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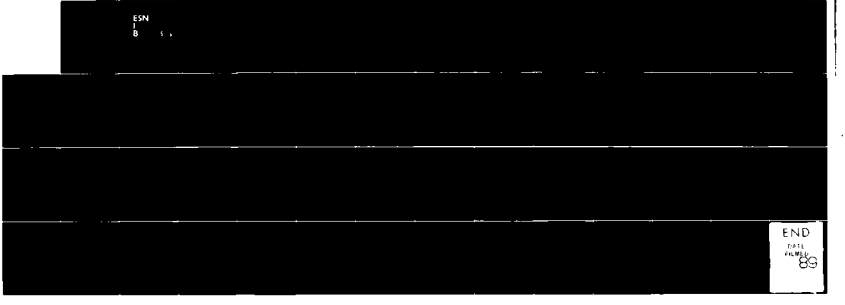

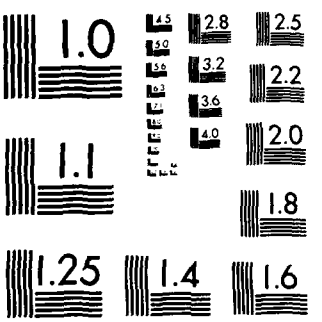

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This publication is approved for official dissemination of technical and scientific information of interest to the Defense research community and the scientific community at large

Commanding Officer ..... CAPT Terry J. McCloskey, USN
Scientific Director ..... James E. Andrews
Editor ..... C.J. Fox

BEHAVIORAL SCIENCES

The Center for Research in Cognitive Psychology, located at the University of Provence in Aix-en-Provence, is the largest of all France's CNRS-supported psychology research groups. The author sets the context for, and describes the nine major research themes that will guide the Center's researchers into the 1990's.

BIOLOGICAL SCIENCES

The consensus conclusion of this meeting held in February 1988 in London, England, was that practical application of neural networks will be within the next 5 years. The author gives brief summaries of the papers presented under the 11 different topics of the meeting's scientific program.

Presentations at this conference, held in December 1987 in London, England, are briefly summarized. The presentations covered the entire range of drug delivery and drug targeting systems.

COMPUTER SCIENCES

Activities in the various research areas of this center, located at Fountainbleau, France, are briefly reviewed. The areas are: optimization and large complex systems, nonlinear control and filtering, parallel computer architecture, self-structuring data bases and large data bases, and adaptive control.

Research activities of four of the university's Department of Computer Science professors are briefly described.

FLUID MECHANICS

The activities and some of the facilities of the Swiss Federal Technical University's Fluid Mechanics Institute and its Institute for Energy Technology are discussed. The author is impressed by the strong connection between the research at the university and the industrial base in Switzerland.

MATERIALS SCIENCES

PHYSICS

NEWS, NOTES, AND ABSTRACTS

BEHAVIORAL SCIENCES

France's Center for Research in Cognitive Psychology

by William Crano. Dr. Crano is the Liaison Scientist for Psychology in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Texas A&M University, where he is a Professor of Psychology.

The Centre Nationale de la Recherche Scientifique (CNRS) is France's principal agency for the support of scientific research. In American terms, the importance of the CNRS for funding psychological research can be compared with that of the National Science Foundation, Office of Naval Research, and National Institute of Mental Health all rolled into one. It is no exaggeration to say that in France, when CNRS sneezes, psychology contracts pneumonia.

The Center for Research in Cognitive Psychology (hereafter, the Center) is the largest of all of the CNRS-supported psychology research groups, having received support from the funding body for the past 20 years. Its home is the University of Provence in Aix-en-Provence. It is directed by the social psychologist Jean-Paul Codol. In 1987, the Center's staff included 45 researchers, 20 paid directly by CNRS, and 25 by the university (a form of cost sharing). In addition, 35 research assistants were employed there. It is my intention in this report to discuss briefly the main research themes under investigation in the Center. As will become apparent, although directed by a social psychologist, the program of work undertaken in France's largest psychology center ranges across the spectrum of human cognition. This presentation is meant both to inform the reader of current research interests and to foster interaction between researchers and the Center. As Codol said in an earlier discussion with me, the Center "would like to further develop its joint projects, both short and long term, with public and private organizations interested in its work, not only nationally but also internationally....Do not hesitate to contact us." As I will suggest later, this is not an idle invitation, but a conscious strategy aimed at maintaining the vitality and contribution of an important scientific resource.

The pages that follow hold descriptions of the major research themes that will guide the Center's researchers into the 1990's. To lend some continuity to this presentation, prior research that forms the bases of these new research directions also will be presented, along with the names of those primarily responsible for the conduct and outcome of the research. Finally, for the convenience of the reader, some representative publications of each research group will be cited, along with some others that help identify the central area of each group's work. Since Center personnel published more than 500 books and articles over the past 3 years, the publications cited will provide only a snapshot of the work undertaken in Aix-en-Provence.

Let us now move to a consideration of the major research groups active today in the Center.

Theme 1: Cognitive Functioning and Development: Formation Period – Elementary Logical Thought

From 1984 through 1987 the principal thrust of this research group, directed by Francine Orsini-Bouichou, was the study of the necessary and sufficient conditions that propelled infants from preoperational (alogical) cognitive levels to logical or "intuitive" thinking (cf. Orsini-Boichou and Paour, 1982). The idea developed in this group was that by teaching children general systems of rules, cognitive development could be accelerated. Research lent strong support to this hypothesis; indeed, learning general rule systems is considered to be a central feature of all development.

This theme is evident in the research to be conducted into the 1990's. The group of central interest is children from 3 to 8 years of age. Three fundamental questions are at issue in the research of the Cognitive Functioning and Development Group. First, studies will be undertaken to learn more about the general parameters of destabilizing phenomena. This search reflects a belief common in most stage theories of cognitive development that the organism must reach some form of impasse, and resolve the impasse, before it can progress to the next (higher) stage of thinking. In the case of the young child, this means that he or she must be exposed to a situation or problem that is not amenable to methods of solution that had been adequate in the past. By moving beyond previously successful (but probably inefficient) solutions, the child begins the tortuous ascent to logical thinking. Destabilization will be studied under a range of experimental conditions, in hopes of discovering the ways in which this process fosters cognitive growth.

A second research direction in this group is the study of the (cognitive) malleability of mentally retarded children through experimental intervention of their

rapid-eye-movement (rem) sleep. The researchers hope that by studying the reactions of mentally retarded children to variations in disruption of the sleep cycle, they will be able to understand better how this population of subjects functions cognitively – and subsequently, to be able to modify the manner of such functioning (cf. Paour, 1985).

A final research interest to be pursued in this group will involve the analysis of very slight modifications in behavior of normal children (via videotape recording) to study certain successive functional dominances during learning-sensitive periods. The extent to which a child attends to an adult or peer in a learning situation will be studied. Attempts will be made to investigate the link between the cognitive level of the child with (a) variations in attention, and (b) as a consequence of the requirements of the task.

Theme 2. Learning by Disjoint Inferences

In this work group, directed by Claude Bastien, researchers are concerned fundamentally with the relationship between developmental status and learning. In the earlier phase (1984-1987), research was focused on the evolution of methods by which children from 4 to 10 years of age solve logical problems (cf. Bastien, 1986; Bastien et al., 1986). The stability of strategies children employed, the effects of different methods of presentation of logical problems, and the understanding of negation in logical choice problems were studied.

The principle that guides much of the new work in this group is that knowledge acquisition is the outcome of a series of disjoint inferences that are organized into more or less efficient processing schemas. As the cognitive schemas become more and more automatic, they combine with other (automated) schemas to form higher order processing mechanisms.

Two general longitudinal research projects are planned in this group. In the first, the evolution of the use of logical operations will be studied; the second project will focus on learning (primarily learning of mathematics) in the school environment.

Theme 3. Social and Socio-Educational Regulation of Individual Cognitive Constructions

Michel Gilly, the director, and his group have been concerned with the refinement of a method that they believe can be made to accelerate children's cognitive development. The early research of this group was based on a popular European theoretical model that emphasized the importance of social and cognitive conflict in the developmental process (Mugny, 1985). However, in their new work, Gilly and his collaborators have attempted to move beyond the theory of sociocognitive conflict; in their view, conflict is not a necessary ingredient for accelerated cognitive growth.

In this research, young children are paired and asked to work collaboratively on problems that are typical of research in Piagetian developmental psychology (e.g., conservation of volume). The situations are constructed in such a manner that the children have a personal stake in the problem's solution. For example, in a diagnostic test of volume conservation, children are asked to compare the amounts contained in two vessels; but unlike typical conservation research, the containers are filled with small candies (vs. water), which the children may keep at the end of the experimental session. In this circumstance, children do conserve much earlier than Piaget would have expected, and with no conflict (for a detailed account of such a study, see *ESN* 41-4:178-181 [1987]).

Future research will focus on the nature of interactive problem solving, and on the social significance (for children) of the tasks under investigation. The role of social variables in task representation and problem solving will be stressed in the forthcoming research.

Theme 4. Social Cognition: Categories, Schemas, and Assimilation Processes

Early work undertaken by Jean-Paul Codol, the director, and his group was focused on the extension of some of the classic models and findings in cognitive social psychology. For example, studies were conducted to expand upon our understanding of:

- The implications and utilization of cognitive dissonance theory
- The application of the low-ball technique (Cialdini et al., 1978)
- The foot-in-the-door phenomenon, a very subtle (pressure-free) tactic of persuasion (cf. Crano and Sivacek, 1982).

A brief illustration of two of these research interests follows:

The low-ball technique is an interesting if unethical method of persuasion, whose use unfortunately is not completely unknown in sales and marketing. In the application of this technique, a product is offered for a ridiculously low price; however, upon acceding to the price, the prospective buyer is informed that a mistake has been made, and that a considerably higher price must be paid to obtain the product. Surprisingly, those who have been "low-balled," as this tactic is called, often prove much more willing to pay the high price than those who were not mislead in this fashion, and instead were quoted the true price initially. Many of us who have bought American automobiles, where the prices generally are not fixed, have experienced this tactic in action.

Codol showed that a variant of the technique could be used to control habitual behavior. He offered smokers a large incentive to abstain from smoking for 18 hours. All agreed. Then Codol backed down, and reduced the offer of payment to a trivial amount. Nonetheless, of those who had agreed initially, 95 percent actually refrained from smoking for the period requested. This compares with a 12.5-percent acquiescence rate in control group subjects who had not been given the initial offer, but who were treated in all other ways identically to the experimental group. How and why this tactic works as well as it does was investigated by Codol and his colleagues.

Codol also studied the foot-in-the-door phenomenon, a technique of persuasion that involves almost no pressure on the receiver, yet can prove very effective. In this method, a person is asked to perform a small service for another – essentially to acquiesce to a trivial request. Then, a more major favor is requested. Those who have received (and agreed with) the earlier, trivial, request are much more likely than those who had not received it to acquiesce with the later, more major one. In previous research, for example, people were telephoned and asked to answer a survey of approximately 2 minutes duration. Of course, all agreed. Three days later, these same people were called, ostensibly by a different organization, and asked to engage in social research that involved their driving to a somewhat distant locale, and being interviewed for 1-2 hours. These people were much more willing to do so than those who had not first received the trivial (2-minute) request 3 days earlier. In Codol's research, an attempt is being made to study the application of the foot-in-the-door phenomenon in a smoking-cessation clinic. Results to this point are not available, but it would be shortsighted to discount the likelihood of the study's success (cf. Joule, in press). Previous work on this phenomenon has produced some powerful results, even when involving behaviors that would not appear at first glance to be readily amenable to simple manipulation.

In addition to this work, Codol and his coworkers have mounted an intense experimental effort to understand the processes by which people define themselves in relation to others, and in the process, create, bolster, or change their cherished beliefs. Research has demonstrated that people tend to assume that others belong to the same category as themselves, but at the same time, they do not make the complementary assumption, that they belong to the same category as others. Understanding how and why this cognitive asymmetry operates could provide some very interesting information on the nature of social cognition. (Whether this is a uniquely French, or a more universal cognitive reaction, remains to be seen.) This work brings Codol and his group into the mainstream of social cognitive research on schemas, and promises to expand their already broad coverage of the field.

Theme 5. Psycholinguistics: Production and Comprehension of Language

In this very active group, directed by Joel Pynte, almost the entire range of psycholingusitic phenomena have come under investigation. Of this research, some of the most interesting has focused on semantic (cognitive) representation in bilinguals (cf. Frenck and Pynte, 1987a, 1987b). As these researchers explain, semantic representation is concerned with the question of whether there exists in memory several different representational systems, each specific to a particular surface form, or whether all possible physical and perceptive forms of a concept ultimately converge into a single cognitive representational system. In the case of bilinguals, the issue is whether there exists one representational system for the first language and another for the second, or whether, ultimately, a single cognitive meaning system subsumes both languages. Questions regarding the form of representational system are very important, since their solution will provide enormous insight into the nature of human cognitive processing.

In attacking this issue, Frenck and Pynte (1987b) tested French-English bilinguals in a lexical decision task. In this type of task, a word or picture is momentarily projected on to a video screen (for, say, 250 milliseconds). The word is called a prime. Its function is to activate that part of the subject's cognitive lexical system in which resides the target word, whose presentation follows the prime. The subject's job is to determine as rapidly as possible if the target is a real word. The central measure is the speed at which such a decision is made. (The target word generally remains on the screen until the decision is signaled.) To given an example: For some subjects, the prime "FRUIT" might be presented, followed by the target "PEAR." For other subjects, "FRUIT" might be followed by the target "KEAR." For yet others, only the target (PEAR or KEAR) would be presented. If a single system of representation operates, then a target-relevant prime should facilitate the decision and lower the time necessary to reach a decision, whereas those whose prime word was irrelevant to the target should produce decision times similar to those of subjects who received no prime.

In Frenck and Pynte's (1987b) research, the language of the prime and target words was systematically varied. Thus, some subjects received a French prime and an English target, others received the opposite order, while for others the prime and target were in the same language (either French or English, but not mixed). Additions to the experimental design included presence/absence – and relevance – of the prime, and the extent of the subject's experience in the second language (greater than

10 years in the country of the second language, or less than 4 years).

A number of interesting results were discovered in this experiment, but for present purposes, the most important of these were that significant priming effects occurred both within and across language conditions: primed targets were identified faster than unprimed target words irrespective of language similarity/dissimilarity of prime and target. However, upon closer inspection of the data, this result was found to hold most strongly in the less skilled bilinguals. Those who were extremely conversant in the second language (French) were less prone to show a priming effect. These results suggest that the priming phenomenon might not be an "automatic, effortless" process as some have hypothesized. Rather, conscious attention might be needed to take advantage of priming. Further research to be undertaken in this group will focus on issues of this type. It is important that strong evidence regarding the automatic versus conscious attentional processes debate be settled, because on its solution depends the answer to the semantic representation puzzle.

Theme 6. Social Influence and Social Representations

Without question, the two central issues in French social psychology over the past decade have been the influence of minority groups on a majority, and the nature of social representations. Since this latter topic has been discussed earlier in these pages (see *ESNIB* 88-01: 8-9, [1988]), it will not be treated here.

The influence of minority groups on the majority is interesting to an American audience for a number of reasons:

- It is apparent that minorities can influence majorities. The "voice crying out in the wilderness" *can* change things.
- The focus on minority influence is at variance with the bulk of American research on social influence, which typically has been concerned with the impact of the majority on minorities.
- The study of minority influence holds the promise of enlarging our vision of the entire process of persuasion, of transforming the study from the micro (or individualistic) to the macro (or societal) level of analysis.

Previous, and very controversial, research on minority influence has purported to show that under appropriate conditions, minorities could influence not only the attitudes of minority group members, but even fundamental perceptual processes (Moscovici, et al., 1985; Moscovici and Personnaz, 1986). There is controversy in this field because of the failure of some later research to replicate these findings. Accordingly, new research in the Center will focus on bolstering the validity of the minority group influence effect, to specify more concretely the conditions under which "conversion" phenomena occur.

The new work on social representations, directed by Serge Moscovici, will address, among others, the diffusion of social theories (in this case, Marxism) and the representation of the environment by scientists and laymen. How people come to structure and know the social and physical world is the central issue of research on social representations.

Theme 7. Cognitive Dynamics of Identity Construction and Functioning: Inter- and Intra-Individual Differentiation

This research group, originally directed by Codol, but now headed by Jean Massonnat, has been concerned with the fundamental processes involved in the development and change of the self-concept. How we come to define ourselves, and the ways in which this definition influences our use of self-relevant information, is the central research issue of the identity construction group (cf. Codol, 1987; Hardoin and Codol, 1984).

Three central research projects are planned for the future:

- First, the researchers will study the processes in adults by which self-schema are developed over time: How does an individual access knowledge about the self, and use this knowledge?
- The second study is concerned with the ways in which adolescents come to define themselves, and to differentiate themselves from others. Intra- and intergroup comparisons in individual differentiation are the focus of this study.
- The final series of research projects deal with the topic of identity development during the first 3 years of life, and will make use of longitudinal observational techniques. How infants form object relations, and how they differentiate themselves from the external environment is the central theme of this final set of studies.

The life-span developmental coverage of this research group is impressive, as is the systematicity with which the research theme is developed. On the basis of past form, it is reasonable to expect that this group will produce some interesting and useful information regarding the ways in which the self concept is formed, and the manner in which, once formed, it influences the perception and processing of self-relevant information.

Theme 8. Judgment Processes in Evaluation and Decision Making

The sequence of mental operations that people employ in coming to an evaluation or decision is the

central focus of this research group headed by Jean-Paul Caverni. Although the group is relatively new (having started in 1986), its perspective is informed by the classical cognitive models of judgment. The working assumptions of the group are that the mental operations employed in judgment are dependent upon the judge's structured knowledge, which includes, among other things, an index of qualifications accompanied by a set of conditions for their application.

Research to be undertaken in the future falls under two major headings. In the first, cognitive functioning is studied in a series of different experimental situations. The group will focus on:

- The dimensions of judgment in the evaluation of symbolic and of physical size
- Comparison judgments – the perception of similarity and difference relationships
- Judgment processes in medical diagnosis
- Expert judgment processes – how do experts form judgments, and how do these processes differ from those employed by nonexperts.

The second project will consist of a review of the decision-making literature to develop a better understanding of the contribution of cognitive psychology to the development of a psychology of expertise. This is an intriguing possibility, in that such a "psychology" will have ramifications not only for cognitive psychology, but for social, developmental, and educational psychology as well. At this stage, it is still much too early to determine the directions the research will take, but it is reasonable to guess that the review of the decision-making literature is being undertaken with an eye toward the development of experimental tests of the hypotheses that will result from the review.

Theme 9. Cognitive and Graphic Activities, Transformation of the Design Profession

This is by far the most applied of the work groups. Directed by Jean-Pierre Poitou, its focus is shaped by the conceptualization of cognitive phenomena as the means by which knowledge is related to work. It is specifically concerned with the problems with which the technical design professions must deal relative to the continual refinement of the hardware and software of computer assisted design (CAD). Research in this group takes place in design studios, where the physical and mental activities of designers, technicians, engineers, etc., are studied in relation to the introduction of, or refinements in, CAD. Three broad lines of research are planned in this group:

- The study of the organization of technical progress – how the changes in technology affect design consulting offices. Longitudinal and comparative studies will be undertaken to study this issue.
- The cognitive psychology of complex, technical operations.
- The sociology of technical knowledge and expert systems.

Research will focus on the collective and individualistic nature of such information to determine the social conditions under which diffusion of information is maximized. Methods of discourse analysis, which focus on this diffusion process, will be developed.

Conclusion

The Center for Research in Cognitive Psychology at Aix-en-Provence is one of the most active institutions for psychological research in France. It is involved in many of the most central issues of psychology, and the work produced under its aegis is almost uniformly first rate. Although its topical coverage is broad, continuity is lent to the work of the Center through its persistent focus on fundamental cognitive processes. This is a useful tack, since it allows all of the many involved in the Center to speak the same language, as it were.

Unfortunately, like most of the French CNRS-supported psychological research outfits, the Center is under increasing financial pressure. There are fewer and fewer openings for new researchers, less and less money for research subjects, support staff, and equipment. The combined effects of this financial squeeze have been offset, to this point, by increased personal investments of Center personnel. People are working longer hours, at sometimes inappropriate jobs, in order to maintain progress. How long such deductions from personal resources can be maintained is anyone's guess, but it is unlikely to be forever.

One means of averting the resultant unavoidable decline, short of an increase in funding, is to collaborate with others whose interests intersect with those of researchers in the Center. This is why Codol was so insistent on opening opportunities for collaboration both nationally and internationally. Affiliation with the personal resources of the Center could prove to be a very positive experience for new or experienced psychological researchers. Through this method, we can make virtue from necessity. It is my hope that this brief description of programs is sufficiently informative to serve as the basis for an initial negotiation for collaboration between US psychological researchers and the fine staff of the Center for Research in Cognitive Psychology. For more details, write to Professor Jean-Paul Codol, CREPCO, Université de Provence, 29 Avenue Robert Schuman, 13621 Aix-en-Provence, Cedex, France.

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BIOLOGICAL SCIENCES

EUROPEAN CONFERENCE ON NEURAL COMPUTING

by Claire E. Zomzely-Neurath. Dr. Zomzely-Neurath is the Liaison Scientist for Biochemistry, Neurosciences, and Molecular Biology in Europe and the Middle East for the Office of Naval Research's London Branch Office. She is on leave until July 1989 from her position as Director of Research, the Queen's Medical Center, Honolulu, Hawaii, and Professor of Biochemistry, University of Hawaii School of Medicine.

Introduction

This informative conference dealing with a rapidly developing area was held in London, UK, over a 2-day period, February 8 and 9, 1988. The meeting was organized by IBC Technical Services Ltd, London, UK, with the scientific program arranged by leading UK scientists.

There were 122 delegates to this conference with the majority from the UK. However, nine West European countries were also represented as well as the US and Japan. Sixty-five percent of the attendees were from industrial organizations with the balance from academia.

Neural computing (based on the computational structure of the brain) is a revolutionary area providing major breakthroughs in commercial pattern recognition and learning applications. The primary applications areas are: image processing, speech recognition and synthesis, control of robot motion, and authentication systems.

An international group of expert speakers presented this 2-day seminar on the application areas, the connectionist models underlying the applications, and the hardware and software systems of neural computing. The strengths, weaknesses and appropriate domain of all aspects of this technology were examined in detail.

Neural computing technologies subdivide into connectionist models and parallel neural computers. Connectionist models can be further classified into two groups: associative memory systems and learning systems, each of which was discussed. Massively parallel neural computers are required to achieve the full potential of connectionist models. These computers execute neural models much in the same way that traditional computers perform number-crunching tasks. During this meeting, a review of the hardware and software requirements for neural computers was given. In addition, neural computing developments are being commercialized in the US, Japan, and Europe, and applications such as process control, computer-aided manufacturing,

medical instrumentation, etc. in the respective markets were reviewed by three experts.

The topics of the scientific program were:

- Neural systems and models
- Connectionist models: background and emergent properties
- Programing languages for neural computers
- Associative memories and representation of knowledge as internal states in distributed systems
- Neurocomputing applications – a US perspective
- Parallel architectures for neurocomputers
- Combinatorial optimization on a Boltzmann machine
- Neural networks: a European perspective
- Adaptation in open systems: learning and evolution
- Neurocomputing: neurons as microcomputers
- Trends in neural computing.

Brief summaries of the topics presented at this conference are given in this report. Detailed presentations are available in ONRL Report No. 8-010-C. There are no plans for publication of the proceedings of this conference.

Review of the Topics

Neural Systems and Models. D. Willshaw (Center for Cognitive Science, University of Edinburgh, UK) gave a paper on neural systems and models. He discussed two aspects of the structure and function of the nervous system which were examined: (1) the complex mode of action of the nerve cell, particularly the way in which nerve cells can influence each other and have been held to "program" each other, and (2) the highly intricate patterns of connections between nerve cells – the basis for the highly parallel operation of the nervous system.

Connectionist Models: Background and EmergentProperties. This talk, given by M. Recce (Departments of Computer Science and Anatomy, University College, London), provided an introduction to the current connectionist research areas which were examined in detail in later talks at this conference.

Recce said that the goal of neural computers is based on an attempt to mimic the brain's function by emulating its structure. However, he added it is the abstraction of these neuroscience concepts in the field of *connectionism* which has provided the progress into designing and programing neural computers.

Prior to the current wave of interest in connectionism, the framework was established in the 1960's by the development of *perceptron* models. The primary contribution during this period, according to Recce, was a simple perception learning paradigm which, along with its limitations, he discussed.

Recce said that current research in connectionism subdivides into two areas, namely, associative memories and learning systems. With associative memories, information can be retrieved based on the content of the memory (auto-associator), or a relationship between remembered pieces of information (pair-associator). With learning systems, data is presented according to a set of rules, and the task is for the system to extract the underlying patterns.

Programing Languages for Neurocomputers. According to P. Treleaven (Department of Computer Science, University College, London), programing languages for neural computers still remains one of the least developed research areas. Historically, each novel class of parallel computers is associated with a corresponding class of high-level programing language. Neural computer programing languages will develop, he said, through absorption of appropriate concepts from current parallel languages. He reviewed the major classes of parallel programing languages and discussed their potential contribution to neural networks. Language classes he presented include: communicating processes, object-oriented, data flow, logic, and semantic network. Treleaven also discussed current proposals for neural network languages such as P3 and AXON, etc.

Associative Memories and Representations of Knowledge as Internal States in Distributed Systems. T. Kohonen (Laboratory of Computer and Information Science, Helsinki University of Technology, Espoo, Finland) described distributed associative memories and discussed their capacity and damage resistance. Kohonen also showed that the ability of generalization to some extent conflicts with efficient storage and high-quality recall. Certain network structures are demonstrated to form internal representations which are abstractions of sensory signals.

Neurocomputer Applications – a United States Perspective. In addressing this topic, R. Hecht-Nielson (Neurocomputer Corporation, US) said that neurocomputing is the engineering discipline concerned with non-programed adaptive information processing systems called neural networks that develop transformations in response to their environment. Neurocomputing is a fundamentally new and different information paradigm, he said. It is an alternative to the programing paradigm. He discussed the nature of neurocomputing, surveyed some specific neural networks' information processing capabilities, discussed applications of neurocomputing, and reviewed neurocomputing activities in the US.

Hecht-Nielson thinks that neurocomputing is a technology that is both intellectually stimulating and potentially valuable. He said that if current worldwide enthusiasm is followed by successful applications within the next 2 or 3 years, it seems likely that the field will spawn a new academic discipline as well as new manufacturing and market services. It is not often that a technology capable of significantly altering the future comes along. Hecht-Nielson said that with neurocomputing

now on the scene, the next few years should turn out to be a period of revolutionary expansion of our information processing capabilities.

Parallel Architectures for Neural Computers. Recent advances in "neural" computation models will only demonstrate their true value with the introduction of parallel computer architectures designed to optimize the computations of these models, according to P. Treleaven (Department of Computer Science, University College, London). He said that there are three basic approaches for realizing neural computers: (1) special-purpose neural network hardware implementations that are dedicated to specific models and therefore have potentially a very high performance; (2) neural network simulators utilizing conventional hardware which are slow but allow implementation of a wide range of models; and (3) general-purpose neural computers to provide a framework for executing neural models in much the same way that traditional computers address the problems of number crunching, for which they are best suited. This framework must include a means of programing (i.e., operating system and programing languages) and the hardware must be reconfigurable in some manner. In his talk, Treleaven surveyed current work in these three areas f parallel neural computer hardware and indicated the need for general-purpose neural computers.

Combinatorial Optimization on a Boltzmann Machine. The problem of solving combinatorial optimization problems on a Boltzmann machine was discussed by E.H.L. Aarts (Philips Research Laboratories, Eindhoven, the Netherlands). It was shown that by choosing a specific connection pattern and appropriate connection strengths many combinatorial optimization problems can be mapped directly onto the structure of a Boltzmann machine. Thus, according to Aarts, maximization of the consensus in the Boltzmann machine is equivalent to finding an optimal solution of the corresponding optimization problem. Aarts said that the approach taken by him and his group is illustrated by numerical results obtained by applying the model of Boltzmann machines to randomly generated instances of the max cut, the independent set, and the graph coloring problem. From these results, Aarts concluded that near-optimal solutions can be obtained by using in an efficient way the characteristic features of a Boltzmann machine, viz., massive parallelism and a distributed memory.

Adaptation in Open Systems: Learning and Evolution. This topic was presented by H. Muhlenbein (Institute for Mathematics and Data Processing, Bonn, West Germany). He said that neural networks are proposed for at least two reasons: (1) as a model to explain how part of the brain works and (2) as a new paradigm for parallel computation. Muhlenbein and his group have focused on the second – the engineering approach and the investigation of neural networks – from a performance point of view. The performance of two models was demonstrated with complex combinatorial problems – the partitioning of general graphs and the traveling salesman problem. Muhlenbein then outlined a minimal model for adaptation in open systems. Within this model, the fast dynamics represents learning by the individual, while the slow dynamics pushes an ensemble of individuals through a fitness surface (evolution).

European Perspective on Neural Computing. A survey of European research resources was presented by J.Y. Le Texier (Division of Electronic Systems, Thomson-CSF, Paris, France). He said that a large number of European companies such as Siemens, Philips, Thomson-CSF, etc., have undertaken research efforts on neural computing. Supporting these efforts, national and European Community research programs (BRAIN, Esprit, Brite, etc.) provide ground for cooperation between these industries and university research groups. Le Texier presented a survey of the main goals and directions of this cooperative effort. He said that integration of results stemming from neural network research is of critical importance for European information technology since those models appear to offer a framework for taking advantage of hardware improvements and also a complement to symbolic Artifical Intelligence by providing real-time sensory-processing capabilities. According to Le Texier, in order for Europe to maintain its level of competence in this emerging field, it is essential to organize European research and to encourage initiatives of creation of dedicated research centers, analogous to the Computer and Neural System Center at the California Institute of Technology or the Center for Adaptive Systems at Boston University, both, of course, in the US. Le Texier added that there should also be an increase in communication between academic and industrial researchers in order to enhance coherence and coordination of the efforts and to anticipate and prepare for the industrialization of results.

Conclusion

Research in the area of neural computing has recently become a prime research target both at universities and industrial organizations because of the tremendous potential for application. Research on neural networks is being pursued vigorously, not only in the US, but also in Europe and Japan. Although the work is still at an early stage of development, the consensus at this meeting was that practical application will be available within the next 5 years – an exciting prospect. Since the work presented at this conference is complex, I have been able only to summarize very briefly the various research projects dealt with in this report. However, a fairly detailed account is available in ONRL Report No. 8-010-C.

4/14/88

BIOTECHNOLOGY CONFERENCE: DRUG DELIVERY AND DRUG TARGETING SYSTEMS

Claire E. Zomzely-Neurath

Introduction

This focused and informative conference, "Drug Delivery and Drug Targeting Systems," took place in London, UK, from 14 through 15 December 1987. The meeting was sponsored by IBC Technical Services Ltd, UK, and was organized by leading UK scientists. There were 155 delegates, including the invited speakers, with 76 percent from industrial organizations and the balance from academia. Although the majority of attendees were from the UK, 11 West European countries were also represented as well as the US and Israel.

Nearly 80 years ago, Paul Ehrlich conceived the idea of the "magic bullet," a drug targeted directly to the pathogen, but completely nontoxic to the host. Even today's drugs fall far short of this ideal, and conventional oral or systemic drug administration still involves the difficulty of achieving effective plasma levels without reaching toxic concentrations.

In recent years, however, a whole new range of possibilities has become available for delivering constant therapeutic drug levels, or even for targeting the drug to its site of action for more specific effect. The aim of this conference was to look at this new science of drug delivery and the related concept of drug targeting.

The topics presented at this conference were as follows:

- Impact of new formulations in drug delivery
- Hydrogels and drug delivery
- Mucoadhesives for delivery across mucous membranes
- Nasal delivery of protein/peptide therapeutics
- Liposomes as drug delivery devices
- Design of novel ocular drug delivery systems
- Clinical development of drug delivery systems
- Polymers in controlled-release systems
- Site-specific delivery and optimal drug action
- Design of transdermal systems
- Drug targeting using monoclonal antibodies
- Biosensors
- The future of drug delivery.

Brief summaries of the presentations at this conference are given in the following report. However, a detailed discussion of the various topics is available in ONRL Report 8-007-C.

The Presentations

Impact of New Formulations in Drug Delivery. S.S. Davis (Department of Pharmacy, University of Nottingham, UK) discussed how new approaches to formulation can have a significant effect upon the delivery of pharmacological agents. He first spoke about developments that have taken place in producing new dosage forms for existing drugs and then concentrated on the area of controlled release to include oral dosage forms, implants and transdermal systems. He considered the possibilities of greater selectivity in drug delivery, and reviewed the possibilities and limitations of currently available systems intended for drug targeting including liposomes, macromolecules, monoclonal antibodies, and prodrugs. Davis then discussed the challenges that are now presented to drug formulators by the new generation of polypeptide drugs that cannot normally be delivered by conventional systems; opportunities exist here, he said, for delivering peptides and proteins via the gastrointestinal and nasal routes.

Hydrogels and Drug Delivery. A review of hydrogels and drug delivery was presented by A.T. Florence (Department of Pharmacy, School of Pharmacy and Pharmacology, University of Strathclyde, UK). Florence said that hydrogels prepared from cross-linked hydrophilic or hydrophobic polymers can be synthesized to have virtually any desired physical characteristics, which may be altered to control drug release rate. Their extent of swelling in contact with body fluids is determined by the degree of cross-linking and by the nature of the cross-linking molecules, according to Florence. Hydrogels can be fabricated into a variety of pharmacuetical forms ranging from microgels to macroscopic slabs of material and can be grafted onto other polymeric surfaces to provide materials ranging from medicated wound dressings to tablet matrices for slow release.

Mucoadhesives For Delivery Across Mucous Membranes. Mucoadhesive drug delivery systems are therapeutic systems that incorporate materials, typically polymers, capable of binding to the glycoprotein components of the mucous overlying mucosal epithelia. They can be used on a variety of mucosal epithelia that have demonstrated capability for, or show characteristics amenable to, drug absorption. This topic was discussed by J.R. Robinson (School of Pharmacy, University of Wisconsin, Madison,). Robinson said that both water-

soluble and insoluble mucoadhesives have been shown to be clinically useful to optimize drugs in several areas of the body. The use of water-soluble mucoadhesives has been reported for treatment of local conditions in the mouth and cervix, as well as for improving nasal absorption of insulin, according to Robinson. He also presented studies on ocular, rectal, and buccal delivery of drugs, including peptides, all of which employ a water-insoluble mucoadhesive.

Nasal Delivery of Protein/Peptide Therapeutics. J.P. Longnecker (California Biotechnology Inc., Mountain View), who addressed this topic said that the systemic delivery of protein/peptide therapeutics by noninjectable routes of administration is a topic of increasing interest as a consequence of the emergence of recombinant DNA technology and the resulting expected availability of new potential drugs. The majority of this work for efficient delivery, according to Longnecker, has concentrated on nasal delivery because of the easy accessibility of the site and its rich submucosal blood supply. However, absorption of DNA compounds across the nasal mucosa requires use of absorption enhancers, which often have deleterious effects. Longnecker said that a novel group of absorption enhancers (Nazdel^{R}) with little local or systemic toxicity has been developed at California Biotechnology Inc. He said that nasal formulations of a number of protein therapeutics including insulin, calcitonin, LHRH agonists, human growth hormone, and others are under development by this company. Longnecker also discussed formulation, mechanism and safety studies, and the preclinical and clinical testing of these nasal-dosage forms.

Polymers in Controlled-Release Systems. The use of polymers for use in controlled-delivery systems, with particular attention to the delivery of polypeptide drugs was discussed by R. Langer (Department of Applied Biological Sciences, Massachusetts Institute of Technology, Cambridge). He also discussed approaches for using the polymer systems to deliver polypeptides at constant rates for up to 2 years as well as about ways of providing self-regulated systems in response to external molecules. In addition, Langer discussed some novel approaches, using polymers, for delivering vaccines.

Design of Transdermal Systems. The success or failure of a transdermal delivery system will depend on a design appropriate to the physicochemical and pharmokinetic properties of the drug, according to J. Hadgraft (The Welsh School of Pharmacy, University of Wales Institute of Science and Technology, UK). He reviewed different designs which included membrane-moderated systems, matrix systems, and conventional "ointment" dosage forms. According to Hadgraft, the transdermal route of administration for certain drugs is very attractive. It will be expanded with the use of penetration enhancers and the possible development of iontophoresis. Coadministration of drugs from more complex devices also provides new potential. However, Hadgraft also said that there are disadvantages of transdermal delivery which cannot be ignored and that when the whole phenomenon of skin absorption is understood in more depth, perhaps even to a molecular level, the development of this means of delivery should be facilitated.

Clinical Development of Drug Delivery Systems. The last decade has witnessed many applications of delivery system technology; most, however, confer advantages to preexisting products, or offer the safer use of previously clinically unacceptable dosage forms, according to G.W. Guy (Ethical Pharmaceuticals Ltd., UK). He said that in the past, clinical development of these formulations has been almost by way of reconciliation and not through the mainstream of new product development. However, modern approaches, increased regulatory requirement, and market demand now require even the most up-to-date active ingredients to be formulated and clinically developed from the onset in a delivery system. Guy described these aspects in detail.

Design of Novel Ocular Drug Delivery Systems. R. Gurny (School of Pharmacy, University of Geneva, Switzerland) presented a review of designs of these systems as well as recent studies for them. Gurny said that, traditionally, ophthalmic dosage forms have been virtually limited to solutions, ointments, suspensions, and emulsions. Nevertheless, there have been a few successful efforts with ocular inserts. Such inserts have been described in the pharmaceutical literature for more than 50 years. According to Gurny, with the usage of the Ocusert, a diffusion-controlled system developed by ALZA Corp. in the 1970's, the excessively rapid drug exchange between the insert and the tear fluid was overcome. Even then, inserts, in general, have the disadvantages of poor compliance. Gurny said that in recent years, several new formulations such as pH-sensitive dispersions, temperature-setting gels, liposomes, and nanoparticles have been developed, and he went on to discuss them. Viscosity enhancers, such as polysaccharides and mucopolysaccharides, have also recently been studied. Some of these systems have already been evaluated in man, and the results were presented by Gurny.

Site-Specific Drug Delivery and Optimal Drug Action. Site-specific delivery serves to attain the maximal potential *intrinsic* activity that a drug can have and to reduce any toxic events according to E. Tomlinson (Division of Advanced Drug Delivery Research, Ciba-Geigy Pharmaceuticals, Horsham, UK). In his presentation, Tomlinson examined some of the criteria used to determine whether an existing drug is a candidate for drug targeting. He also described the enabling (patho)-physiological events and biotechnologies which can help

to achieve site-specific drug delivery and discussed recent advances in the production of genetically defined drug delivery systems and the understanding of the relationship between drug chronopharmacology and site-specific delivery.

Liposomes as Drug Delivery Devices. I. W. Kellaway (Welsh School of Pharmacy, University of Wales Institute of Science and Technology, UK) addressed the use of liposomes as delivery devices. He said that the clinical rationale for using drug carriers is to achieve greater selectivity than can be obtained through drug design alone. Liposomes can carry a relatively large drug payload which will be protected within the inner confines of the liposome structure from degradation while decreasing the toxicity of the drug and metabolite levels in blood and at organ sites. According to Kellaway, cellular uptake can occur by various mechanisms without cytotoxic effects; thus, enhanced cellular drug levels can occur. Liposomal encapsulation will inevitably result in altered pharmokinetics which can lead to reduced toxicity and enhanced therapeutic effects. Kellaway said that such claims can be made on behalf of any putative carriers but that some additional benefits may apply more specifically to liposomes. These include the use of endogenous, biodegradable, and generally nontoxic constitutents. A wide range of components leads to liposomes of different properties (both physical and biological) and hence it is possible, according to Kellaway, to design a liposome for a specific therapeutic target. Kellway then discussed in detail the properties of liposomes which make them attractive as drug carriers, and presented some experimental data on their use.

Drug Targeting Using Monoclonal Antibodies. This subject was addressed by B.A. Rhodes (RhoMed Inc., US). He said that the application of monoclonal antibodies (Mabs) to the targeting of radioisotopes, drugs, and toxins to cancer has been repeatedly demonstrated; however, the efficacy of this approach for treatment of solid tumors has been limited due to the heterogeneity of tumor antigen expression. Rhodes proposed a "patient-centered" system which integrates immunohistochemistry, diagnostic imaging, and antibody targeted therapy to improve the efficacy of antibody-based drugs. He said that the key to this system is the use of cocktails of antibodies prematched to the expressed antigens of an individual tumor.

Biosensors. Biosensors are small probes which can detect, for instance, substances of biomedical interest, usually without added reagent. J.C. Pickup (Division of Chemical Pathology, United Medical and Dental Schools, Guy's Hospital, London, UK), who addressed this subject, said that electrochemical, fiber optic, and other sensors are being increasingly used in clinical pharmacology to monitor drug levels of their responses *in vitro* in body fluids, including detection of overdose, for continuous sensing with feedback control of a drug delivery system, and for laboratory drug analyzers.

Conclusion

The presentations at this focused conference on drug delivery and drug targeting systems showed that much work has been carried out in developing more effective and safer methods for delivery of drugs to the host (human) as well as the potential of delivery to specific targets. These studies are being done not only at university centers but also at industrial companies. Most of the speakers were from the UK, but certainly much research in this area is also being done in Europe, the US, and Japan. Although significant advances have been made further research in this area is still required.

2/25/88

COMPUTER SCIENCES

RESEARCH IN INFORMATION TECHNOLOGY AT FRANCE'S CENTRE D'AUTOMATIQUE ET INFORMATIQUE

by Daniel J. Collins. Dr. Collins is the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The Centre d'Automatique et Informatique (CAI) is one of 21 research centers established throughout France by l'Ecole Nationale Supérieure des Mines. L'Ecole Nationale Supérieure des Mines, founded in 1783, is one of

the "Grandes Ecoles" of France. One should not be misled by the name of the school since, although there is some emphasis on mining and geology, it is a true polytechnic institution. The French government has made an effort to decentralize the Nationale Supérieure schools by relocating them to places other than Paris. As part of this decentralization CAI has been relocated to Fontainebleau, which is still only about an hour's drive from Paris. CAI has a scientific staff of 14 and about 17 research students. In a recent year there were three doctoral students. The course structure includes informatics, microprocessor application, elements of control theory, identification, and signal and telecommunication treatment. A curriculum option in information technology, under the direction of Dr. M. Lenci, also director of CAI, is given at the center.

Dr. G. Cohen, associate director, and my host for the visit, indicated that there were seven research areas or projects at the center. These are:

- Optimization and large complex systems
- Control of energetic systems
- Nonlinear control and filtering
- Parallel computer architecture
- Self-structuring data bases (SIGMINI) and large data bases
- Adaptive control.

I shall consider each of the projects in turn in this review.

Optimization and Large Complex Systems

By large complex systems one means, for example, the water distribution system of Paris or the urban heating system. Cohen indicated that present activity is directed at the determination of losses due to broken conduits in the Paris water system. An earlier developed operation program for the water distribution system based on artificial intelligence (AI) has not met with much success since it is not used by the operators. (Interestingly enough, the Japanese have also experienced operator resistance to using an AI-based program for water distribution [*ESNIB* 88-01: 33 [1988].) An interactive computer program has been developed to estimate the losses for the static condition where one has continuous measurements. Improvements in the "observability" of the system by adding different or more sensors are also being considered. A complete dynamic model of the distribution system is now being developed which will include estimation of consumption. Optimization techniques are used in the analysis of the systems using iterative and decomposition techniques (Cohen and Culioli, 1986).

Similar work from a static and dynamic viewpoint on urban heating systems has resulted in a doctoral thesis by R. Lidin (1986), who has developed a computer program for the analysis of a network containing several heating sources. Such a heating system network when analyzed by means of optimization techniques exhibits many local minima. Lidin's program is being used in a study to determine the global minimum for the series of local minima. This is, of course, an active world problem in optimization. CAI's studies of complex systems are actively supported by contracts from French utility companies such as Generale des Eaux, Generale de Chauffe, and Gaz de France.

Cohen, in perhaps one of the more interesting CAI projects, is working with a group that is studying what could be called a new or exotic algebra of discrete-event systems typified by flexible manufacture or microprograming. They have developed an algebraic presentation of discrete-event systems based on two formal variables. In this formulation the concepts of transfer functions, rationality, eigen problem, minimal realization, and connection with Petri nets are explained from a system theoretic viewpoint (Cohen et al., 1987).

Control of Energetic Systems

The control of air-conditioning and heating systems is the principal activity of this area of study, headed by Dr. Y. Lenoir. A computer code, OPENSOL, has been developed which takes into consideration meteorological conditions that a building might face over a given period of time. The code is in the process of being expanded to deal with multizoned heating and air-conditioning in a building. Optimization techniques such as decomposition and analysis similar to that described above for networks are also being applied, but they would be relevant at the level of large buildings.

Nonlinear Control and Filtering

Dr. J. Levine indicated that there are two principal areas of application – robotics and distillation columns – for his research in nonlinear control and filtering. In robotics the effort is to balance an inverted pendulum at the end of a robot arm (using the PAMIR program). While this work appears to be successfully progressing, there does not seem to be much interest by industry. The distillation column work includes nonlinear control of biotechnology fermentators. The technical aspects of the research concern linearization by dynamic loops (Charlet, 1986) and control based on nonlinear adaptive methods. The latter effort is supported by a contract under the ATP-CNRS program in "Automatic Methodology and the Analysis of Systems," which is a national project. The linearization work is in cooperation with the University of Rome Secondo (*ESNIB* 87-01:16-19 [1987]). A CAI logic computer code, written in Macsyma

and called C.A.O., was developed for the control of nonlinear systems.

Fundamental investigations of the structure of nonlinear filters of finite dimensions are being conducted based on the properties of the Lie Algebra of differential operators (Levine and Marino, 1986). Investigations of the link between filters and asymptotic-state observers have resulted in some direct applications in the guidance of targeting (contract Sopelem-DRET) and passive trajectory determination of submarines (under contract with the consortium of international aircraft manufacturers, GERDSM).

Parallel Computer Architecture

Dr. F. Irigoin is responsible for the program in parallel computer architecture, which is primarily concerned with software generation, from vector statements, of parallel tasks for multiprocessor machines such as the Cray-2. His recent doctoral thesis is on nested DO-Loops (Irigoin, 1987). He was able to experimentally verify his ideas on a multiprocessor machine – the Alliant FX/8 – at the University of Illinois, Urbana. Another reference in English to his work is on automatic DO-Loop partitioning for improving data locality in scientific programing (Irigoin and Triolet, 1987). He has also reported on the computing dependence direction vectors and dependence cones with linear systems. This group has been recently expanded to three permanent staff plus also three student researchers.

Self-structuring Data Bases (SIGMINI) and Large Data Bases

CAI under the direction of Dr. P. Mordini has developed an information management system based on the computer code SIGMINI. This system has been installed in universities in France and in the French School (of archeology) in Athens, and CAI people expect that other institutions will increase their use of the code (Brisbois and Mordini, 1986). It is possible to couple a given data base with video disks, which permits relatively easy organization within the data base of the archeological artifact data. SIGMINI is specifically designed to handle complex data items such as those concerning ancient artifacts. The code has application to the problem of automatic documentation. CAI is also conducting studies of large data bases and the automation of contemporary city archives.

Adaptive Control

Dr. L. Praly directs an active program in adaptive control and has made some contributions to several recent books in this area (Praly, 1986). The research has two axes: the first deals with an effort to extend current well-established research results in adaptive control to industry. This is part of a large project – GRECO SARTA – whose aim is to foster increased industrial utility of adaptive control methods. The second axis is more fundamental and is directed at the extension of local adaptive control results to a global framework. There appears to be some international cooperation in this area since the University of Illinois and the University of Southern California are also involved.

Conclusions

In spite of its small number of researchers the CAI laboratory produces significant results. It has excellent interaction with French industry and its applied research is well complemented by some fairly fundamental investigation, particularly of parallel computer architecture. The group has created several computer codes which they are exploiting both in applied and fundamental research. Most of their important contributions are published in English, which, along with their good contacts in the US, makes their work particularly available to the US researcher.

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1/15/88

COMPUTER SCIENCE RECORDS AT THE HEBREW UNIVERSITY

Daniel J. Collins

The Hebrew University, founded in 1918, now has a student body of 17,000 and a teaching staff of about 1400. It places strong emphasis on humanities, agriculture, medicine, and science. My visit was confined to the Department of Computer Science, which has a staff of 16. The main areas of research in the department are concerned with complexity of computations, design and analysis of algorithms, natural language processing, operating systems, computation with distributed systems, computer architecture, and computer vision. The institute has a Vax 11/780 and a Vax 750. Of the two laboratories in the department one is concerned with distributed computations and the other with computer vision and image processing. I want, in particular, to highlight the work of two of the department's professors, A.B. Barak and M. Bercovier.

Barak directs the distributed computations laboratory. His research is directed at the experimental and theoretical aspects of distributed processing systems. He has developed a general-purpose multicomputer distributed operating system for a cluster of loosely coupled independent computers. The present system with seven nodes, based on the NS32000 family of computers, was used to demonstrate for me algorithms in networking, scheduling, and load balancing developed by Barak (Drezner and Barak, 1986). What is interesting about the laboratory is the ability to experimentally test theoretically developed parallel and distributed algorithms. The distributed operating system is a UNIX system.

Bercovier's primary research is in numerical analysis. He has been applying the finite element method to nonlinear elasticity problems, which in this case means rubberlike materials – with particular reference to tires. In a contract with Israel's Urdan company, Bercovier has simulated the metal-casting cooling process. He is also active in software engineering for large industrial processes using computer aided design. At present he is investigating partial differential equations of advection-diffusion problems where the advection dominates the diffusion. In his approach, finite differencing of the total derivative yields schemes which do not require upwinding. Bercovier has applied his method with some success to problems involving the Navier-Stokes equation, the Euler equation, and to the advection-diffusion linear problem.

I would also like to mention two other of the department's research areas. Dr. S. Peleg is concerned with digital image processing and pattern recognition. His work has been supported by a joint French and Israeli project and by the Israel Aircraft Industries. In a recent article he used a vector space representation to invert image blur, enabling nonlinear restoration with relatively small computations (Shvaytser and Peleg, 1987). The second area is in artificial intelligence, in which Dr. D. Lehmann is seeking the development of a program capable of negotiating with other programs or human beings. He is also conducting work directed at a connectionist approach which aims at the development of intelligent highly parallel machines built out of a large number of simple components. Also in expert systems, Dr. C. Beeri has developed an advisory system for birth control which can be used by people prior to discussion with a human consultant.

Some further topics include cryptographic protocols in distributed systems, data-based management systems, and parallel processing. In this last area is a paper with the intriguing title, "Competitive Snoopy Catching." The department publishes a yearly summary of all research activities; it is available from Bercovier, who is at present the department chairman.

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2/23/88

FLUID MECHANICS

FLUID MECHANICS AT THE SWISS FEDERAL TECHNICAL UNIVERSITY IN ZURICH

by Daniel J. Collins. Dr. Collins is the Liaison Scientist for Aeronautics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from the Naval Postgraduate School where he is a Professor of Aeronautical Engineering.

The largest technical university in Switzerland – the Swiss Technical University (ETH) – is in Zurich. The student body numbers 9000, and the teaching staff totals 825. Instruction is in German. In order to ensure a close relationship between industry and academia, ETH professors have typically had extensive industrial experience as research directors or department heads before their selection as professor. My visit coincided with a planned information day on energy technology at ETH so that in addition to discussions with the principal researchers in fluid mechanics I also obtained a very current (January 1988) bulletin (in German) on all research activities.

My visit was concentrated in the university's Fluid Mechanics Institute and (the new name as of 1 January this year of the former Aerodynamics Institute) the Institute for Energy Technology (IET). I shall discuss the work which I found interesting in both of these institutes, which, by the way, have a close relationship.

Fluid Mechanics Institute

The Fluid Mechanics Institute is directed by Professor H. Thomann, who is assisted by about five Ph.D. students. I was impressed by the high degree of experimental competence of the group, particularly in turbulent flows of low velocities as encountered in ship, vehicle, and civilian aircraft movement.

The institute has a newly constructed wind tunnel for investigating three-dimensional (3-D) turbulent boundary-layers. As part of the new instrumentation for this facility the institute has developed over a number of years a skin friction balance for direct measurement of shear stress in strong pressure gradients (F. Hirt et al., 1986). The gap around the circular floating element of the gage is sealed by a liquid with a high-surface-tension liquid which prevents contamination to the principal flow by secondary flows due to the balance. The balance uses a displacement-free force measurement system. Thomann indicated that he has long-term support for the development of such basic instrumentation as the skin friction balance, and it will be interesting to see the results of their systematic investigation of turbulent boundary-layers in their new facility. The experimental work is complemented by ongoing numerical work on large eddy simulation so there will be a productive interaction of experimental measurements and theoretical analysis.

Another recently completed facility is a large 22-meter canal for the study of the diffusion of heavy gas clouds caused by industrial or drilling accidents. The diffusion velocity and concentration of the heavy gas will be measured in the facility. This research is motivated by the recent incidents in Bhopal and the Cameroons. A somewhat similar study concerning the underwater blowout of gas from oil wells at sea is being conducted in a transparent cube filled with water. An effort is being made to model in detail the blowout process and to confirm the model construct by detailed measurements of concentration of the gas in the water and on the surface. Still with essentially the same concerns are present efforts to analyze numerically the leaking of gas from buried pipes – depending on the geology of the land in which the pipe is buried, leaks can propagate for 10 or more miles before surfacing. Safety and economic considerations are, of course, paramount. The analysis is based on the finite element method and, contrary to previous calculations, the analysis shows strong transient in the viscous flow in the pipe.

Further study of transient turbulent boundary layer flows with weak transient – rather than the strong transient discovered in leaking pipes – is being conducted in a transparent tube with a slight overpressure with the end closed by a diaphragm. Rupture of the diaphragm causes an expansion wave which generates a transient turbulent boundary-layer on the side of the tube. Since the experiment is concerned with weak transients, analysis can be based on small perturbations which lead to the Orr-Sommerfeld equation. An analogous experiment involving the sinusoidal excitation of a closed tube near half the fundamental frequency has recently been reported (Althaus and Thomann, 1987). Nonlinear effects produce a resonance at the first overtone. In a beautifully selected experiment Thomann showed experimental measurements which fully support the nonlinear theory of Keller.

Further numerical work on 3-D boundary layers and on the Navier-Stokes equations will be emphasized start-

ing next year when ETH obtains a Cray XMP. At present there is a Cray I at the polytechnic at Lausanne, and the ETH also has a connection to the Cray II in Stuttgart. Locally, the institute has a VAX II.

Institute for Energy Technology

IET, formed in 1983, consists of four laboratories:

- Energy systems
- Power stations and nuclear technology
- Thermal turbomachines
- Internal combustion engines.

I visited only the last two laboratories of this group but I will say a brief word about the other two.

Energy Systems. The energy systems laboratory is concerned with all aspects of what could be termed "building technology." This includes the thermal comfort, health, productivity, and safety of the occupants. The laboratory, which consists of one professor and 18 associates, has a large number of projects financed from external sources. A study of the dynamics of floor heaters is a typical project.

Power Stations and Nuclear Technology. Much of the research of the nuclear technology laboratory, which consists of one professor and nine associates, is in association with the Swiss Institute for Reactor Research. The main research directions are in the study of thermal hydraulics as associated with reactor safety, simulation of nuclear power plants, transport theory, and reactor analysis. The investigation of the safety of a light water reactor is a typical project. The institute is investigating the the optional cooling of reactor rods and analyzing the flow of liquid metal flows.

Thermal Turbomachines. The thermal turbomachines laboratory is directed by Professor G. T. Gyarmathy, who has 10 associates and four technicians. Gyarmathy has had 16 years of industrial experience, two of which were spent in the US. Research projects include the development of fast-flow sensors for turbomachinery; investigation of turbulent diffuser manifold flow, flow instabilities in radial compressors, and labyrinth compressors; and power station processes for gas and steam turbine installations.

To me the most exciting project of the laboratory was their work on miniature sensors for turbomachinery pressure measurements. The sensors have an average diameter of about 2.5 millimeters and contain four built-in pressure sensors of a piezoresistive type. The sensors, which are assembled under a microscope and take some 100 hours to fabricate, are fine examples of the fabled Swiss craftsmanship. A special calibration procedure under computer control and in a heated oven takes over 2 weeks to fully characterize the thermal and resistive properties of the probe. Further systematic flow-field calibration occurs in a small wind tunnel. The probe permits over 200,000 pressure measurements a second. This frequency of measurement is necessary in order to distinguish the coherent structure of the flow from the turbulence structure. To fully use this capability a special electron data management system has been developed with eight input channels, 12-bit resolution, and a 100-kilohertz bandpass. Diplome Engineer C. Grossweiler showed me some measurements taken in the output plane of the rotor of a radial compressor. With a 2-megabit memory one can obtain 10 seconds of data. Although preliminary data reduction can be done on the local micro VAX II, the volume of data requires full data reduction on the ETH central computer. Gyarmathy and his group have developed a unique fast measurement system which can be used to gain a deeper understanding of complex turbomachine phenomena.

In a specially designed experiment Gyarmathy has investigated the energy stratification in radial compressors. For a number of years it has been known that a part of the total pressure in the exit plane of the rotor can be greater than the corresponding total pressure for ideal flow. The experimental measurements show that energy stratification can occur where there is acceleration in the cross-plane of the flow, and where there is also a high level of turbulence. Application of the fast sensor probes to such radial flows may give insight for correcting turbulence modeling of the flow and a deeper understanding of the effect of turbulence in the energy stratification.

A large radial compressor proof-stand (450 kW) is being used in a 3-year study of radial compressor. This stand has the capability of operations with Freon. Work is also beginning on a Francis Turbine with a labyrinth diffuser. Future work will be directed at small gas turbines and at the development of axial turbine blades.

Internal Combustion Engine Laboratory. Professor M. Eberle, who directs the internal combustion (IC) engine laboratory, is the only professor in IC engines in Switzerland, and he has also had extensive industrial experience which includes 2 years of working at General Motors. Of the 25 associates working with him, 12 are supported by external contracts with Swiss industry. Research is directed at improvements in the IC engine which lead to less exhaust emissions, less noise, and less fuel consumption. Also of importance in automobile research is greater safety for the passenger with smaller vehicle size. In the 4 years since his appointment as professor, Eberle has created an advanced computer-controlled engine test laboratory that matches the test facilities that I saw at the Fiat Research Center in Turino (*ESNIB* 87-01:60-61 [1987]). Contrary to earlier times, present automobile research requires sophisticated methods. The laboratory is equipped with the several of the latest engines which are undergoing tests for industry. Eberle indicated that the technical challenge is to improve the efficiency of modern engines with respect to

fuel efficiency – not of 10 year-old engines – and in this respect Eberle's close ties and contacts with industry are important. One of the recent laboratory tests has been on the VW Golf engine which is used in taxi service in Zurich. Three other engines were undergoing tests.

One of the recent projects of the laboratory has been the design of an advanced lightweight engine based on the Otto cycle. Using the designed engine, which is based on present technology, and a small light car, a fuel saving of 20 percent over present automobiles is possible. The engine incorporates a kinetic fly wheel and a continuous variable transmission. Eberle stated that the development of such an automobile is not a technical problem but an economic one in that the automobile manufacturers would need to replace high-speed, heavy, prestigious cars with small, slower, light cars that cost more than the present cars.

I will point out two further projects in the laboratory. The first is concerned with the reduction of emission from high-speed direct injection diesel engines. The investigations studied the effect of preinjection of fuel before the main fuel injection. Preinjection caused a significant reduction in NOX emission and in the noise level. No improvement in particle emission, which is a severe problem with diesel, was noted. In the second project a detailed analysis accompanied by experiments was made of NOX emissions. Comparisons between predictions from analysis and experiment were made – with good results – and the effect of emission control devices were studied.

Conclusions

There is a strong connection between the research at the ETH and the industrial base of Switzerland. In fact, professors at ETH must have some industrial experience before they are appointed to a chair. The research has a strong experimental element with well-designed facilities and with new sensors and data systems. Support for research appears to be strong, which permits some fine fluid mechanic experiments – as in Professor Thomann's institute. Industrial support can comprise as high as 50 percent of an institute's work, as appears to be the case for Professor Eberle and also to some extent for professor Gyarmathy. It will be interesting to follow the development of fast sensors for turbomachinary by Gyarmathy in the future.

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2/25/88

MATERIALS SCIENCES

The 4th International Conference on Interconnection Technology in Electronics

by Robert W. Vest. Dr. Vest served as an ONRL liaison scientist while on sabbatical during 1986-87 and is now Director of the Turner Laboratory at Purdue University, West Lafayette, Indiana.

Introduction

Science and technology issues of microjoints formed by soldering, welding, or adhesive bonding were addressed at the 4th International Conference on Interconnection Technology in Electronics held from 23 through 25 February 1988 in Fellbach, West Germany (near Stuttgart). This biennial conference, organized by the German Welding Society, was attended by over 300 scientists and engineers, and since fewer than 10 of the attendees were from outside Europe, a more appropriate name would have been the *European* Conference on Interconnection Technology in Electronics. The conference was organized into 37 lectures with simultaneous translations in German and English, four tutorial papers, 24 poster papers, and six workshops. The scientific complexity of microjoining requires a multidisciplinary approach in both basic and applied research, and this was extremely evident from the diversity of the technical papers. The topics ranged from theoretical models of microstructure development, grain boundary migration, and low-temperature oxidation, to studies designed to set practi-

cal limits for impurities in solder pots. The majority of the attendees were from industrial organizations with very practical problems, but the fundamental papers drew as much interest and discussion as the applied papers because the value of and the need for basic research in this field was widely appreciated.

A 212-page Proceedings of this conference is available by writing the Deutschen Verband für Schweisstechnik e.V., Postfach 2725, 4000 Düsseldorf, West Germany, but it may be of limited value to most *ESNIB* readers. The papers in the Proceedings vary from 75-word abstracts to very complete manuscripts of eight pages, and only 22 of the 61 papers are in English. I will not attempt to review all of the research presented, but instead will discuss what I consider to be the significant new contributions in the areas of materials science, design and packaging, and joining technology.

Materials Science

An excellent theoretical paper on model calculations of the kinetics of oxidation of metals at 300 K was presented V. Grajewski of the Max-Planck Institute für Metallforschung, Stuttgart, West Germany. He started his modeling by dividing the overall oxidation reaction into six steps: physical adsorption of oxygen molecules on the surface; chemisorption of those molecules by electron capture from the solid; electron transport to the surface; formation of interstitial ions or vacancies; transport of either metal or oxygen ions through the oxide film; and reaction at either the oxide-gas or metal-oxide interface. In order to keep the number of free parameters in the model calculations small, he considered only one chemisorbed, one ionic, and one electronic species, and assumed that the concentrations of all other species were small; this is a good assumptions in many real systems over limited temperature and pressure ranges.

The electron transport through the oxide film was modeled as either a tunneling or a thermally activated process as shown in "a" of Figure 1. The electron tunneling is very fast for film thicknesses the order of 1 nm or less, but decreases exponentially with layer thickness. For thicker layers, electrons jump by thermal activation into the conduction band of the oxide, a process which is orders of magnitude slower than the initial tunneling process but one which must be considered in a reaction model if growth rates for extended exposure times are included. The ionic lattice defects in the oxide are transported by chemical diffusion driven by the concentration gradient and the electric field, as shown schematically in "b" of Figure 1. The formation and consumption of charged lattice defects by interface reactions is also a field-dependent process, and the rates of these partial reaction steps depend on the field as well as on the concentration of the reacting species.

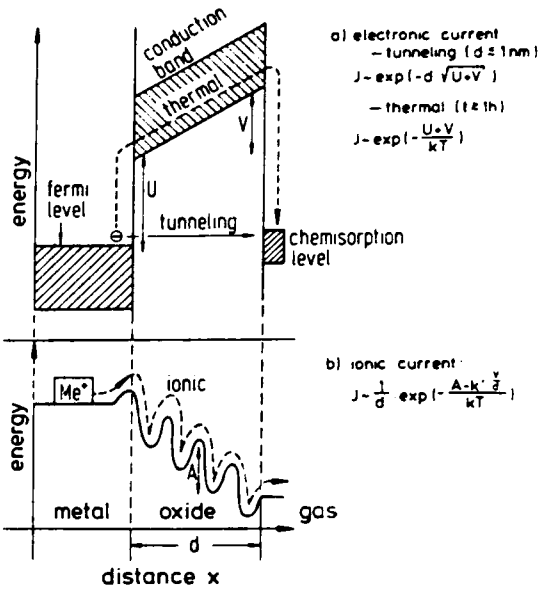

Figure 1.
Schematic of transport mechanisms: (a) electronic; (b) ionic.

The procedure used to make the model calculations was as follows. First, the reaction rate equations for the interface reaction and the transport equations were written as functions of the concentrations of ionic, electronic and chemisorbed species, the electric field, temperature, and layer thickness. It was then assumed that in the steady state the diffusion rates and the rates of the partial reactions are coupled by the condition that the concentration of intermediate reaction species (i.e., defects, electrons, and chemisorbed ions) are not changed at each position of the reaction path. For constant pressure, temperature, and oxide layer thickness, these assumptions gave an equation for the electric field (E) which could be solved numerically. With this value of E, the ion current was determined; this gave the growth rate for the actual state. Numerical integration finally yielded the layer thickness as a function of time for a theoretical oxidation.

Figure 2 shows a curve for such a model calculation using reasonable parameters for the reaction equations and the electronic structure of vanadium oxide, and the curve is compared with experimental data. Three branches of the oxidation curve are observed. In stage I, electronic equilibrium is established between the chemisorbed O_2 species on the surface of the metal due to the very fast tunneling process. Across the layer a more or less constant potential is established, which strongly increases the ionic current. With increasing layer thickness, the electronic tunneling current is reduced and the tunneling forward current and ionic current are equilibrated by the value of the potential. The

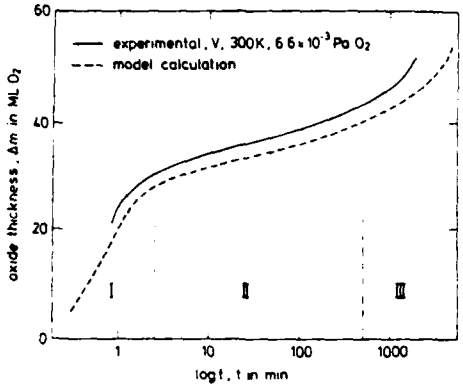

Figure 2.
Experimental and calculated oxidation curves at 300 K.

rate-determining step in stage II is the tunneling current, and the time dependence become logarithmic. Finally, in stage III, the thermal electronic current, which is not dependent on layer thickness, becomes larger than the tunneling current and is rate determining.

The general shape of the oxide thickness versus time curves in Figure 2 was found to depend strongly on parameters such as oxygen partial pressure, temperature, charge of the defects, electronic band structure, and electronic energy levels on the surface of the oxide. The model calculations demonstrated that (1) the room-temperature oxidation of metals cannot be described adequately by mechanisms with only one rate-determining partial step and (2) that the main features of experimental oxidation curves are simulated only by models which consider the defect structure of the oxide; the band structure of the metal and oxide; the chemisorption and the electronic states on the oxide surface; the transport mechanisms of atomic, ionic, and electronic defects; and the kinetics and equilibrium constants of interface and adsorption reactions.

In contrast to the fitting of experimental curves by empirically selected parameters, the modeling developed by Grajewski leads to a better understanding of the influence of individual parameters and partial steps on the shape of the oxidation curves, and provides valuable data for an improved understanding of the complex phenomena involved in room-temperature oxidation. This paper represents a very significant contribution to understanding low-temperature oxidation of metals.

In a paper concerning experimental work, K. Roser (Siemens AG, Munich, West Germany) described the effect of microstructure on the reliability of metallizations and demonstrated that there were fewer failures due to electromigration if the grain size of the aluminum metallization was greater than the width of the metallization lines. The theoretical aspects of this problem were considered by W. Gust from the Max-Planck Institute für Metallforschung, Stuttgart, West Germany. His modeling related the grain boundary mobility to the driving force for a number of discontinuous solid-state reactions such as discontinuous precipitation, discontinuous coarsening, and diffusion-induced grain boundary migration. The mobilities derived from these reactions were shown to be fundamentally different than those deduced from recrystallization experiments. He demonstrated that these differences arise basically from the fact that the recrystallization process involves atomic jumps across the boundary (transverse grain boundary self-diffusion), whereas in the other three reactions the diffusion takes place along the boundary (longitudinal chemical grain boundary diffusion). The diffusion distances in these types of reactions differ considerably. Gust demonstrated that there is a linear relationship between grain boundary mobility and the driving force for the discontinuous precipitation reaction, and predicted that the linear relationship will hold in general for other such reactions.

A very interesting paper on a thermodynamic interpretation of wetting experiments was presented by H. Reiss of Brown, Boveri and Cie AG, Heidelberg, West Germany. He used a high-resolution wetting balance and a high-temperature microscope to measure wetting forces, wetting angles, and spreading rates of PbSnAg and PbInAg solders, and correlated the observed time dependence of the wetting forces with variations of the free energy of diffusion or solution processes that proceed at the solid/substrate interfaces. He showed that there is a strong coupling between the time-dependent wetting force and the change in free energy at the solder/substrate interface, which allowed him to use the time dependence of the wetting force to predict the nature of interfacial reactions occurring. This is a potentially very important technique for analyzing and predicting interfacial behavior during soldering operations.

I do not feel that it is proper for me to comment on my own paper titled, "Structure and Physical Properties of Thick Films," but anyone wishing a copy of this paper can obtain it by writing to me at Purdue University, Potter Engineering Center, West Lafayette, Indiana 47907.

Design and Packaging

Packaging parameters such as circuit density, propagation delay, signal degradation, power dissipation, reliability, and cost are all important, but their relative importance depends upon the particular application. This fact was vividly demonstrated by two papers which considered the desirability of various packaging techniques for circuits operating at 1 MHz and above.

C.A. Neugenbauer (GE, Schenectady, New York) compared wafer-scale integration of five packaging approaches (printed wiring board, thick film multilayer

hybrid, ceramic multilayer hybrid, thin film multilayer hybrid populated on one side, and thin film multilayer hybrid populated on both sides), and concluded that the thin film multilayer hybrid populated on both sides was by far the best technology. He developed a "package figure of merit" which showed that the thin film multilayer hybrid populated on both sides was 200 times better than the thick film multilayer hybrid approach.

P. Dullenkopf (Ruhr-University, Bochum, West Germany) discussed the advantages and disadvantages of thick film multilayer hybrids and concluded that this is the technology of choice for high-frequency circuits. He went on to point out that thick film hybrids would be ever better yet if higher conductivity materials such as copper were used as the conductors with substrates having lower dielectric constants than Al_2O_3, even if the thermal conductivity of the new substrate was not as good.

Regardless of the packaging approach taken, the problems of microjoining are basically the same. K. Holdik (Standard Electric Lorez AG, Stuttgart, West Germany) discussed signal degradation due to attenuation, dispersion, reflection, and crosstalk, and showed that the degradation in rise time (dispersion) was related to both solder joints and wire bonds while the increased crosstalk was primarily related to wire bonds for frequencies between 100 MHz and 10 GHz. His results demonstrated that improved joining technologies are required in order to achieved improved circuit performance.

Joining Technology

The main reason that ball bonding of aluminum wires has not become more popular in microelectronic joining is because of the low pull strength of the bonds due to breakage of the aluminum wire in the necking zone immediately adjacent to the ball. L. Tielemans (Interuniversitair Micro-electronic Centrum, Leuven, Belgium) showed that the necking is caused by heat conduction through the wire during the cooling process after the ball is formed, and hence cannot be avoided entirely. By understanding the mechanism of necking he was able to show that the length of the necking zone was decreased to a minimum by decreasing the power during ball formation to the minimum required to form a proper ball. With this approach, the ball bonding of fine aluminum wires may become a more viable joining technology.

The results of an extensive study of ultrasonically bonded gold wires to aluminum and aluminum alloy thin film metallizations on silicon were reported by S.T. Riches (The Welding Institute, Abington, Cambridge, UK). The quality of the wire bonds was shown to be independent of the metallization alloy type (Al, Al-Si, Al-Cu, and Al-Si-Cu), but differences in wire bondability were observed between thin films with nominally identical compositions. This effect was shown to be due to the processing parameters used to produce the thin film metallizations, with annealing treatment having the most significant effect.

The results of an important reliability study were reported by Th. Walla (Schrack Electronic AG, Vienna, Austria). He studied the adhesion of a low-temperature solder (BiSn43) to thick film metallizations after high-temperature storage and after thermal cycling, and showed that the adhesion degradation was much more pronounced after the thermal cycling experiments. Postmortem examinations showed that the fracture surface was situated in the bulk alloy of the thermally cycled samples, whereas the samples stored for a long time at high temperature showed a fracture surface situated at the boundary between the thick film and the solder. Intermetallic phases that formed between the thick film and the solder were found to be the dominant contributor to failure after thermal storage, whereas the effects of the intermetallic layer were negligible after thermal cycling. There was no scientific explanation of this effect, but it was an important observation.

Summary

The improvements being achieved in increased circuit density and improved performance by silicon technology are becoming more difficult to translate to the system level due to the interconnects which will always be required to connect the integrated circuit to the outside world. Microjoints often present the weak point in the system because the materials and joining techniques used constitute a very complex system, the science of which cuts across many traditional disciplines. Only when the fundamental relationships of the processes involved are thoroughly understood and correctly applied can the appropriate joining techniques be raised to the level of performance and reliability consistent with the VLSI chips. The results reported at the 4th International Conference on Interconnection Technology in Electronics showed that progress is being made but that there is still a long way to go.

4/23/88

MATERIALS SCIENCE RESEARCH INSTITUTES IN MADRID, SPAIN

by Louis Cartz. Dr. Cartz is the Liaison Scientist for Materials Science in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on leave until June 1988 from Marquette University, College of Engineering, Milwaukee, Wisconsin.

The Spanish Council for Scientific Research (CSIC – Consejo Superior de Investigaciones Cientificas) is responsible for 92 research institutes in Spain, covering all aspects of basic and applied research related to the Spanish economy. The CSIC was established in 1939, replacing earlier research organizations dating back to 1907. Of the current total of 6,300 staff in the institutes, some 1,600 scientists are involved. A high proportion of the institutes are located in the area of Madrid.

Although the universities in Spain have not had a tradition for undertaking research studies, having been only teaching institutes in the past, the CSIC, a very enterprising organization, is changing that, pushing research forward in the best scientific tradition. Much of the research at CSIC institutes is undertaken in collaboration with various international and European research programs.

Special action programs and priorities including materials science, microelectronics, and lasers and their applications have been set up by CSIC. With the exception of the Institute of Ceramics and Glasses (covered separately, page 23, following) this article reports visits to the CSIC research institutes in the Madrid area, in the fields of materials, acoustics, and microwaves.

The Institute of Materials

The Instituto de Fisica de Materiales, located in the center of Madrid, consists of about 25 scientists. Several studies are of interest, and some of these are described below.

Metal Surface-Gas Absorption. These studies are related to catalytic processes at heterogeneous interfaces involving H-containing molecules and oxidation. The surface physics of the reaction of gases with metals and oxides are being studied under the direction of Dr. Jose L. de Segovia. In particular, there studies have determined the reactivity of H_2O and CO_2 on Nb and W surfaces. The thermal desorption of CO_2 adsorbed on W at room temperatures has been studied by electron stimulated desorption (ESD) (Gonzalez et al., 1987). The interaction of CO_2 is considered to give rise to nondissociative states of CO at high temperatures since the electronically excitable states of CO are undissociated; this CO covers about 27 percent of the surface. The dissociated O remains on the surface as atomic oxygen.

Studies by ESD have also been carried out of H_2O on polycrystalline niobium, when the local bonding of H, O, and OH fragments are determined (Rey et al., 1987). Some of these studies are in association with Dr. T.E. Madey at the National Bureau of Standards (NBS) in Washington. The experiments are carried out in an ultrahigh vacuum system with residual pressure (N_2 equivalent) of $2x10^{-10}$ mbar, by quadropole mass spectrometry with hemispherical grid to perform ion energy distribution determinations. The H_2O adsorbed on polycrystalline Nb at 150 K is characterized by dissociated H and OH. Under e^- bombardment, the induced dissociation products are H, O, and OH. The H and OH are bonded to the same surface atom. The O atom is directly bonded to a Nb surface atom, as are F impurity atoms.

Characterization of Semiconductor Surfaces. The characterization of semiconductor surfaces represents a difficult problem. A series of equipments and techniques have been developed in the institute to undertake such investigations. Available to the investigators are a scanning Auger electron spectrometer (with resolution of 500 Å), a low-energy electron diffractometer, a molecular beam epitaxy system, and an x-ray photoelectron spectrometer. Many of these systems have been constructed at the institute, which is well staffed with trained personnel able to construct or modify vacuum systems and electronic devices. The surface reactions of oxygen with GaAs surfaces have been studied (Alonso et al., 1987). In the (111) orientation, the surface Ga layer has a 1/4 monolayer of vacancies. Absorbed oxygen fills the first nonvacancy overlayer sites bonded to Ga atoms. Oxidation begins with the occupation of underlayer sites below the first GaAs bilayer. Up to two monolayer coverage by oxygen does not disturb the GaAs structure, nor is there any loss of Ga or As atoms.

Characterization of Small (nm) Particles. The detection and size analysis of small metal particles, of dimensions less than 1 nm, on an amorphous substrate is difficult because of the phase contrast background structure of the support. Soria et al., (1987) have developed digital image processing to aid in transmission electron

microscopy (TEM) observations. Observation by TEM requires control of focus, astigmatism, and specimen drift; a small deviation can give rise to a 50-percent error in size measurements in the 1- to 2-nm range. Image processing can aid in the unambiguous observation of particles of Pd on C substrate of 0.8-nm mean diameter, corresponding to aggregates of about 13 atoms, of cubo-octahedral or icosahedral crystal structures. This work is in collaboration with NASA-Ames Research Center, Moffett Field, California.

Magnetic Materials. The magnetic properties of Nb-Fe-B are under investigation as part of the Concerted European Action on Magnets (CEAM) study; the head of the department of magnetism is Dr. Francisco Carmona. The CEAM program is reviewed in a series of newsletters published by the Commission for the European Communities (Stimulation Action). Newsletter No. 1 was issued December 1985; No. 7 was issued in June 1987.

Institute of Acoustics

The Instituto de Acustica, directed by J. Pfretzschner, is located in the center of Madrid. This institute shares some facilities with the Institute of Materials. Typical studies undertaken are indicated by topics of recent papers published in international scientific periodicals. These studies include:

- Secondary methods for microphone calibration in normal rooms
- Physical parameters involved in ultrasonic aerosol coagulation
- High-power ultrasonic equipment for industrial defoaming
- Automatic system for dynamic control of resonance in high-power ultrasonic transducers
- Directional single-element underwater acoustic projectors
- Comparison of dB(A) and ISO ratings in assessing sound insulation
- Factors influencing dB(A) ratings for sound insulation
- Pistonlike underwater radiator using flexural vibrating plates
- Physical considerations in the frequency limits of birdsong
- Insertion loss versus transmission loss on ear-protectors.

The institute has been awarded several patents. One patent, which is used extensively in industry involves the use of ultrasonics in industrial defoaming, particularly concerning the filling of bottles with liquids. The institute is also involved with J. Magill (European Institute for Transuranium Elements, Karlsruhe, Germany [see *ESNIB* 87-01:63-64 and ONRL *Science Newsbrief* 5-6]) in a project on open-air scavenging of radioactive waste, for which joint applications for research funds are being made to European programs of research.

Institute of Electronics for Communication (IEC). The Instituto de Electronica de Comunciaciones is located in the center of Madrid, sharing facilities with the Institute of Materials and also with the Institute of Acoustics. Reorganizations in progress will transfer the department of microelectronics to a new Institute. The present director of IEC and also of the department of microwaves is Carlos M. Martin Pascual.

The work of the department is most dynamic. The workers have carried out extensive design and construction of radar equipment, and are deeply involved in cooperation with the European Space Program, and with many industrial teams in Europe, designing communication equipment for shipping, trucks, and aircraft, and in the construction of remote sensing equipment. Their projects include:

- Low gain mobile terminal antennae
- Electronically steerable mobile terminal antennae
- Millimeter wave radiometers
- Transmission line distribution network for multifeed antennae.

Discussion

All of the research institutes visited in Madrid displayed a very high level of scientific activity in the best scientific tradition. Extensive collaborations on an international scale take place, where all of the Spanish scientific staff have spent considerable time studying and working in the US, UK, or France. Most of the scientists are fluent in English, though some prefer to speak in French, especially those who have studied extensively in France. As an example of international involvement, Jose L. de Segovia is President-elect of the International Union of Vacuum Science. Many scientists have attended Imperial College, London, UK.

If Spanish universities in the past have not had a tradition of undertaking research studies, this is not the case for the research institutes. The Spanish scientists are fully aware of scientific developments in the industrialized world, and are striving to aid Spanish industry to develop and be abreast of all modern developments. All institutes and laboratories develop and construct their own equipment, develop the use of computer aids, and are in no way different from a typical laboratory of the US, UK, or France.

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3/4/88

CERAMICS RESEARCH INSTITUTE MADRID, SPAIN

by Louis Cartz.

Introduction

The Instituto de Ceramica y Vidrio, the ceramics and glass research institute, Madrid, Spain, is one of the many research institutes organized by the Consejo Superior de Investigaciones Cientifica, Spain (CSIC) – described in preceeding article, page 21.

The ceramics research institute is located about 25 kilometers from the center of Madrid at Arganda del Rey. There are some 30 scientific staff, with appropriate support staff, and several visiting staff and postgraduate students. It is an active institute, comparing well with other ceramics institutes in Western Europe; for example, in 1986, there were over 30 publications by this institute's staff in the international (reviewed) scientific press (English and French) and 15 publications by them in the Spanish Scientific Literature and, in addition, three Ph.D. theses were completed in 1986 by students from the Universidad Autonoma de Madrid.

The institute has undertaken four groups of investigations; these cover several aspects of properties of glasses, the mechanical properties of ceramics, the microstructure of sintered ceramics, and electroceramics. The Vice-Director of the institute, Dr.Pedro Duran, and two scientists, Dr. J. Jurado and Dr. Carmen Pascual, took me around the institute.

Following is a review of several of the institute's research projects, showing its high level of activity in a range of projects well-chosen.

Reaction Sintering of ZrO_2-Al_2O_3-SiO_2

The reaction sintering of zircon-alumina powders is an effective way to form dense ZrO_2-mullite ceramics with good characteristics. The chemical reaction is

$$2ZrSiO_4 + 3Al_2O_3 \leftrightarrow 2ZrO_2 + Al_6Si_2O_{13}$$

(mullite)

carried out at approximately 1550°C for 2-3 hours. As sintering aids, 0.25-mol-percent TiO_2, or 1-mol-percent CaO can be added, giving rise to reactions of the type

$$4ZrSiO_4 + 4Al_2O_3 + CaO \rightarrow 4ZrO_2 + Al_6Si_2O_{13} + CaAl_2Si_2O_6$$

(anorthite)

$$2ZrSiO_4 + (3+x)Al_2O_3 + xTiO_2 \rightarrow 2ZrO_2 + Al_6Si_2O_{13} + xAl_2TiO_5$$

The institute has carried out extensive studies in collaboration with G. Thomas (University of California, Berkeley); see Rincon et al. (1986a,b). Scanning transmission electron microscopy (STEM and TEM), x-ray diffraction, and scanning electron microscopy (SEM) methods have been used to examine the microstructure, crystalline phases, and the nature of any glassy phase at the grain boundaries (GB). The investigators have carried out shrinkage-versus-temperature measurements using a dilatometer; tests of the bend strength, using three-point bending tests; and measurements of the critical stress intensity factor (K_{IC}) by indentation. The properties of reaction-sintered ZrO_2-mullite are superior to those of specimens prepared by the sintering of a mullite precursor (premullite) with ZrO_2. The microstructure of the reaction-sintered mullite-TiO_2 consists of equiaxed mullite grains, twinned and rounded intergranular zirconia with some noncrystalline component, with solid solutions of TiO_2 in mullite and in ZrO_2. This project on Mullite-ZrO_2-Al_2O_3 reaction sintering, is sponsored in part by UNESCO.

Sol-Gel Processing

The institute, in a collaborative program with the University of Sheffield, UK, is carrying out an extensive study of the sol-gel process for the formation of noncrystalline materials (Orgaz and Rawson, 1986a). Typically, in the sol-gel process, solutions of 36-volume-percent $Si(OC_2H_5)_4$, tetraethoxysilane (TEOS), 23.6-volume-percent ethanol, and 28-volume-percent H_2O, are hydrolyzed by 12.4-volume-percent HCl. Gelling times of 10-12 hours give rise to (2- to 3-mm thick) gels, dried at room temperature, and then dried at 70°C. The inves-

tigators have followed the sol-gel transition by viscosity measurements, infrared spectroscopy, surface area measurements, water absorption, infrared reflection spectroscopy, TEM, x-ray diffraction, differential thermal analysis (DTA), thermogravimetry (TG), and optical absorption techniques. They have observed that organic components are totally removed at 350°C, when an amorphous SiO_2 is produced. Isolated and bound silanol groups disappear at about 1100°C. The C_2H_5OH/TEOS ratio is generally about 1/5, and the H_2O/TEOS ratio from 1-20.

A porous amorphous silica is obtained which can be converted to a continuous nonporous glass by sintering at temperatures of about 1250°C. It is not easy to prepare bulk glasses by this technique; cracking, bloating and crystallization tend to occur. The sol-gel process is suitable to prepare coating. Colored coatings have been prepared by the sol-gel process (Orgaz et al., 1986b). Clear coatings can be obtained, colored by the incorporation of transition metals. Crystalline precipitates (ppt) are observed of Co_3O_4, Mn_2O_3, CuO, and Cr_2O_3. Both light scattering and absorption mechanisms occur, though only the light scattering colors of Mn, Fe and Cu are sufficiently strong to give useful colored coatings. Coatings of thickness less than 0.5 μm have been made on soda-lime glass; the coatings have compositions of $SiO_2.M_xOy$ where M is Co, Cr, Mn, Fe, or Cu. Good clear tranparent coatings can be obtained, of good adherence for $SiO_2.Fe_2O_3$ where most of the Fe_2O_3 occurs as ppt, coloring the glass by scattering-absorption mechanisms. In the case of Co, the metal (up to ~13 mol percent) is incorporated into the glass structure, coloring the glass by ionic absorption; the adherence is less favorable in this case, and the films are thinner than those possible with Fe-oxide.

A gel, or porous silica can be prepared from a dispersion of colloidal silica. This gel converts on heating to 1250°C to silica glass, the sintering or merging of the particles starting at about 900°C. Above 1250°C, bloating and crystallization is observed. The institute has carried out studies on the transformation from gel to glass by BET surface area measurement, DTA, TG, SEM, and dilatometry. Temperature, Time, Transparency (TTT) measurements have been carried out. The properties of SiO_2 glass prepared from colloids are essentially those of a typical SiO_2 glass.

The sol-gel preparation can be extended to form alkaline silicate glasses, with up to 30-mol-percent alkaline oxides. At higher alkaline oxide content, there is a tendency for crystallization to occur at relatively low temperatures. The alkali content must not exceed 5 mol percent.

Sol-gel coatings are also being used to improve the mechanical strength of glass rods. The coatings should affect surface flaws, reducing their stress concentration effect, and so improving their mechanical properties. Coating solutions were prepared from TEOS with metal precursors in acidified ethanol, giving coating solution of

30 Al_2O_3. 70 SiO_2 (H_2O/TEOS 10, EtOH/TEOS 20, HCl/TEOS 0.2)
30 TiO_2. 70 SiO_2 (H_2O/TEOS 6, EtOH/TEOS 15, HCl/TEOS 0.1)
30 ZrO_2. 70 SiO_2 (H_2O/TEOS 6, EtOH/TEOS 17, HCl/TEOS 0.8).

The mechanical strength is measured by 4-point bending tests from 500-700°C with film thicknesses from 200-400 nm. There is an enhancement in the mechanical properties, which become dependent on film thickness at temperatures above 500°C.

Electroceramics

Institute personnel have investigated the solid-state reaction for forming lead zirconate titanate PZT (Jaren and Duran, 1986). The reaction $PbO + ZrO_2 + TiO_2 \rightarrow$ PZT is not one-step, but proceeds by first forming $PbZrO_3$ (PZ) or $PbTiO_3$ (PT), depending on reaction temperature and time and on the processing. The reaction has been followed by x-ray diffraction and by DTA. There are differences in the reaction mechanism when starting from amorphous ZrO_2 or from crystalline ZrO_2.

The group has also studied the electrical properties of tetragonal ZrO_2 doped with Y_2O_3 or Er_2O_3, examining the microstructure and mechanical properties. The ceramic is obtained by sintering at temperatures up to 1550°C, using co-ppt powder of ZrO_2 and 3 mol percent of the other oxides. DTA, TGA, and x-ray diffraction studies were used to follow the sintering and the electrical properties by complex plane impedance spectroscopy. The bulk conductivities and related bulk activation energies and GB activation energies have been determined and discussed (Duran and Moure, 1986a) in relation to the microstructure and sintering details. This work is continuing.

Switching and memory effects in Ge-Se-Te glasses can be induced thermally and electrically. Institute personnel are investigating these phenomena for $GeSe_2$-$Ge_{17}Te_{83}$ compositions. On increase of voltage, the conductivity of the material can change drastically, so that two states of conductivity can be induced, providing a switching ability. Differential scanning calorimetry (DSC), and x-ray diffraction examinations have been carried out. The electrical conductivity measurement were made on polished discs at 25 to 150°C and 0 to 550 V. The threshold voltages versus composition and versus temperature have been determined. Several crystallization peaks and several melting peaks were observed using DSC. It was found that (1) the threshold voltage for switching depends on the Te content and (2) the effect depends on the heat treatment of the glass, so that switch-

ing depends on the fictive temperature. Criteria are being obtained for the preparation of suitable switching or memory devices.

Copper Phosphate Glasses

An extensive study is being carried out of the electrical and photoconducting properties of copper phosphate glasses. Unusual photoresponse and Seebeck behavior have been observed in several transition metal oxide (TMO) glasses. These phenomena are under investigation in glasses of composition 70 P_2O_5-15 BaO-15 CuO (mol percent), prepared under different oxidation-reduction atmospheres to give a range of ratios of Cu^+/Cu (total); see Duran and Jurado (1986b). The researchers have made field effect and switching measurements by I-V transistor test equipment at temperatures from 100 to 200°C and applied voltage up to 500 V. Seebeck measurements have been made by Chromel-alumel thermocouples. Photoconductivity was measured, with illumination from a high-pressure Xe lamp using a grating monochromator (400-800 nm). Thermally stimulated polarization current (TSPC) and field effects measurements show the impurity trap levels to be approximately 0.6 eV, and band gap 1.5 eV, values that are very similar to those for crystalline Cu_2O. The photocurrents have been studied in the "on" and "off" switching conditions. In the "off" state, several photocurrent features are similar to those of crystalline Cu_2O. In the "on" state, switching events produce greater structural transformation effects. At a high electric field a filamentary electric path of Cu_2O, detectable by x-ray diffraction, joins the two electrodes. The photoresponse depends on the glass structure; the electrical behavior depends on the TMO. Cu-phosphate glasses are p-type electronic as found in crystalline Cu_2O photoconductors. The glassy matrix does not participate in the electronic mechanism, except by the effect of the small size of the colloidal Cu_2O particles.

Zirconia, Alumina, and Mullite Ceramics

A range of studies are being undertaken on ceramics based on ZrO_2, Al_2O_3, and $Al_6Si_2O_{13}$. A TEM examination of the microstructure of mullite sintered from premullite shows the different grains of mullite to have different concentrations of Al. Refractory aluminas have different mechanical properties and microstructure depending on the preliminary treatment of the bauxite minerals. Zirconia ceramics – Yttria-stabilized polycrystalline tetragonal zirconia (Y-TZP) – have been prepared by wet chemical methods, using the liquid precursors $Zr(C_4H_9O)_4$-C_4H_9OH and $Y(NO_3)_3 \cdot 6H_2O$. The influence of pH has been determined on the morphology of the co-ppt powders, and hence on the final microstructure of the sintered body.

Discussion

The research studies at the Instituto de Ceramica y Vidrio cover a wide range of activities from reaction sintering of ceramics, sol-gel processing, electroceramics and electroglasses, to studies of ZrO_2, Al_2O_3, and mullite ceramics. Studies on borosilicate glasses and Li-silicate glass ceramics are also in progress. These studies are carried out in collaboration with several international research bodies such as the National Center for Electron Microscopy, the University of California, Berkeley (with Dr. Gareth Thomas); the Department of Glass Technology, University of Sheffield, UK (Dr. H. Rawson); the Laboratorio Nacional de Engeharia e Tecnologia Industrial, Lisbon, Portugal (M.F. de Melo); and the University of Aveiro, Portugal (M.G. Ferreira da Silva). Very many of the institute's studies are in collaboration with other Spanish research bodies. Funding for the research projects is obtained from UNESCO (six projects), under EURAM (with Queen Mary College, London, UK and the University of Portugal, Lisbon, Portugal), and from a wide range of Spanish industries and Spanish governmental agencies.

The standard of the research work is very high, comparable to that of any of the other ceramic research institutes in Western Europe.

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3/9/88

MATERIALS RESEARCH AT EPFL LAUSANNE, SWITZERLAND

by Louis Cartz

Introduction

The Ecole Polytechnique Fédérale de Lausanne (EPFL) in Lausanne, Switzerland, is a university very active in the sciences and deeply committed to research studies. There are approximately 3,000 undergraduate students, about 300 doctoral students, and nearly 2,000 faculty and staff in the fields of engineering and architecture. Materials science is one of the specialities of EPFL, and its Department of Materials (DMX) is probably the largest such department in Switzerland. The studies at DMX concern new materials (ceramics, polymers, metals, composites, amorphous phases, and III-V semiconductors), relating the materials' behavior to their microstructures. DMX consists of eight laboratories devoted to metal joining, metal physics, mechanical properties of metals, chemical metallurgy, polymers, ceramics, construction materials, and the conservation of ancient stone edifices.

This report covers the activities of the DMX laboratories of ceramics, metal physics, and polymers.

The Laboratory of Ceramics

The studies of this laboratory, directed by Professor A. Mocellin, concern the development of new materials and their behavior under severe thermal and mechanical stresses. Their work on the development of superplastic properties in ceramics is of particular interest as well as their work on the chemical reaction between TiO_2 and Al_2O_3, and between TiO_2 and AlN.

Superplasticity in Ceramics. The superplasticity of a range of fine-grain ceramics is under investigation. The materials involved include Al_2O_3, $BaTiO_3$, ZrO_2, TiO_2, SiC with additives (see Carry and Mocellin, 1986a). The objective of this study is to enable the forming of ceramics specimens at high temperatures. A high degree of ductility has been obtained for ZrO_2 ceramics, and a systematic study is in progress on ZrO_2 with 3 percent Y_2O_3. Fine-grained material ($\sim$0.3 μm) has been extruded at 1600°C. The flow of the material can be displayed by the inclusion of a flat sheet of graphite paper. On extruding the zirconia ceramic, the graphite deforms into a deep loop which can be seen as a black line within the ceramic. Dense zirconia ceramics of uniform density have been prepared by high-temperature (1600°C) extrusion methods. The superplastic creep of fine-grained $BaTiO_3$ is also being studied (see Carry and Mocellin, 1986b).

The Al_2O_3-TiO_2 reaction. The group investigating the solid-state reaction of mixed powders of Al_2O_3 and TiO_2 has conducted their study very systematically. They have investigated the mechanisms of materials transport and shown that aluminum diffuses rapidly through TiO_2, that all reactants diffuse slowly through Al_2O_3, and that there is also surface diffusion (see Freudenberg and Mocellin, 1987). The solubility of Ti in Al_2O_3 is negligible. Severe instabilities occur at the interface of TiO_2 and Al_2O_3, with perturbations of up to 10 μm and with the formation of pores. The phase Al_2TiO_5 grows out of this complex microstructure. The group has carried out studies using sandwiches of $Al_2O_3/TiO_2/Al_2O_3$ single crystals, with temperature differences across the TiO_2 of $\sim$20 K, when a solid-state diffusion process of the Al occurs across the TiO_2. This confirms the importance of this mechanism in the solid-state reaction forming Al_2TiO_5 from the two oxides. Other studies in process concern the preparation of Al_2O_3-TiO_2 composites from organometallic precursors (see Brugger and Mocellin, 1986).

Study of the Composite Formed by AlN-TiO_2 Reaction. The objective of this study is to prepare a ceramic composite by a type of reaction sintering, rather than by the incorporation of fibers into the mixed powders. The reaction between powders of AlN and TiO_2 (and also between AlN and ZrO_2) is being studied in detail. Composite materials with a fine microstructure are formed having useful mechanical properties (see Sperisen et al., 1986b). The chemical reaction and the resulting microstructure of the ceramic have been followed by x-ray diffraction, scanning electron microscopy, microprobe analysis, elastic wave velocities, and indentation testing.

A displacement reaction occurs between TiO_2 and AlN given by $6TiO_2 + 8AlN \rightarrow 4Al_2O_3 + 6TiN + N_2$.

This reaction at temperatures of 1200-1400°C can lead to a dense ceramic of a very fine and complex microstructure with particle sizes ranging from less than 1 μm up to several microns. The reaction details are being systematically examined. Vacuum hot pressing (45 MPa) for 1 hour at 1400°C gives material of density $\sim$4.5 Mgm^{-3}, hardness comparable to Al_2O_3, toughness $\sim$4.8 $MPa\sqrt{m}$ greater than that of Al_2O_3, and Young's modulus ($\sim$470 GPa) greater than that of Al_2O_3. In the Al_2O_3-TiN composite, the TiN is more resistant to cracking than is Al_2O_3, so that crack deflection by the TiN par-

ticles leads to an improvement in the fracture toughness of the Al_2O_3.

Other Studies. Propagation of microcracks in alumina ceramics is studied by acoustic emission (Sperisen et al., 1986a). The high-temperature deformation of fine-grained alumina with Ti or Y additives is carried out at 5-1000 MPa and 1200-1600°C, following the microstructural changes by transmission electron microscopy (with a special apparatus designed for this purpose). An Al_2O_3 doped with Ti and with a grain size of ~ 0.5 μm deforms under tension at 1250°C and 10MPa, with a strain at rupture of ~30 percent.

Center for the Treatment of Materials by Laser (CTML)

The special center for laser treatment of metals (the CTML) was set up in 1984 beside the Laboratory of Metal Physics. CTML, directed by M. Rappoz and R. Dekumbis, is conducting several studies in cooperation with industry on wear, erosion, corrosion, and other surface properties (Kurz and Dekumbis, 1986).

A schematic of CTML's laser assembly is shown in Figure 1. As shown in the figure, the laser operates in air. It can deposit several kilowatts into an area as small as $\sim 10^4$ μm^2 to one of several cm^2. The beam can be oriented, focused, and scanned very accurately over a surface. The CTML people have carried out calculations and simulations of the heated zone of the material, giving the theoretical shape of the molten region and the temperature contours and gradients in the solid, and have compared experiment with calculations. The very rapid cooling and solidification obtained by laser heating gives rise to a very different type of microstructure formation from that of more traditional heating methods. Studies of the molten front and of dendritic growths are being undertaken (Trivedi, 1986).

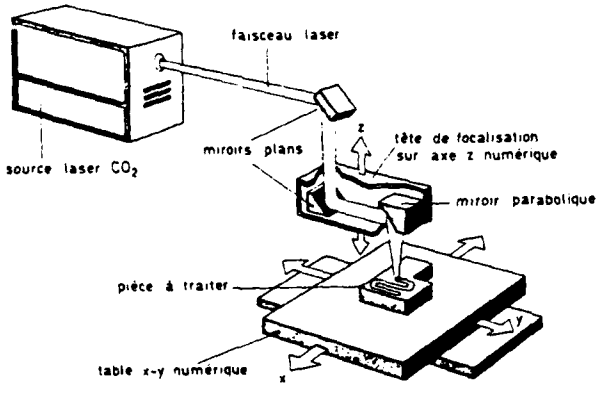

Figure 1. Schematic of the CTML laser installation.

Other Laboratory of Metal Physics studies concern: computer simulation of casting and solidification processes after rapid cooling; abrasive wear mechanisms of cast Fe; oriented monocrystal dendritic growths of superalloys; and deformation and rupture of Al-Si alloys.

Laboratory of Polymer Sciences

While the Laboratory of Polymer Sciences is headed by Professor H.H. Kausch, Dr. A.C. Roulin-Moloney is a very active participant. The studies in this laboratory are wide ranging; they cover most aspects of polymer formation (molecular orientation, polymer alloys, reticulation) and the mechanisms of polymer deformation and rupture. These studies concern the breakdown of macromolecules during laminar or turbulent flow, low-angle x-ray investigations of the microstructure of the microcracking of polymers, the interdiffusion healing of microcracks, deformation and fracture of modified thermoplastics, the interface rupture of composite materials, and fractography and fracture mechanisms of filled, cross-linked polymers (Nguyen and Kausch, 1986).

This polymer laboratory, probably the most important center for polymer research in Switzerland, is involved in extensive cooperation with industry, including Braun Bavarie, Ciba-Geigy, and FN/Micafil.

Comments

There are many DMX activities not reported here. These include studies of atomic clusters and molecular jets, permanent magnets, semiconductors, and developments in microscopic and spectroscopic methods. Of considerable interest to me is that DMX is a model of the internationalism and practical relevance of science. It is a very active materials science department in the mid-stream of all European materials research. This is particularly so since the scientists are multinational, being drawn about equally from France, Germany, Italy, the UK, and even the US as well as from Switzerland. In general, French is the language at DMX, though all the scientists are fluent in English. DMX (as well as EPFL) has excellent relationships with industry, having many ongoing collaborative projects and providing a very good and well used system of consultation.

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1/27/88

CHALCOGENIDE THIN FILM p-n DEVICES, PATRAS, GREECE

by Louis Cartz

Chalcogenide p-n junctions are known to form between bulk glasses of Ge-Se-Te containing small amounts of Bi when thin films of $Ge_{20}Se_{80}$ (or As_2Se_3) are evaporated onto the polished glass surface (Tohge et al., 1986). The chalcogenide glasses are mostly p-type semiconductors; the addition of Bi does result in n-type behavior.

Mytilineou et al. (1987) have been able to prepare thin film p-n devices consisting of As_2Te_3 (p-type) on $Ge_{20}Se_{70}Bi_{10}$ (n-type). The current voltage characteristics are compared in Figure 1 to those reported by Tohgue et al (1986). Mytilineou uses sputtering to deposit the thin film in a vacuum of 10^{-6} mbar. The sputtering device has three targets so that it is possible to prepare the thin films without breaking vacuum. Sputtering is found to be very effective in preparing films of constant composition with very little segregation. Mytilineou and coworkers are carrying out electrical and optical measurements of thin films of $Ge_{20}Se_{80-x}Bi_x$ with x up to 13. The Bi increases the electrical conductivity by 10 orders of magnitude at room temperature, and decreases the electrical and optical band gaps. Studies are in progress to understand the behavior of the Fermi level between the $Ge_{20}Se_{80}$ alloy (p-type) and the $Ge_{20}Se_{80-x}Bi_x$ alloy, with $x > 11$ (n-type).

Mytilineou plans to prepare devices with a narrow band gap material (say As_2Te_3) and a wide band gap ($Ge_{20}Se_{80}$) to see if there are any rectifying effects due to the differences of the band gaps and not of the Fermi levels, as is the case in the usual doped semiconductors where the band gap is the same.

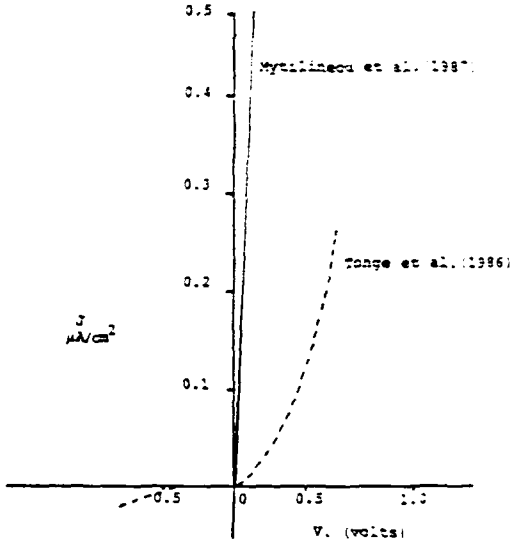

Figure 1.
Voltage-current characteristics of As2Te3-Ge20Se90Bio10 p-n device.

Further information can be obtained from Dr. E. Mytilineou, Institute of Chemical Engineering, P.O. Box 1239, University Campus, GR-26110, Patras, Greece.

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3/11/88

PHYSICS

SENSOR TECHNOLOGY AND APPLICATIONS IN EUROPEAN SCIENCE

by Paul Roman. Dr. Roman is the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research's London Branch Office. He is on assignment until September 1988.

Sensor technology in Europe was reviewed at the Third European Conference on Sensors and Their Applications (EUROSENSORS '87) convened in Cambridge, UK. The meeting was organized by the Institute of Physics (UK) and supported by the Commission of European Communities under the plan "for the transnational development of the supporting infrastructure for innovation and technology transfer." (The citation may sound pompous, but the European effort to focus on research and development in crucial high-technology areas is very real!) Several UK scientific and engineering institutes acted as cosponsors. The lectures (and the exhibition) were hosted by the Cavendish Laboratory of classical fame (now located in shining new buildings outside town.) There were about 300 participants – an ideal number for a meeting of this type. The national distribution of participants was unexpected, to me, at least. Inevitably, scientists from the UK dominated the meeting, since EUROSENSORS originated as purely UK-sponsored conferences in the past. But the second best show was shared between the Netherlands and West Germany! France came next, but just about equal in strength with Switzerland; then Finland and Sweden, with almost equal showing. Other nations, including a few from the East Block and China, made a token appearance, together with (inevitably) a few Japanese and American representatives. The Soviet Union was conspicuously absent.

Seventy talks were presented; nine of them were invited papers, introducing the major sessions. The invited speakers were given about 30 minutes, whereas the contributed papers lasted 15. (The alloted times included discussion, if any – clearly a too crowded schedule. Crowding was further aggravated by the fact that all contributed papers were presented in two simultaneous sessions.) Distressingly, there were also 48 posters put up (and viewed, by those who felt like it, during the lunch breaks). In the late afternoons, the conference talks were followed by brief workshop sessions (free roundtable discussions with audience participation), which were labelled as "Euro-workshops." It may shed light on European preoccupations in the sensor area to quote the titles of these three workshops; they were:

- Sensors in the Syllabus
- European Funding of Sensor Research
- Software for Sensor Systems.

The scientific talks of EUROSENSORS '87 were grouped as follows:

- Silicon sensors
- Metrology (3 sessions)
- Sensors in industry (2 sessions)
- Chemical sensors (2 sessions)
- Optical sensors (3 sessions)
- Flow sensors
- Biosensors
- Magnetic sensors
- Physiological sensors

The selection of session-topics seems surprising: it was a mixture of basic research concerns and rather overspecialized particular development work. But, again, even this may shed light on the European sensor-scene.

The conference was well balanced by a small but quite interesting exhibition (British exhibitors only).

Following are the highlights of a few, almost randomly selected talks (that fell vaguely into my areas of interest or competence): these were taken from sessions on silicon sensors, chemical sensors, and optical sensors.

Silicon Sensors

In an invited paper (which, somewhat suprisingly, also served as one of the keynote addresses to the entire conference) S. Middelhoek (Delft University, the Netherlands) characterized the area of silicon sensors as one which is full of promises and also pitfalls. The main point is that silicon, as a sensor material, permits the integration of a sensing element and a signal-processing circuit on a single chip. But in order that this attractive concept can be realized for a given measurement, it is necessary, not only that the silicon shows a suitable physical or chemical effect and that a sensor can be designed based on this effect but also that the sensor is compatible with the desired circuit technology. Middelhoek presented a very detailed overview of the most important effects in silicon, including some quite recent ones. The possible effects and sensor applications were grouped as follows:

- Light detectors (especially CCD's, color sensitive photodiodes, nuclear radiation sensors, IR detectors based on integrated thermopiles)
- Sensors for mechanical signals (such as vacuum sensors, tactile imaging sensors, integrated optical potentiometers)
- Sensors for thermal signals (specifically, integrated thermopiles)
- Sensors for magnetic signals (including three-dimensional magnetic field sensors)
- Chemical sensors.

Subsequently, Middelhoek talked about the need for developing "smart sensors," which should have a standard output and where unwanted cross-sensitivities should be compensated. In addition, for these smart sensors, offset, drift, and other hard-to-handle effects should be minimized. Self-testing should be possible. All these needs require integration. While hybrid structures are possible, the most elegant solution is obtained when the sensor and the signal processing circuit are made from the same material and integrated on the same substrate. Silicon technology appears suitable to achieve this goal. Special examples in this line were mentioned; these included: a piezoelectric pressure sensor with a current-to-frequency converter, a capacitive pressure sensor based on a square-wave oscillator, a pressure sensor based on a two-ring oscillator with a frequency ratio output, flip-flop sensors, and sensors with bus-compatible outputs. In concluding the presentation, the speaker pointed out that many difficulties connected with the development of silicon sensors (especially smart ones) have been often grossly underestimated. However, recent developments are more encouraging and the industry should pursue smart silicon sensors with great perseverence, patience, and adequate budgets.

Among the contributed papers on silicon sensors, the report of J.C. Greenwood (Standard Telecommunications Laboratories [STL], Harlow, UK) caught my imagination. He talked about resonant silicon sensors, an idea which he proposed in 1969 and which, by now, has reached true maturity. Resonant sensors consist of a mechanical resonator supported so that the force to be measured changes the tension in the resonator in such a way that it modifies the restoring force and therefore the natural frequency. The most advanced geometry currently under investigation at STL is an altimeter, capable of resolving measurement to within a few centimeters of height. More specifically, this silicon-based resonant absolute pressure sensor has a resolution better than one part in 10^{-6}, and has a drift less than 0.04 percent per year. This sensing technology is now adapted to measure other quantities, such as differential pressure, acceleration, and temperature. Optical, magnetic, thermal, and electrostatic excitability of resonant silicon sensors has been also demonstrated, opening up the way to a family of sensors suitable for use in harsh environments.

Chemical Sensors

There was little coherence in the talks presented in the area of chemical sensors; most of the talks described improvements and technologies related to specific devices.

As a typical and interesting example I call attention to the paper by G. Horner and colleagues (Technical University, Munich, West Germany), who reviewed significant improvements of the selectivity of a gas sensor system, achieved by the use of an array of sensors. Horner recalled that, in the past 2 years, it has been clearly demonstrated that sensor elements can be successfully grouped to a sensor array and that their signals can be evaluated and correctly interpreted by pattern recognition methodology. In this way, one can identify substances which could be identified only by much more sensitive (often unavailable) individual sensors. In recent experiments, the Munich researchers used an array of up to four metal-oxide gas sensors. A computer controlled the calibration, the measuring, and the scavenging procedures. Using mixtures of known substances, calibration vectors were computed and their mean values stored in the computer. In the testing procedure of a single unknown gas, the computer then compares the test vector with the calibration vectors in the memory, using either pattern recognition or correlation algorithms. As a practical example, results for gas mixtures of CO and CH_4 (or of vapors from whiskey and a special liqueur!) were presented.

Another, imaginative presentation was given by V. Dibbern, on behalf of the Philips Research Laboratory, Hamburg, West Germany. Dibben reported that by using a silicon substrate, thin film processes, photolithography, and anisotropic etching, it was possible to fabricate a miniaturized gas sensor based on semiconducting tin oxide. Not only size but also power consumption and costs were thus reduced. Indeed, the crucial problem in this effort was to secure excellent thermal insulation, since, in view of the high (about 300°C) operating temperature, power must not exceed 100 mW. This goal was achieved by a membrane technology. The active part of the device is situated in the center of a thin membrane, etched into $< 100 >$ silicon. In the prototype device chip, membrane, and active area are squares with edge lengths of 2700, 1350, and 450 μm, respectively.

There was also a scholarly invited talk, mostly tutorial in nature: W. Göpel (University of Tübingen, West Germany) gave an overall review of solid-state chemical sensors. He gave a thorough treatment of adsorption, absorption, and transfer reactions, then described experimental approaches to the study of interface reactions

and recounted experimental results on prototype inorganic, as well as organic, sensors. He concluded with a review of future trends, including comments on new materials and new technologies, microstructured devices, and even complex tasks involved in evaluating sensor data (such as pattern recognition.)

Optical Sensors

The numerous contributed talks in this area were proceeded by an invited topical survey talk on novel optical fibers for sensor applications. This comprehensive and analytical review was presented by W.A. Gambling (University of Southhampton, UK). He concentrated on recent considerable advances in the area, achieved by appropriate selection of core and cladding materials, and by novel fiber structures and designs. In particular, he explained that, by spinning the preform during fiber drawing, a high degree of circular birefringence can be introduced while, at the same time, linear birefringence becomes negligible. Such fibers are eminently suitable as sensors of magnetic fields and of electric currents. On the other hand, fibers caused to have a high linear birefringence, are best suitable for fiber gyroscopes measuring angular rotation. As another example, he pointed out that the introduction of rare-earth materials into the core of a fiber produces absorption bands with steep edges, which have a strong wavelength selectivity to change in temperature – this, in turn, provides the basis for constructing distributed sensors that cover a wide range of temperatures.

Two contributed papers touched on topics of immediate concern to naval needs. The first, a report by P.W. Forder (University of Kent, UK) described research done at his institute in cooperation with the Royal Signals and Radar Establishment (Malvern, UK). This work concerned laser velocimetry using fiber optics with diode sources and detectors. The researchers designed and constructed fiber-based dual-beam Doppler difference laser anemometer systems suitable for use in a wide variety of fluid dynamics studies. The primary concern was the development of a compact and portable system. A probe-type optical configuration was developed, in which the laser source, modulators, and detectors form one assembly, joined to the transceiver optics in a second (passive) assembly by a cable of fibers. Two single-mode fibers were used, together with one multimode receiving fiber.

The second paper directly addressing naval needs described the development of a laboratory prototype fiber-optic velocity hydrophone. It was presented by T.R. Empson, on behalf of Cambridge Consultants Ltd, Cambridge, UK. Velocity hydrophones respond to the particle velocity field, rather than simply to the pressure field associated with the acoustic signal (as conventional hydrophones do.) Hence velocity hydrophones have an inherent directionality, independent of frequency – this makes them particularly useful for passive sonar applications. The sensor head, developed by Cambridge Consultants with the support of the UK Ministry of Defense, is an all-optical device, sensing the movement of a mechanical "leaf" which is coupled into the acoustic wavefield. The structure of the sensor head is illustrated in Figure 1. The head is linked to a transceiver unit by two optical fibers. The operating principle of the head is based on a dual-wavelength displacement sensor, earlier developed for other (non-underwater) purposes. The transceiver launches light at two operating wavelengths alternatingly into the input fiber. At the sensor head, mechanical movements of the "leaf" in the field are converted into changes in the relative light-intensities at the two wavelengths. The modulated light-signal then returns (along the output fiber) to the transceiver unit, where the vane displacement and velocity are determined from the output of the optical detector by the processing electronics. Studies were conducted (with both simulation and experiments in a water tank); further development aims was at improving performance, primarily by replacing the current p-i-n detector with an avalanche photodiode.

An interesting, innovative paper, describing recent research at the rather new Sowerby Research Center of British Aerospace (Bristol, UK) was read by D. Hickman. It described research toward the development of an optical sensor based on temporal coherence properties. In

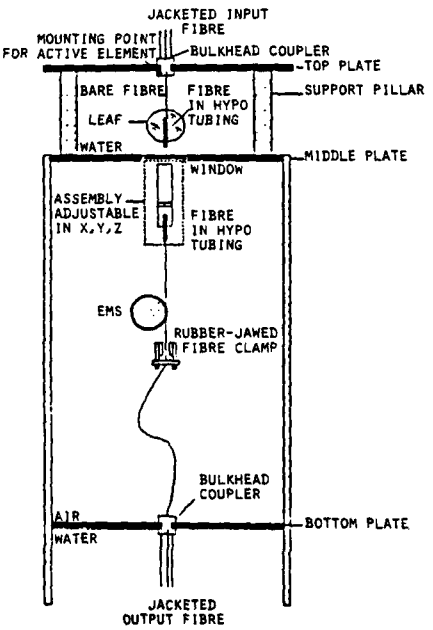

Figure 1.
Schematic of the sensor head. EMS: electromagnetic sensor.

conventional optical detector systems, a single detector is usually insufficient whenever one wants to detect a signal that is both less intense and has a spatial frequency content similar to that of background objects (cluster). This is so, because only time-averaged intensity is measured – hence information concerning coherence and polarization is lost. The British Aerospace scientists pursued an alternative approach, which is based on selectively modulating the various signals by using their characteristic coherence or polarization properties prior to the detection stage. This approach can be expected to give significant improvements in both the signal-to-clutter ratio and the signal-to-noise ratio. The principle of the system is represented in Figure 2. Experimental results are encouraging: for filtered white light against white-light background a gain of 10^3 in the signal-to-clutter ratio has been obtained, without additional filtering. For white light versus laser discrimination the gain was greater than 10^5.

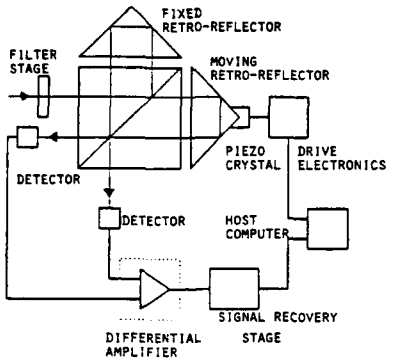

Figure 2. Schematic of the temporal coherence sensor.

I will mention one more innovative optical sensor system (which, actually, was presented in the Biosensors Session). It was described in the contribution by P. Nellen, on behalf of the Swiss Federal Institute of Technology, Zurich, Switzerland. Nellen reported on experiments with grating input couplers on planar waveguides. This device can be used, for example, as a sensor for the absorption of molecules out of a liquid on the waveguide surface, or as a differential refractometer. The clever device is shown in Figure 3, and its function is self-explanatory. The s- and p-polarized He-Ne laser beams ($\lambda = 632.8$ nm) are incident on the film waveguide (in most experiments, made of SiO_2/TiO_2 on glass substrate, 160 nm thick), under different angles chosen in such a way as to permit excitation of the TE_0 and TM_0 modes. This was achieved by rotating the rotation stage on which the waveguide was mounted. Very small rotation angles are required. The effective refractive indices of the two modes could be determined with an accuracy of $\Delta n \approx 5 \times 10^{-5}$. (This required a careful measurement of the optimum incoupling angles for the two modes.) When the device was used for actually measuring adsorption of a (biologic) substance from a solution, the molecules adsorped on the waveguide surface caused effective refraction index changes for the two modes – and these were then determined from the angular shifts of the two resonance incoupling curves. "Continuous" measurements with 1000 points could be taken in a 2-second scan over 1.25°. Scans can be repeated every 20 seconds.

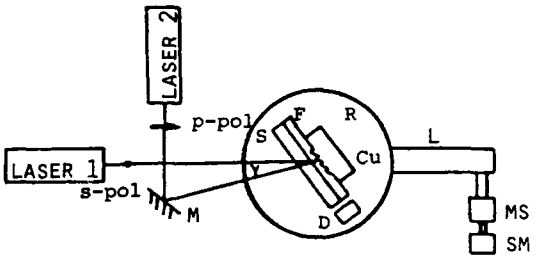

Figure 3.
Schematic of the grating input coupler. M: mirror; S: substrate; F: waveguide film with grating; Cu: cuvette with sample; D: photodetector; R: rotation stage; L: lever arm; MS: micrometer screw; SM: stepping motor.

Concluding Remarks

The conference and the exhibition clearly demonstrated growing awarness in Europe of the need to step up efforts toward more rapid development of sensor-related research and industrial development. It has been well recognized that the "sensor scene" is more multidisciplinary than it ever was, ranging from basic physics, chemistry, solid-state devices, optoelectronics, microelectronics, micromechanics, and computerization to materials-technology, and so on. The conference underscored that the trend today is toward miniaturization and toward distributed "intelligent" (or "smart") instrumentation. In more practical terms, some speakers pointed out that, whereas "technology push" is strong, "market pull" is ill-defined. Others emphasized that a far higher percentage of R&D funds should be used to improve design aids and to investigate manufacturing methods. Finally, the need for increased government- and industry-supported technical education and training was pointed out.

The conference ran smoothly, although the program was overcrowded. Technical facilities and the atmosphere were superb. Attendance, up to the end, was very heavy. Future EUROSENSOR conferences are surely worth attending.

I have a list of participants (with full addresses) and a booklet of abstracts of all contributed papers, as well as of the posters. On request and specification of the session title, I will be glad to supply copies of specific items to interested colleagues. The texts of the invited papers

were published (in a special issue) in the *Journal of Physics E (Scientific Instruments)*, Volume 20, No. 9, 1987. The publisher is IOP Publishing Ltd, Techno House, Redcliffe Way, Bristol BS1 6NX, UK. Copies of the above-mentioned abstract books may be obtained (while their supply lasts) from The Institute of Physics, 47 Belgrave Square, London SW1X 8QX, UK.

In addition, I have a short booklet listing the exhibitors and their products (or services) in the sensor area. I will be glad to supply copies.

ADVANCED OPTOELECTRONIC TECHNOLOGY AT AN INTERNATIONAL SYMPOSIUM IN CANNES

by Paul Roman

Introduction

Optoelectronic systems are becoming more and more crucial elements in defense, as well as in industry, communications, and commercial applications. Among the many conferences that are devoted to optoelectronic subjects, the frequently held European "Technologies for Optoelectronics International Symposia" play a prominent role, partly because they find an excellent balance between basic theory, ongoing frontline experiments, and industrial concerns for suitable manufacturing technologies. Furthermore, while these symposia attract large crowds, their agenda is split into independent, coherent, only partially overlapping "conferences," and thus, crowding is avoided. Until recently, this series of symposia was organized by the French Association Nationale de la Recherche Technique (ANRT), together with the International Society for Optical Engineering (SPIE). But the latest meeting, held in Cannes (France) heralded a change: the place of ANRT was taken by Europtica Services I.C., the "logistical partner" of the new all-European professional association Europtica, which in turn is a superstructure, joining efforts of national optics-societies, branches of the European Physical Society, and some other scientific organizations. (See *ESNIB* 88-01:66-67 [1988]). In fact, this was apparently the last meeting called "Technologies for Optoelectronics"—the future events will be titled "International Co: gress on Optical Science and Engineering," with the first to be held in Hamburg (West Germany) in September 1988.

The Cannes Symposium was made up from nine topical conferences:

- Advanced optoelectronic technology
- Quantum wells and superlattices in optoelectronic devices and integrated optics
- Materials and technologies for optical communications
- Optoelectronic technologies for remote sensing in space
- Focal plane arrays
- Optical interconnections
- Optical devices in adverse environments
- Industrial optoelectronic measurement systems
- Real-time image processing.

In addition, there were tutorials as well as an interesting table-top instrument exhibit by leading international firms.

The nine conferences comprised over 240 papers (sessions were usually preceded by keynote-addresses or invited papers); and there were, in addition, nine plenary sessions, joining all symposium attendants to hear leading personalities reviewing the more interdisciplinary concerns.

By far the largest conference was the one on advanced optoelectronic technology (AOT). This paper reviews only selected topics from this particular conference. (See, however, page 36 for a brief article on another of the conferences.) The AOT conference covered the following areas:

1. Integrated optics and optoelectronics
2. Nonlinear integrated optics (two sessions)
3. Nonlinear organic materials
4. Nonlinear wave mixing
5. Nonlinear fiberoptics
6. Coherent communication systems and components.

The preponderance of topics on nonlinear phenomena and their applications was striking.

Following are reviews of a few selected presentations taken from areas 1, 2, 3, and 5.

Integrated Optics

The importance of this area was emphasized by the fact that one of the eight interdisciplinary plenary sessions of the entire symposium was dedicated to a survey of recent progress in integrated optics. This 45-minute presentation was given by M.R. Papuchon (Thomson-CSF, France), who emphasized that the field of integrated optics became a subject of investigation only in the 1970's and by now, quite a number of devices are already commercially available from several companies. The general area of integrated optics can be divided into two main types of technologies: first, hybrid techniques (especially those using $LiNbO_3$ substrates) and second, semiconductor devices with monolithic integration of optical and electronic elements. In the rest of his talk Papuchon reviewed specific progress in very low loss waveguides, broadband modulators and switches, switching matrices, and fiber sensor chips.

The papers presented in the AOT Conference itself, were introduced by a keynote paper, also from Thomson-CSF, and read by J.P. Castera. It dealt with the still novel topic of nonreciprocal devices. It gave a general description of how such devices (in particular isolators and circulators) use the nonreciprocal interactions between light and a magnetic medium. The two, already realized integrated devices of this type (both isolators) were described in detail; their advantages and drawbacks were analyzed; and solutions proposed to overcome the difficulties.

Optical properties and nonlinearities in multiquantum-well structures were discussed in yet another Thomson-CSF paper, presented by J.P. Pocholle. It was revealed that the researchers have successfully demonstrated a multiquantum-well laser, a loss modulator, an optically bistable device, and an intersectional total-reflection switch with high-speed capabilities. In more basic research, polarization-dependent absorption in waveguide structures, nonlinear transmission, and voltage-dependent absorption coefficients have been studied as a function of wavelength and device-structure. Experimental results for GaAs/GaAlAs and InGaAs/InP structures were presented. Possibilities for devices based on waveguides and two-dimensional configurations were also discussed.

Apparently, in Europe the French dominate the area of integrated optics and optoelectronics: besides those papers reviewed above, there were three more French (and one Italian) presentations only in this session. I am under the impression that this preponderance is essentially a realistic (not conference-organizational) reflection of the European arena.

Nonlinear Optics

I found it interesting that some topics from the area of integrated optics (see above) were taken out from the general framework and discussed in special sessions on nonlinear integrated optics.

Nonlinear Integrated Optics. These presentations started with a keynote address by W. Sohler, who represented a West German (University of Paderborn) and Italian (Torino Polytechnic) cooperation. He reviewed recent developments of integrated optical frequency conversion devices. He explained how, using optimized Ti-doped $LiNbO_3$ channel-waveguides and waveguide-resonators, the researchers succeeded in fabricating harmonic generators, difference-frequency generators, and optical parametric oscillators.

An American-Swedish-Italian cooperative research group reported on nonlinear all-optical guided-wave devices. The participants represented the University of Arizona, Bell Communications Research, Ericson (Sweden), and Fondazione Ugo Bordoni (Italy); the paper was read by C.T. Seaton. The speaker explained how by including intensity-dependent refractive index materials into integrated optics devices one can construct systems that have power-dependent response characteristics – this then makes such devices suitable for all-optical signal processing (such as switching, or logic.) In particular, nonlinear devices based on directional couplers, Bragg reflection gratings, Mach-Zehnder interferometers, and mode-sorters were described (i.e., the theoretical foundations of such devices were analyzed), and then the required material properties compared with those of known materials.

Although to all purposes this was a European conference, the Japanese made, not unexpectedly, several independent contributions. T. Taniuchi (Matsushita Electric Industrial Co.) gave a second keynote paper in the field: he described second-harmonic generation in proton-exchanged $LiNbO_3$ waveguides. As expected, the presentation was in the area of technology (rather than basic research) and related how, from the emission of a GaAlAs laser diode, 1-mW Cerenkov radiation at 420 nm was generated. But the largest part of the talk described the proton exchange technology he used.

D. Persegol (Ecole Superieure de Physique, Grenoble, France) concluded the sessions with an interesting talk on a novel type of bulk electro-optical light-modulator. This device uses guided wave resonance in a planar zinc-oxide waveguide.

Organic Materials for Nonlinear Optics. In this rapidly growing field, I select two contributions which were distinguished by their generality.

The session's keynote paper was given by J. Zyss (the French National Telecommunications Research Center [CNET]), who talked about new trends in devising high-

ly efficient organic materials for nonlinear optics. He described how, using now well-established molecular engineering guidelines, a new generation of organic materials with greatly enhanced quadratic nonlinear coefficients have been grown and tested in his laboratory (both in bulk-form and in waveguiding configurations) in his laboratory. Stable materials were synthesized which had efficiencies up to two orders of magnitude above that of $LiNbO_3$, and exhibited sub-picosecond response times.

A second, general basic-research-type paper in this session was contributed by M.J. Goodwin, on behalf of Plessey Research, Caswell (UK). It concerned nonlinear polymer waveguides. The very short time-constant associated with the nonlinear behaviors of polymeric materials makes them attractive for high-speed optical logic and signal processing in waveguide devices. The paper detailed problems for fabrication techniques of polymeric waveguide structures doped with nonlinear organic materials, and it described the characterization procedures of both their linear and nonlinear properties. Particularly interesting examples of nonlinear functions (such as intensity-dependent prism-coupling, polarization switching induced by the Kerr effect, and electro-optic modulation) were described.

Nonlinear Fiber Optics. Because of the fascination this field holds for me, I take the liberty of reviewing five papers out of the total of seven presented – a definitely higher proportion than I followed in other areas.

The keynote paper was given by D.N. Payne (University of Southampton, UK). He reviewed the recent rapid progress in the field of rare-earth-doped fiber-lasers. He described several, previously unreported dopant and glass-matrix combinations. He reviewed his achievements with tunable fiber lasers operating at 0.9, 1.06, 1.08, and 1.55 μm. He also reviewed successful experiments in Q-switching and mode-locking. Finally, Payne outlined how rare-earth-doped fibers, exploiting fiber laser sources (or alternatively, absorptive and fluorescent effects) may be exploited for novel sensor applications.

Self-phase-modulation (SPM) in optical fibers was the topic of a talk by G. Veith (Standard Electric Lorenz AG, West Germany). He pointed out that SPM occurring at moderate power levels in single-mode fibers has important implications on long-range optical fiber transmission. In fact, SPM causes both limitations on advanced high-bit-rate optical communications systems, as well as being the source of some beneficial effects. After discussing these aspects of SPM, Veith concluded his talk with a discussion of the use of SPM for optical pulse compression to pulse-width in the femtosecond range.

K.I. White, reporting on research done at the British Telecom Research Labs in the UK, talked about nonlinearity effects in optical fiber waveguides with organic single-crystal cores. He discussed future prospects for all-optical devices (such as amplifiers and wavelength shifters) which are based on these nonlinear phenomena.

Finally, K.C. Byron (STC Technology Ltd, UK) reported on pulse compression and Raman amplification in optical fibers. He explained how, by exploiting the group velocity delay difference of the signal- and pump-waves in a Raman fiber amplifier, simultaneous amplification and pulse compression has been observed in his lab. This comes about because the rising edge of the signal-wave differentially depletes the pump-wave.

Concluding Remarks

The Cannes Symposium on the Technologies for Optoelectronics was, as were its predecessors, a success. In fact, this time the organizing committee seems to have been more careful than in the past in the selection of topics and in finding a good balance. In particular, the interdisciplinary plenary sessions were highly appreciated. The conference facilities were superb: the new Palais des Festivals et des Congres of Cannes (as well as the deep blue skies) provided an ideal background. There never was crowding; and the easy accessibility of all lecture rooms (from small ones, holding about 30 people, to huge auditoriums) made it possible to switch from one constituent "conference" to another.

The proceedings of the nine conferences are to be published by SPIE approximately in June 1988, in their well-known Symposia Proceedings series, as volumes 860 through 868. In particular, the Advanced Optoelectronic Technology conference is represented by volume 864. It will cost $43.00 (for nonmembers of SPIE). The eight plenary sessions of the symposium will be collected in volume 869. Orders or further enquiries from colleagues in the US should be addressed to SPIE, P.O. Box 10, Bellingham, Washington 98227-0010.

MULTIQUANTUM-WELL TECHNOLOGY FOR OPTOELECTRONICS DEVICES

by Paul Roman

In the preceding article (page 33) I reported on the Cannes International Symposium on the Technologies for Optoelectronics, and gave a somewhat detailed description of one of the nine "conferences" (the one on Advanced Optoelectronic Technology) that made up the symposium. This note is a brief review of another of the conferences, entitled, "Quantum Wells and Superlattices in Optoelectronic Devices and Integrated Optics."

The great interest in this rapidly growing field lies in the fact that multiquantum-well devices have an electroabsorption effect about 50 times larger than conventional semiconductors; they are compatible with existing light-source and detector material systems; and they lead to compact and high-speed devices. Thus, they are eminently suitable for monolithic integration of optoelectronic elements.

The large interest in this area was recognized by the symposium organizers by dedicating one of the few special plenary sessions to a review of novel quantum-sized electronic and optoelectronic devices based on semiconductor heterostructures. This plenary session talk was presented by G. Weisbuch (Thomson-CSF, France), who analyzed the pros and cons of low-dimensional systems in the context of optoelectronic devices. I was quite intrigued by his brief discussion regarding the future use of zero-dimensional systems.

In the conference proper, the talks were grouped (somewhat arbitrarily) into the following sessions:

- Modulators and switches
- Quantum-well lasers and related topics
- Phonons and plasmons
- Strained layer structures
- Growth, integration, high-speed photodiodes, and other miscellanea.

Following are very brief reports on some, surely arbitrarily selected presentations. G. Döhler (University of Erlangen, West Germany) gave an invited paper on optoelectronic device applications of doping-type superlattices. Such systems, composed of alternating n- and p-doped layers (possibly with an intrinsic region in between – i.e., n-i-p-i structures) exhibit unexpected electrical and optical properties. Döhler explained how these could be soon utilized for building a variety of new electro-optical and opto-optical devices.

D.R.P. Guy reported ongoing research at the Royal Signals and Radar Establishment (Malvern, UK), concerning previously announced work on optical devices that use III-V multilayers and quantum wells.

L. Bányai, on behalf of the well-known Haug research group of the University of Frankfurt (West Germany) talked about optical nonlinearities and bistability in semiconductor wires (i.e., one-dimensional quantum systems.) He presented exact theoretical calculations regarding nonlinear properties of such wires due to exciton and bi-exciton absorption.

P. Blood (Philips Research Laboratories, UK) felt it appropriate to present, in an invited paper, a reappraisal of GaAs/GaAlAs quantum-well lasers.

The invited paper opening the strained layer structure session was given by P. Voisin (Ecole Normale Supérieure, Paris, France), who talked about heterostructures of lattice-mismatched semiconductors. He discussed structural properties, electronic and optical properties, and potentialities of these new materials for practical device applications.

D. Bimberg (Technical University, Berlin, West Germany) gave a thorough, scholarly invited paper dealing with the influence of interrupted growth on the luminescent properties of quantum wells.

Finally, I call attention to the work of the research group at the University of Glasgow (Scotland, UK), led by J.H. Marsh. Planar integration of linear and nonlinear III-V multiquantum-well optical components was the topic of Marsh's talk. I found it particularly interesting how the speaker approached the significance of the nonlinear optical processes present in monolithically integrated active and passive optical components within the same epitaxial layers.

In summary: this conference supplemented well the sessions on integrated optical and optoelectronic devices that were presented in the Advanced Optoelectronic Technology conference. The complete Proceedings of the conference discussed in this note will be available by June 1988 from SPIE (PO Box 10, Bellingham, Washington 98227-0010), as Volume 861 in the well-known Symposium Proceedings Series. The price (for nonmembers of SPIE) is $43.00.

NEWS, NOTES AND ABSTRACTS

British Boost for Nanotechnology Projects

It has been recently announced that the UK Department of Trade and Industry, through the intermediary of the National Physical Laboratory (NPL), makes substantial funds available for the support of projects which can lead eventually to the commercial exploitation of nanotechnology techniques. The purpose of the program is to stimulate more UK activity and assist UK companies to become more competitive in world markets. However, this is not an industrial process-technology effort; it rather emphasizes innovative basic research and development projects likely to lead to improvements in manufacturing techniques and the development of new commercial products and processes. In line with this philosophy, industry and academic institutions will be encouraged to initiate collaborative projects. They may receive support of up to 50 percent of eligible costs. Attention will be initially concentrated on applications in the fields of ultraprecision mechanical engineering, metrology, materials research, and optics.

Interestingly enough, NPL was chosen to be the coordinator because of its early success in nanotechnology in x-ray optics. This research led to development of precision bearings. A current application is in the ductile-mode and subsurface damage-free machining of materials normally considered to be brittle (such as glasses and ceramics) which is possible if the depth of cut can be controlled to 100 nm or better. The objective is to eliminate the need for lapping and polishing in optics and electronics, so that a grinding machine will impart an optical finish.

Future progress is needed in optics where surface finishes in the region of 0.1 nm (peak to valley) and surface figures accurate to a few nanometers are required for mass production of, say, laser gyroscope mirrors or for x-ray optical components (used in x-ray lithography, microscopy, materials analysis, etc.). Yet another area to be supported by the new program is nanotechnology in the production of thin optical films and coatings.

Paul Roman

Superior Integrated Photon Counter marketed in England

Lambda Photometrics Ltd. (UK) recently announced the availability of a fully integrated, versatile, compact, computer-controlled, inexpensive photon (or particle) counting instrument, labeled SR400. It can operate in boxcar, lock-in, background subtraction, source compensation, pile-up correction, and many other modes. The count rate is 200 MHz and the pulse pair resolution is 5 ns. It is claimed that the signal-to-noise ratio approaches the theoretical limit.

Some further details may be found in MASB 30-88. For additional information please contact directly the Marketing Manager, Lambda Photometrics Ltd., Lambda House, Harpenden AL5 5BZ, UK. Telephone: (011-44-5827) 64334.

Paul Roman

UK Plans New R&D Program for Information Technology

In late March, the UK's Department of Trade and Industry (DTI) issued draft plans for the new national collaborative research and development program in information technology. The newly formed Information Engineering Directorate, which includes the former Alvey Directorate and parts of the former Electronics Application Division, will be responsible for most of the DTI's support of collaborative research and development in information technology.

The draft plans, which have not yet been formally endorsed by Government, represent a first approach to the program and were issued for consultation. Comments were invited from the research community and others with an interest.

The three research areas will each be monitored by a director, seconded to the Directorate from outside the DTI (including industry). They cover:

- Very large scale integrated (VLSI) advanced microchips and computer aided design (CAD)
- Systems architecture, including parallel processing, speech, vision, and distributed systems
- System engineering, including intelligent knowlege-based systems, software engineering, and human/computer interface.

The proposals also cover work that may be done under other related programs such as ESPRIT.

C.J. Fox

West Germany is a Leading Player in the European Integrated Services Digital Network Buildup

The German Federal Post Office initiated two pilot projects (in Mannheim and in Stuttgart) in order to test the Integrated Services Digital Network (ISDN), which is to provide an integrated network for all forms of telecommunications. These two projects, each handling some 400 users from the administration and business sectors, represent the start of a European system capable of simultaneously transmitting voice, text, video-picture, data, and on-line drawn diagrams. By the fall of 1988, ISDN will be commercially available throughout West Germany, and it is hoped that by 1993 most of the nationwide demand for ISDN ports and networks will be met. By then, integration with other countries will have also proceeded substantially.

The system allows for very sophisticated communications. For example, while conducting a telephone conversation or even a videophone interaction, a user will be able to telefax on the same line a text to his partner, or use a "telewriter" for simultaneously transmitting explanatory diagrams.

Most of the sophisticated digital switching equipment (and much of the peripherals) will be supplied by Siemens A.G. The compact, high-performance CP 113 switching processor recently developed and demonstrated by Siemens is claimed to be the most powerful in the world. It controls the setting-up of calls between subscribers, and it also records and administers traffic and change data. Its final version will serve up to 250,000 lines, and will be able to carry out 1.2 million "busy hour call attempts."

Paul Roman

West German Breakthrough in Conductive Polymers

Even though electrically conductive polymers have been known for over a decade, their lack of stability and low conductivity made practical applications seem remote. However, in late 1987, the Max Planck Institute for Polymer-Research, in Mainz, and the University of Bayreuth reported that they developed a stable polyacetylen compound which has conductivity as high as metals.

The research was done within the heavily sponsored materials-science program of the West German Federal Ministry for Research and Technology (BMFT); industrial scientists were also involved.

Interested colleagues may contact directly the Direktor, Max Planck Institut, Saarstrasse 23, Postfach 3060, D-65 Mainz, West Germany.

Paul Roman

West Germany Launches Long-Term Subsidy Program for Neural Networks

In January 1988, the Federal Ministry for Research and Technology (BMFT) of West Germany initiated a 5-year subsidy program to further research and development in the area of neural networks. A second project phase is expected to follow, with the aim of implementing nationwide the systems to be developed during the first 5-year phase. The close attention paid to the area of neural networks (or more generally, connectionalist computer systems) by the federal German government is further emphasized by the fact that 50 percent of the funding of this program has been "scavenged" from other, already running programs.

The program, at this time, focuses on algorithms for data representation and system organization. Emphasis will be placed on methods of expressing external sensory and motor situations, and on methods suitable for perceiving, evaluating, and generalizing knowledge in a neural network. It is expected that the proposed projects will pay special attention to the development of flexible systems that can function in a variety of changing and unpredictable conditions.

Industry, research institutes, and universities are all invited to participate in the BMFT's program, which, incidentally, is coordinated by scientists in the Information Sciences Division of the J. Gutenberg University in Mainz.

Paul Roman

Superb Diode Laser Arrays from Siemens

About a year ago I reported that Siemens A.G. (West Germany) had begun marketing a variety of phase-coupled laser array diodes (see *ESN* 41-9:528 [1987]). However, recently Siemens terminated the production of these simple heterostructure devices and developed superior graded-index, separate-confinement heterostructure single-quantum-well laser arrays. These new GaAlAs systems have a remarkable efficiency (over 0.7 W/A) and output power up to 1.2 W in CW operation (or 2 W in pulsed operation). The customizable frequencies range from 780 nm to 885 nm. The spectral bandwidth can be arranged to be between 2 and 4 mm. Threshold currents vary between 125 mA and 280 mA.

One version is a simple 12-stripe array, and it can now be ordered off-the-shelf. Another version is a $5\times(1\times12)$-stripe laser array (mounted on a 10-mm row), which has a 1-W/cm package density. So far, only

samples are available. Tests with this latter device demonstrated that, when used for pumping a Nd:YAG laser, the latter had a stunning CW output: 100 W.

Preliminary work has been successfully completed toward the fabrication of these single-quantum-well laser arrays with 40 stripes. When operating in CW mode at a moderate output level (1 W), these experimental devices exhibited lifetimes of up to 4x10 hours.

Some additional technical details and some specifications of the currently available devices can be found in MASB 16-88. For further information, please contact directly: Konrad Pöbl, Deputy Director, Components Group, Siemens A.G., St. Martin Str. 53, D-8 Munich 80. Telephone: (011-49-89) 4144-2770. Please refer to this news item.

Paul Roman

Sum-Frequency Generation of Coherent Ultraviolet Radiation

Lambda Physik GmbH, Göttingen, West Germany, reported recently the successful conclusion of experiments in which sum-frequency generation (SFG) in the novel nonlinear crystal beta-barium-borate (BBO) led to tunable ultraviolet (UV) radiation in the range between 189 and 197 nm.

In the research conducted by W. Muckenheim (and including also Hungarian scientists), one commercial dye laser was frequency doubled and set to the fixed wavelength of 248.5 nm. A second, tunable dye laser was operated in the infrared between 780 and 950 nm. The first frequency-doubled laser had a pulse energy of 4.5 mJ, and the second laser's output varied between 8 and 1.5 mJ. The mixing of these outputs in the BBO crystal produced UV radiation, covering continuously the range between 188.93 and 197 nm. (Between 191 and 192 nm, and also between 194.5 and 195.1 nm, some absorption intervened.) The maximal output pulse power was 100 μ J, and in the entire range it was well over 20 μ J (with the exception of the two absorption windows, where it fell below 10 μ J.) The efficiency of the SFG process ranged from 0.3 to 3 percent over the main parts of the tuning range.

In a subsequent experiment, the frequency-doubled dye laser (with the fixed, short wavelength) was been replaced by various KrF excimer lasers operating at 248.5 nm. The SFG process was used to produce radiation at 193 nm. When a broadband picosecond excimer laser (with a 20 MW/cm^2 output power density) was used, the SFG efficiency reached 7 percent.

Paul Roman

A Spanish Private Foundation for the Support of Basic Research

There are several medium-sized, stable, private foundations in Spain which have a very important role in promoting basic research at the universities and at research laboratories of other institutions. These foundations work somewhat differently from the large American foundations (Ford, Carnegie-Mellon, etc.) in that they are more project-oriented and keep in closer touch with leading figures in the country's scientific community. An excellent example is the Fundación Ramón Areces (FRA), with head offices in Madrid (Paseo de la Castellana 93, E-28046 Madrid). It was founded in 1976 by the industrialist Don Ramon Areces Rodriguez. As a "private cultural foundation," by law it is under the protection of the Ministry of Education and Science. The mandated objectives of FRA are the furthering and development of scientific and technologic research in Spain, and also general assistance in national education and culture.

These objectives are pursued by three approaches:

- A competitive grant support program, for preannounced, definite scientific or technical project-areas
- An incidental assistance program for other projects presented by institutions or individuals
- Cultural activities and publications, as well as conference support activities.

Overwhelming tactical (if not fiscal) emphasis is put on the competitive, "thematic" grant program. Currently there are, each year, about 10 projects in this program. The amount of support rendered is over 150 million pesetas ($1.3 million). The ad hoc support program receives 200 million pesetas ($1.73 million); and the cultural activities program involves 95 million pesetas ($840,000). The division of monies between the three activities may vary substantially from year to year.

An insight of the broad scope of the competitive grant program may be gained by listing the nine project areas that have been supported in the 1984/85 fiscal period:

- Solar energy
- Oceanology
- Robotics
- Sweet-water resources
- Protein production in agriculture
- Neuroscience
- Plant-cytopathology and genetics
- Cardiovascular diseases
- Fetal diagnosis

Despite the apparently "practical" aspects of these project areas,

special interest is payed to proposals that treat the fundamental, basic aspects of the topic.

I have the latest available Annual Report of FRA, and could copy parts referring to the above-listed nine topical areas.

Paul Roman

ESPRIT 2 Gets Formal Go-Ahead

ESPRIT 2, the second stage of the European Community's R&D program on information technology (RACE), was endorsed by the European Community's Research Ministers in Luxembourg on 11 April.

ESPRIT 2 commits 1.6 billion ECU (around $2 billion) to be spent by the Community on collaborative information technology research over the period until 1992. An equivalent amount will be spent by participants, giving a total program expenditure of 3.2 billion ECU ($3.9 billion). This will be for collaborative, precompetivie research involving industry, higher education institutions, and research bodies.

C.J. Fox

ONRL Cosponsored Conferences

ONR, London, can nominate two DOD employees for registration-free participants in the conferences ONRL supports. Readers who are DOD employees and are interested in a free registration to one of these conferences should write to the Scientific Director, ONRL, Box 39, FPO New York 09510. (Please site reference number.)

IUTAM XVII International Congress on Theoretical and Applied Mechanics, Grenoble, France, 21-27 August 1988. (81033)

Thermodynamics Applied to Biological Systems, Sta Margherita, Italy, 11-17 September 1988. (81012)

Physical Mechanisms in Polymer Failure, Lausanne, Switzerland, 16-30 September 1988. (810023)

2nd Workshop on Imagery and Cognition, Padora, Italy, 21-23 September 1988. (81018)

Technical Development in the Area of Submillimeter and Far Infrared Technology, Zermatt, Switzerland, 22-25 September 1988. (81022)

ONRL REPORTS, SCIENCE NEWSBRIEFS, AND MAS BULLETINS

Reports

To request reports, indicate the report number (in parentheses after the title and author's name) on the self-addressed mailer and return it to ONR, London.

Biological Sciences

Biotechnology Conference: Diagnostics' '87, by Claire E. Zomzely-Neurath. **(8-006-C)** A detailed review is given of selected topics presented at this conference held in December 1987 at Cambridge, UK. Topics include thin-layer technology, single-step immunoassays, rapid microbial assays, diagnostic applications of DNA probes, DNA probe *in situ* hybridization assays, new amperometric biosensors, and application of electrochemical methods to immunoassays.

Biotechnology Conference: Drug Delivery and Drug Targeting Systems, by Claire E. Zomzely-Neurath. **(8-007-C)** Presentations given at this conference, held in December 1987 in London, UK, are reviewed in detail. Topics include development of new dosage forms; controlled release (including and dosage forms, in plants, and transdermal systems); the possibilities and limitations of greater selectivity in targeted delivery of currently available systems such as liposomes, macromolecules, monoclonal antibodies, and prodrugs; and delivery of peptides and proteins via the gastrointestinal and nasal routes.

Computational Physics

16th International symposium on Shock Tubes and Waves, by David L. Book. **(8-008-C)** Selected presentations given at this symposium held at Aachen, West Germany, are discussed. Topics are: shock experiments, Mach reflection, and computational methods.

Oceanography

Assessment of Ocean Optics, Remote Sensing and Numerical Modeling in Europe – 1986-87, by Jerome Williams. **(8-005-R)** The focus of this report is on those institu-

tions which were doing the most significant work in Europe in optical oceanography, remote sensing, and numerical modeling during 1986-87. The work of each of the institutions in its strong area of research is reviewed.

Science Newsbriefs

The following issue of *Science Newsbrief* has been published by the ONR, London, Scientific Liaison Division during April. *Science Newsbrief* provides concise accounts of scientific research developments, meeting announcements, and science policy in Europe and the Middle East. Please request copies, by number, from ONR, London.

6-5 Erasable Optical Memory Materials, Patras, Greece, by Louis Cartz

MAS Bulletins

The following *Military Applications Summary (MAS) Bulletins* were published by the ONR, London, Military Applications Division during May. The *MAS* Bulletin is an account of accomplishments in European naval research, development, test, and evaluation. Request copies of the Bulletins, by number, from ONR, London.

28-88 Lighweight Torpedo Recovery System
29-88 Fire Fighting Foam Proportioner
30-88 Superior Fully Integrated Photon Counter
31-88 High-Resolution Scanning Sonar for ROV Installation
32-88 Seabed Surveillance Sonar
33-88 Encapsulated Diver's Communication Headsets

REPORTS ON EUROPEAN SCIENCE AND TECHNOLOGY FROM OTHER COMMANDS

Reports

Information on the reports listed below was furnished by the activity identified by the abbreviations for that office. Report numbers are given in brackets after the titles. Requests for copies of or information about these reports should be addressed to the appropriate office:

USARDSG – US Army Research Development and Standardization Group, Box 15/65, FPO New York, 09510-1500
EOARD – European Office of Aerospace Research and Development, Box 14, FPO, New York 09510

Multidiscipline

Swiss Center for Electronics and Microtechniques, by LTC LaRell Smith, EOARD. (32 pp) [EOARD-LR-88-05]

The Swiss Center for Electronics and Microtechniques is an applied research center with roots going back to the Swiss watch industry. They have several outstanding projects which are state-of-the-art in both lubrication and optoelectronics. They have developed coating processes for ball bearings which produce possibly the best low-friction bearings in the world (TiN and TiC coated). They also claim to have produced the first successful integrated inteferometer – i.e., a complete interferometer on a single chip. This report describes most of the their current research.

Aerospace Research

Italian Research Interests, by COL Phil Conran, EOARD. (4 pp) [EOARD-LT-88-26]

This report covers a brief review of some of the facilities in and around Rome that are active in Aerospace R&D efforts. Principal agencies visited included the Italian AF R&D Center at Pratica di Mare, the Italian Space Agency, Aeritalia, Centro Sviluppo Materiali, and Selenia.

Biological Sciences

Overview of Research Related to Neuroscience, by MAJ Jim McDougal, EOARD. (5 pp) [EOARD-LR-88-09]

Several interesting projects from Technion were reviewed during a visit in November. Professor Bear and coworkers have developed a compartmental model for the human cerebrovascular system which describes flows and pressures of cerebro-spinal fluid and blood in the brain. Dr. Spitzer is involved in single cell recording in the visual areas of Macaque monkeys and relating responses to task difficulty and selective attention. Dr. Gur, also working with the "behaving" monkey, is investigating the specific role of each laminae within the global architecture of the striate cortex. Dr. Hadani is researching mathematical models for human space perception and dynamic visual information as they relate to machine advance filtering methods in head teleoperated systems and helmet-mounted displays.

Drs. Gopher and Lavie are investigating performance and sleep as they relate to attentional processes.

Chemistry

10th International Conference on Molecular Energy Transfer (COMET X), by LTC LaRell Smith, EOARD. (22 pp) [EOARD-LR-88-22]

This conference was held in Emmetten, Switzerland, from 23-28 August 1987. Among the highlights were the apparent settling of long-standing disputes about the contribution of internal energy and the effects of vibrational and rotational states, and the discussion of numerous new spectroscopic methods and tools to investigate ultrafast phenomena and isolate particular energy states. The field has progressed far enough for researchers to confidently talk about the possibility of things like "level specific chemistry" and "laser catalysis" as viable means of controlling reactions and directing specific products. This report covers highlights of the conference and provides abstracts of some selected papers.

Fluid Mechanics

The Swiss Federal Institute of Technology at Zurich, by LTC Bob Winn, EOARD. (4 pp) [EOARD-LR-88-34]

This technical institute is one of two in Switzerland which can grant a Ph.D. in Engineering. This report describes the Institute for Fluid Mechanics, which is part of the Department of Mechanical Engineering. In particular, the department's unique and extremely accurate skin friction drag measuring capability is described.

Turbulence Modelling, by MAJ Tom Speer, EOARD. (4 pp) [EOARD-LR-88-32]

Fluids research is carried out at both the University of Manchester Department of Aeronautical Engineering and the University of Manchester Institute of Technology (UMIST) Department of Mechanical Engineering, UK. UMIST's group, under the leadership of Professor Brian Launder, is a leader in turbulence modelling and computation of turbulent flows, including secondary flows. Current research is concentrated on flows in ducts with bends or undergoing rotation, and on flows in duct junctions. A key goal of the several lines of research is to be able to compute the internal flows of turbine blade passages.

Geophysics

Global NWP R&D, by Owen Cote, EOARD. (27 pp) [EOARD-LR-88-27]

Dr. Palmer presented two seminars, "Parametrization of Subgridscale Orography" and "On the Prediction of Forecast Skill," to the global numerical weather prediction model development group at the Air Force Geophysics Laboratory. He discussed the need for parametrization of orographic gravity wave drag for high-resolution global NWP models and substantiated its use by reference to ECMWF model results and statistics. Dr. Palmer's report includes comments on papers presented at the Bjerknes Memorial Symposium. These comments are extensive and should be of interest to those in the DOD responsible for supporting Global NWP R&D.

Material Sciences

Dispersion Strengthened Aluminum, by LTC Jim Hansen, EOARD. (6 pp) [EOARD-LR-88-06]

Professor Jangg of the Technical University of Vienna, Institute of Chemical Technology, has developed a dispersion-hardened aluminum alloy with Al_4C_3 dispersoids. Produced by reaction milling of aluminum powders with carbon black, a 12-vol- percent carbide alloy has excellent high-temperature properties. A 500°C soak for 100 hours causes essentially no loss in strength, with ultimate tensile strengths of 400 MPa and 180 MPa at room temperature and 500°C, respectively, for laboratory material.

Ultrasonic Fatigue Testing and Powder Processing, by LTC Jim Hansen, EOARD. (4 pp) [EOARD-LR-88-23]

Two separate research groups at the University of Vienna are applying ultrasonic vibrations to fatigue testing and powder metal and ceramic processing. Fatigue testing is accomplished in a factor of 100 to 1000 reduction in time. Research topics in fatigue include short fatigue crack growth, study of frequency effects, evaluation of Ti and Al-Li alloys, combined load effects and random fatigue loading. Compaction of both ceramic and metallic powders is aided by addition of ultrasonic vibrations.

Physics

Electromagnetic Gun Research at the Royal Armaments Research and Development Establishment, Fort Halstead, UK, by Dr. Vince Donlan. (2 pp) [EOARD-LR-88-30]

Work on EM guns at RARDE began in 1982. The research group has since grown to about ten professionals. Current emphasis is on tank and artillery applications of rail guns. To date, they have built a 2-meter rail gun which is housed in an instrumented 300-meter range. The RARDE funding has recently been augmented by a multiyear contract from the SDIO. This report contains details of this EM gun program based on an EOARD liaison visit to RARDE on 8 February 1988.

Fluorescence Research in Organic Dye Thin Films, by Dr. Stacey Lazdinis, EOARD. (4 pp) [EOARD-LR-88-28]

This report describes the research performed at the Institute of Experimental Physics of the Karl Franzens University in Graz, Austria

in time-resolved, picosecond, laser spectroscopy of surface-enhanced optical phenomena; the fluorescence of organic dye molecules; and the production of organic molecular thin films with the Langmuir-Blodgett technique. The Institute possesses unique capabilities to produce, and perform *in situ* diagnostics on, organic thin films which are of interest in the production of semiconductor devices.

THE EMBASSIES: TECHNOLOGY ROUNDUP

ITALY

For further information on Italian items, contact Dr. Gerald Whitman, Office of the Science Counselor, American Embassy, Rome, APO New York 09794-0007.

New Superconducting Material Tested in Milan. Researchers in CNR's Institute for the Technology of Nontraditional Metallic Material in Cinisello, Balsamo (near Milan) have developed a bismuth-strontium-copper-oxygen compound which becomes superconducting at minus 165°C. This temperature is 15°C higher than that reached by YBCO (yttrium, barium, copper, and oxygen). Bismuth is also more easily available than yttrium.

Fiat and CNR Sign Research Agreement for Clean Engine. The National Research Council's Motors Institute in Naples and the Fiat Research Center are developing a "clean" internal combustion engine that should be ready in the early 1990's. The researchers hope to produce a motor with minimal emissions and noise. Initial financing for this project totals 1 billion lire (about $800,000 [$1 = 1200 lire]).

Research Development Financing for Italy's South. The Minister for Scientific Research, the President of the National Agency for Nuclear and Renewable Energy (ENEA), the President of the National Research Council (CNR), and the president of the National Institute of Nuclear Physics (INFN) have committed for 1988-90 an additional 1088 billion lire for research and development in Italy's south. CNR will invest 740 billion lire in the first 3 years and another 760 billion lire in the 1991-1993 period, targeting development in agriculture, biotechnology, environment, informatics, and art preservation. ENEA is investing 300 billion lire in aquaculture, renewable energies, biomass energy, and new coal technologies. INFN is investing 48 billion lire to upgrade its research centers in Naples, Bari, and Catania and to create two more centers in Lecce and Cagliari.

The Minister of Scientific Research also presented legislation to parliament providing 450 billion lire to revitalize the Naples Aerospace Research Center (CIRA) and to provide 25 billion lire for the 1988-90 period for graduate and undergraduate fellowships in the south.

National Institute of Statistics Publishes Data on Research in Italy. According to the National Institute of Statistics 1987 data on scientific research in Italy, total spending amounted to 12,230 billion lire (about $10.2 billion) with an increase in real terms over 1986 of 4.6 percent. Of this amount, 7405 billion lire were spent by the private sector and 4825 by the public sector. The percentage of S&T spending amounts to 1.2 percent of the gross national product. The "patent gap" (technology imports vs. exports) reached 730 billion lire, according to the statistics.

New Method for More Resistant Superconductors. Italian physicists belonging to the National Institute of Nuclear Physics, the Interuniversity Consortium of Physics of Matter, and Selenia Spazio have developed a superconductor with mechanical resistance and chemical stability comparable to that of traditional ceramic material. The research, which adds another gas to YBCO material, is covered by an international patent.

Bio-Manipulation Saves Lake Near Turin. The National Research Council's Institute of Hydrobiology of Pallanza has successfully controlled algae growth in a small lake near Turin through bio-manipulation. The institute introduced a small crustacea, *Daphnia Hyakina,* also known as a "water flea" that eats great quantities of algae. The results were also enhanced by selective control of the fish population.

ENEA Sponsors the First Italian Breeding of Predator Insects. ENEA, the Italian Agency for Nuclear and Renewable Energies, is sponsoring with the Emilia Region in the town of Forli the first breeding of predator insects to protect various crops instead of using traditional pesticides. The insects are *crysoperla carnea, trighogramma maidis, diglyphus isaea,* and *encasia formosa.* ENEA will finance 50 percent of the project, estimated to cost 2 billion lire (about $1.6 million). ENEA is presently studying the opening of other breeding ing centers in Tuscany, Latium, Sicily, and Veneto.

New Magnesium Atomic Clock. Professor Franco Strumia of the University of Pisa has built a magnesium-based atomic clock which he claims is the most accurate in Europe and surpassed only by the cesium-based clocks of the US Bureau of Standards and the Canadian National Research Council. Professor Strumia believes that the magnesium clock can be made superior to the cesium clock through laser modulating techniques to achieve an accuracy of a second every 10 exp 15 seconds.

Italian Air Force to Build Military Satellite. The Italian Air Force has decided to proceed with the construction of Italy's first military communications satellite. Named Sicral (Satellite Italiano Per Le Communicazioni Rapide Ed Allarmi), the satellite will have four UHF spiral antennaes and two parabolic antennaes for military communications, including NATO (7-8 GHZ), civil protection, (11-14 GHZ), and the Navy (20-44 GHZ). The 1700 kilo satellite is expected to be launched the end of 1993 or the beginning of 1994 by an Ariane 4 SLV and is expected to cost about 1000 billion lire (about $830 million). It will be built primarily by Selenia Spazio (70 percent), the French Firm Matra (18 percent) and by American industry (12 percent).

WEST GERMANY

For further information on West German items, contact Dr. Edward M. Malloy, Office of the Science Counselor, American Embassy, APO New York 09080.

Laser Technology. Laser technology has achieved limited penetration of important scientific, manufacturing, and industrial fields in Germany, according to Minister for Research and Technology, Dr. Heinz Riesenhuber. He inaugurated a new funding program primarily for small and medium-sized companies of DM200 million (about $119 million [$1 = DM1.68]) for 1988-1990. The project money will predominantly assist joint research projects (Verbundforschung) in which companies and research institutes cooperate closely to guarantee a quick transfer of technology between the partners, enabling an undelayed commercialization of new products and manufacturing techniques.

List of Mutational Chemicals. The Federal Health Office (Bundesgesundheitsamt-BGA) in Berlin has compiled a list of chemicals with mutational effects. This is the first attempt within the European Communities to classify mutational substances as hazardous materials. The BGA lists 182 chemical substances which cause mutations in the reproductive cells of mammals and thus may cause genetic defects. The BGA will make this compilation available to the EC Commission at Brussels as a working paper.

Institute for Discrete Mathematics at Bonn University. An Institute for Discrete Mathematics was inaugurated at Bonn University on February 1. The main objective of the new institute is the development of complicated logic chips, a first priority for the optimization of highly integrated circuits. A cooperative agreement has been concluded for a 5-year period with IBM, which will make available a large-scale computer and graphic processor with a total value of DM10 million, as well as DM25 million financial assistance. The institute's annual budget of DM175,000 is funded by the state of North Rhine-Westphalia.

Technology Agreement. An agreement on scientific and technological cooperation was signed on February 25 at Bonn by the Bulgarian Minister for Economics and Planning, Owtscharow, and West Germany's Foreign Minister Genscher and Minister for Research and Technology, Dr. Riesenhuber. The agreement is to promote joint research in such fields as shipbuilding, nuclear energy, biology, and philosophy. West German institutions involved at present are the Nuclear Research Center at Juelich, the Max-Planck Institute for Polymer Research, and the universities at Hamburg and Cologne as well as scientific institutions in Berlin.

Aids. In the beginning of 1988, an aids center was established at Berlin, associated with the Federal Health Office (Bundesgesundheitsamt - BGA), to serve as an interdisciplinary scientific advisory institution. Its main functions are:

- Epidemiology: registration of aids cases and infections; evaluation of epidemiological situation; projecting future developments
- Virus diagnostics: evaluation of established and new diagnostic procedures, evaluation of molecular-virological knowledge on pathogenesis, therapy, and prophylaxis
- Collection and evaluation of national and international knowledge on behavioral risks
- Research promotion and coordination, and information and documentation.

Participation in the Superconductor Supercollider Project. In April this year, Dr. Rembser, Assistant Secretary in the Research Ministry, reiterated that West Germany was unable to contribute to the capital or construction costs of the proposed Superconducting Supercollider (SSC), but would wish to participate in scientific experiments at the SSC. In fact, he reiterated potential German interest in participating in scientific experiments and instrument development in the SSC, but reasserted that due to the high level of budgetary commitments to DESY and CERN, West Germany would be unable to make capital or construction cost contributions. Schunk noted that German high energy physics (HEP) spending is already so high that administration officials are extremely reluctant to consider additional government support. While German scientists do not begrudge the investment in HEP, they must compete for limited funds and look

forward to the day when major HEP expenditures will begin to tail off. Rembser also repeated his earlier suggestion for US-European cooperation in first exploiting the Hadron collider in the large electron-position tunnel at CERN and then building a linear accelerator in the United States. He suggested that the meeting in Vancouver, May 10-12, of the HEP working group of the economic summit follow-up group on technology growth and employment (TGE) would be the perfect place to discuss HEP international cooperation. The working group, described as one of few TGE working groups still functioning, will attract high-level participants from the Economic Summit countries.

FRANCE

For further information on French items, contact Mr. Robert K. Carr, Office of the Science Counselor, American Embassy, Paris, APO New York 09777.

US/France Scientific Meeting on Ocean Engineering Research. National Science Foundation (NSF) senior associates, N. Caplan and J. Vadus, together with 11 scientists and engineers from US academic and research institutions, met with French officials and scientists from 13 through 15 April 1988. The meeting was the second of a series designed to develop program definitions for three areas in ocean systems engineering research: robotics and autonomous underwater vehicles, materials in ocean environments, and marine biotechnology.

The meeting was hosted by the Ministry of Research and Higher Education (MRES). Scientists from both countries in the respective groups each made visits to selected French laboratories to discuss mutual research interests.

At a summary meeting on April 15, enthusiasm for collaboration was expressed by participating scientists from both countries. Representatives from MRES expressed similar enthusiasm. A report is being developed jointly by the scientists and engineers to recommend a program definition plan for each research area. A draft report for robotics is scheduled for completion by the end of June. The other reports will be developed later this year.

The Directorate for Engineering at NSF will continue discussions with MRES to develop terms for collaboration and other administrative and management arrangements. It is possible that research under the program could be initiated sometime in FY-89.

SWEDEN

Sweden to Join the EC (in Science). Sweden has decided to pay the entrance fee, SEK10 million (about $1.7 million), which will admit Sweden to the European Community's scientific personnel exchange program.

Sweden will participate in the science program, which is designed to create a "researcher's Europe," promoting increased mobility across the borders while at the same time attempting to stem the scientific brain drain from Europe. EC's science programs are open only to members, but research and development programs generally welcome other nations under a bilateral agreement which Sweden is prepared to sign.

The science program does not address any particular industrial sector or branch. The program will emphasize interdisciplinary technology research in the following fields: mathematics, physics, chemistry, biosciences, maritime research, geology, mechanics of materials, flow mechanics, and the development of scientific instruments.

NORWAY

The Norwegian Space Center. In an attempt to prioritize space research, Norway recently created an independent unit to carry out its scientific program – the Norwegian Space Center (NSC). Established as of June 1987, the center represents a beefed-up version of the Royal Council for Scientific and Industrial Research's former Space Division.

Consistent with new emphasis on space research, and prior to establishing NSC, Norway took one giant step in the direction of increased international cooperation: as of January 1, 1987 it became a full member of ESA, upgrading its affiliation to that organization from associate member status. Enthusiastic about the prospect of joint cooperation, the Norwegians decided to participate in ESA's Ariane V, Columbus Space Station, and Hermes shuttle projects, with a 0.4-percent share in the first two programs and a 0.2-percent share in the latter. The government calculates that the Ariane V project will cost it NOK111 million (about $18 million) between the years 1988-1996, while Columbus Phase 1 expenses (1988-91) are pegged at NOK22 million ($3.6 million).

Specifically, Oslo sees Columbus participation as a way of (1) improving its own remote sensing capabilities, (2) promoting industrial research concerning the exploitation of offshore technology in outer space (and vice versa), (3) developing local expertise in aerospace software, and (4) helping the country maintain its edge in the certification and quality control market. Similarly, joint Hermes efforts, the Norwegians think, would involve experimentation at the government's ocean laboratory in Trondheim and generate added business for the country's certification firms.

The Norwegians view ESA participation as the perfect vehicle for strengthening the country's research ties with the major European nations. Cooperating scientifically with EC countries like France and West Germany, it is felt, compensates a bit for any lost opportunities brought on by Norway's non-EC status. Already, the Norwegian certification firm DET

Norsk Veritas has set up a 15-person space subsidiary – Veritas Industry Service Development A/S – which intends to devote its efforts to ESA-related testing and research.

NSC now finds itself going through an adjustment phase. In the wake of Norway's recent change to full membership status in the ESA and the hefty budget increases which resulted, the center now must decide what directions the Norwegian program should follow. With 76 percent of its 1988 expenditures devoted to ESA-related activities, though, it's clear that the Norwegian officials see cooperation with Europe as the main item on their agenda.

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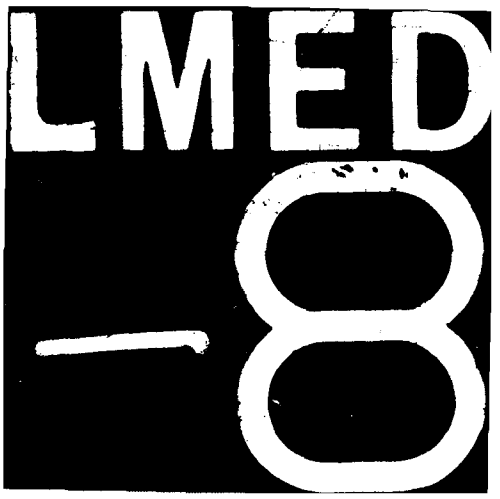
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