 Aug-1 Sep '89)	ABSTRACTS OF CONTRIBUTED PAPERS (6116-EE-02)
B.L. WEISS	ION BEAM IN MULTI-QUANTUM WELL STRUCTURES	FIRST INTERIM (6170-EE-01)
	WORKSHOP ON HYDROGEN EFFECTS IN InP AND RELATED COMPOUNDS	ABSTRACTS (6237-EE-03)

M. PEPPER	PHYSICS RELATED TO FUTURE ELECTRONIC DEVICES	THIRD INTERIM (5940-EE-01)
J.O. WILLIAMS, L.E. DAVIS, R.W. MUNN, J.H.R. CLARKE & T.A. KING	MOLECULAR FILMS FOR OPTO-ELECTRONICS	FIRST INTERIM (6290-EE-01)
A.K. JONSCHER, M.A. BARI & N. SIDDIQUI	DIELECTRIC SPECTRO-SCOPY OF SEMICONDUCTORS	SIXTH INTERIM (5119-EE-01)
S.G. JENNINGS	VOLATILITY OF AEROSOLS IN THE WESTERN EUROPEAN ENVIRONMENT	SIXTH INTERIM (5586-EN-01)
R.P. PEARCE	CO-ORDINATION OF MEO-SCALE METEROLOGICAL RESEARCH BETWEEN ASL AND EUROPEAN GROUPS	FINAL REPORT (5735-EN-01)
F. BORGHESE & V. GRASSO	THE OPTICAL PROPERTIES OF AEROSOLS	FIFTH INTERIM (5318-EN-01)
A. TORUM	MODEL TESTS ON THE CERC FULL SCALE TEST FLOAT-ING BREAKWATER	FINAL REPORT (4907-EN-01)
H. FUGER, H. KAZXMIERCZAK, K. LUTEN, B. NICDEN, W. OTT & M. STEIZ	AUTOMATIC LINE NETWORK EXTRACTION FROM AERIEL IMAGERY OF URBAN AREAS THROUGH KNOWLEGDE-BASED IMAGE ANALYSIS	DRAFT FINAL (5679-EN-01)
R.P. PEARCE	PROJECT WIND - EXPERI-MENTS WITH THE UK METEOROLOGICAL OFFICE MESOSCALE MODEL	FINAL REPORT (5733-EN-01)
E. GRAFAREND	STUDY OF MODERN INSTRU-MENTATION AND METHODS FOR ASTRONOMICAL POS-ITIONING IN THE FIELD	FINAL REPORT (4618-EN-01)
S.G. JENNINGS	INTERNATIONAL CONFER-ENCE ON AEROSOL AND BACKGROUND POLLUTION (13-15 Jun'89, Galway, Ireland)	CONFERENCE ABSTRACTS (6061-EN-02)
H. HANSEN	NUMERICAL MODEL OF TWO DIMENSIONAL BEACH CHANGE	FINAL REPORT (5989-EN-01)

A. GRUEN	ON-LINE POSITIONING WITH SINGLE FRAME CAMERA DATA	SECOND INTERIM (5366-EN-01)
R. BELLOTTI & M. JAMIOLOWSKI	EVALUATION OF CPT AND DMT IN GUSHABLE AND SILTY SANDS	FIRST INTERIM (6134-EN-01)
O. SEUFFERT	2ND INTERNATIONAL CONFERENCE ON GEOMORPHOLOGY	ABSTRACTS (5454-EN-02)
J.O. PEARO	REPAIR WORKS FOR UPLIFT AND SEEPAGE CONTROL IN EXISTING CONCRETE DAMS	FINAL REPORT (5513-EN-01)
A.F. STOCK	DESIGN TEMPERATURES FOR FLEXIBLE AIRFIELD PAVEMENT DESIGN	FINAL REPORT (5852-EN-01)
G. RHETT, D.M.M. ADEMA, P. ROZA & R. HENZEN	APPLICATION AND INTERPRETATION OF BIOASSAY AND BIOMONITORING	FINAL REPORT (5906-EN-01)
G. STEPHENSEN	PERFORMANCE OF WEDGE SHAPED BLOCKS IN HIGH VELOCITY FLOW	SECOND INTERIM (5962-EN-01)
A.D. DEVIR & A. BEN-SHALOM	'SPOT'	SECOND INTERIM (5981-EN-01)
S. ARESKOUG	4TH EUROPEAN CONFERENCE ON INTERNATIONAL SOCIETY FOR TERRAIN VEHICLE SYSTEMS (21-23 Mar '89, Wagenuegen, W. Germany)	INF CONF PROC (6135-EN-02)
W.D. LIAM-FINN	3-D NONLINEAR HYSTERETIC DYNAMIC EFFECTIVE STRESS ANALYSIS	FIRST INTERIM (6197-EN-01)
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M.F. MASUCH	PATTERN RECOGNITION USING NEURAL NETWORKS: OPTIMAL TESTING OF PERCEPTORS	THIRD INTERIM

M. THERA & J.B. BAILLON	INTERNATIONAL CONFERENCE ON FIXED POINT THEORY AND RELATED TOPICS (5-10 Jun '89, Cime, France)	INF CONF PROC (6117-MA-02)
L.C.W. DIXON, Z.A. MAANY & M. MOSHENINIA	OPTIMIZATION ALGORITHMS FOR HIGHLY PARALLEL COMPUTER ARCHITECTURES	FIFTH INTERIM (5850-MA-01)
M.R. BATHE, K.R. MCNAUGHT & S.R. BELTON	DEVELOPMENT OF A COMBAT MODEL WITH A MINI-BATTLE STRUCTURE	SECOND INTERIM (6036-MA-01)
I. EKELAND	ANALYSIS, CONTROL AND FILTERING OF SYSTEMS FROM PHYSICS AND ENGINEERING	FOURTH INTERIM (5801-MA-01)
J.R. WHITEMAN	USE AND ANALYSIS OF FINITE ELEMENT METHODS FOR PROBLEMS OF SOLID MECHANICS AND FRACTURE	FIRST INTERIM (6078-MA-01)
P.L. LIGION	ANALYSIS, CONTROL AND FILTERING OF SYSTEMS FROM PHYSICS AND ENGINEERING	FIFTH INTERIM (5801-MA-01)
P.R. FISK	NON-SMEAR TIME SERIES ANALYSIS AND APPLICATION (12-25 Jul '89, Edinburgh, Scotland, UK)	FINAL REPORT (6219-MA-02)
F.L. BAUER	INTERNATIONAL SUMMER SCHOOL ON LOGIC, ALGEBRA AND COMPUTATION (25 Jul-6 Aug '89, Marktoberdorf, W. Germany)	INF CONF PROC (6267-MA-02)
A. KELLER	HIERARCHICAL STRUCTURE IN POLYMERIC SOLIDS AND ITS INFLUENCE ON PROPERTIES	FINAL REPORT (4794-MS-01)
G.D.W. SMITH	36TH INTERNATIONAL FIELD EMISSION SYMPOSIUM (30 Jul-4 Aug '89, Oxford, UK)	INF CONF PROC (6312-MS-02)

A.M. CAMPBELL & M.F. ASHBY	THE EFFECT OF TWINS ON CRITICAL CURRENTS OF HIGH Tc SUPERCONDUCTORS	FOURTH INTERIM (5909-MS-01)
P. FREER	THE PHYSICS AND CHEMISTRY OF CARBIDES, NITRIDES AND BORIDES WORKSHOP (18-22 Sep '89, Manchester, UK)	INF CONF PROC (6281-MS-02)
A. LORTHOIR	ELECTRODEPOSITION OF DENSE CHROMIUM COATINGS FROM MOLTEN SALT ELECTROLYTES	FOURTH INTERIM (5685-MS-01)
J. FIDLER	ANISOTROPHY AND MICROSTRUCTURE OF HIGH COERCIVITY RARE EARTH IRON PERMANENT MAGNETS	FINAL REPORT (5295-MS-01)
D.G. BRANDON	PARTICULATE CERAMIC MATRIX COMPOSITES FOR HIGH STRAIN RATE PERFORMANCE	FOURTH INTERIM (5544-MS-01)
J. BERNSTEIN, J.Y. BECKER, S. BITTNER & S.S. SHAIK	ELECTRICALLY CONDUCTING ORGANIC MATERIALS: DESIGN, SYNTHESIS AND CHARACTERIZATION	FOURTH INTERIM (5618-MS-01)
S. WINKLER, H. SENF & H. ROTHENHAUSER	WAVE AND FRACTURE PHENOMENA IN IMPACTED CERAMICS	FINAL REPORT (5823-MS-01)
A.J. KINLOCH & G.K.A. KODAKIAN	THE ADHESIVE BONDING OF THERMOPLASTIC COMPOSITES	FINAL REPORT (5553-MS-01)
M.J.P. PAYNE	INVESTIGATION OF SOLID STATE LASERS AND MATERIALS	THIRD PROGRESS (6275-MS-06)
T.R. EMPSON	CUSTOM DIFFRACTION GRATINGS	FINAL REPORT (5970-MS-01)
S. HAMPSHIRE	THE PREPARATION AND CHARACTERIZATION OF OXYNITRIDE GLASSES AND GLASS CERAMICS	FINAL REPORT (4881-MS-01)
S. ELIEZER & J. GILATH	SPALLATION AND DYNAMIC FRACTURE AS AN EFFECT OF LASER INDUCED SHOCK WAVES IN CARBON BASED COMPOSITE MATERIALS	FINAL REPORT (5528-MS-01)

W.H. ROBERTS	ADVANCED TRIBOLOGICAL COATINGS FOR HIGH SPECIFIC STRENGTH ALLOYS	FIFTH INTERIM (5876-MS-01)
D.K. DAS-GUPTA	MODIFICATION OF THE ELASTOMER TEST MACHINE	SECOND INTERIM (6101-MS-01)
A.H. CARDON	INTERNATIONAL CONFERENCE ON DURABILITY OF POLYMER BASED COMPOSITE SYSTEMS FOR STRUCTURAL APPLICATIONS (ANALYSIS AND PREDICTION) (28-31 Aug '89, Brussels Belgium)	PRE CONF LIT (6183-MS-02)
P.B. HIRSCH	VITH INTERNATIONAL SYMPOSIUM ON THE STRUCTURE AND PROPERTIES OF DISLOCATIONS IN SEMICONDUCTORS (5-8 Apr '89, Oxford, UK)	INF CONF PROC (6184-MS-02)
P. FREER	NATO ASI WORKSHOP ON 'THE PHYSICS AND CHEMISTRY OF CARBIDES, NITRIDES AND BORIDES (18-22 Sep '89, Manchester, UK)	INF CONF PROC (6281-MS-02)
A.J. KINLOCH, B. BLACKMAN & J.P. DEAR	THE ENVIRONMENT AND IMPACT RESISTANCE OF ADHESIVITY BONDED THERMOPLASTIC FIBRE - COMPOSITES	FIRST INTERIM (6266-MS-01)
H.J. SALZBERGER	EMAT - SYSTEM FOR ULTRASONIC VARIETY	FINAL REPORT (5932-PH-01)
D.M. ROWE	PRELIMINARY INVESTIGATION INTO THE EFFECT OF HIGH TEMPERATURE THERMAL ANNEALS ON THE FIGURE OF MERIT OF SILICON GERMANIUM ALLOYS	SECOND INTERIM (6106-PH-01)
J.J.H. MILLER	NASECODE CONFERENCE	INF CONF PROC (6245-PH-02)
E. TOSATTI	CONFERENCE - COMPUTATION IN PHYSICS AND PHYSICS IN COMPUTATION (5-9 Sep '89, Trieste, Italy)	INF CONF PROC (6264-PH-02)

G. CASATI	CHAOTIC BEHAVIOUR IN QUANTUM DYNAMICS	FOURTH INTERIM (5653-PH-01)
A. BOARDMAN	NATO ASI CONFERENCE 'NON-LINEAR WAVES IN SOLID STATE PHYSICS' (1-15 Jul '89, Sicily, Italy)	INF CONF PROC (6250-PH-02)
D.M. ROWE	EXPERIMENTAL INVESTIGATION INTO THE EFFECT OF LONG TERM THERMAL ANNEALS ON THE THERMOELECTRIC PROPERTIES OF SILICON-GERMANIUM-GALLIUM-PHOSPHIDE	FIRST INTERIM (6255-PH-01)

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