1993 E-MRS Spring Meeting Provides Forum for Materials Topics

Approximately 500 attendees from throughout Europe and elsewhere participated in eight topical symposia during the 1993 E-MRS Spring Meeting, May 4–7, 1993, in Strasbourg, France. Optoelectronic materials, light emission from silicon, and solidification processes elicited particularly strong interest.

In his opening message, E-MRS President Peter A. Glasow focused on issues related to research policy, and on a vision and awareness of cooperation across borders. "Future materials research, and research in other fields, too, will be characterized by three major features," said Glasow. He identified these features as (1) an increased urgency for innovative approaches and ideas to the products and markets of the future, (2) rising costs of R&D despite declining financial resources, and (3) globalization of world research markets. "Improving the effectiveness of research and, of course, even more, promoting enthusiasm and motivation in research are important objectives," he said.

The following summaries provide highlights of symposia held during the 1993 E-MRS Spring Meeting. For additional information, contact: Paul Siffert, E-MRS Secretary, BP 20, 67037 Strasbourg Cédex 2, France. Phone 33-88-28-65-43; fax 33-88-28-62-93.

Materials for Optoelectronic Devices, OEICs, and Photonics (Symposium A)

Chairs: J.P. Hirtz, Thomson-CSF, Orsay, France; H. Meier, IBM, Rüchlikon, Switzerland; C. Whitehouse, DRA, Malvern, United Kingdom.

About 100 scientists from 15 countries attended this symposium. This meeting was designed to provide a linkage for a large community working on different materials with several growth technologies, specific material characterizations, and processing for a variety of device structures.

Half of the presentations concerned the epitaxial growth of heterostructures and multiquantum wells for semiconductor materials (III-V, II-VI, IV-VI, SiGe/Si). Several invited talks reviewed selective, nonplanar epitaxy or localized epitaxy. A model has been developed that describes the perturbation in materials characteristics produced by MOCVD selective area epitaxy (SAE) of InP, GaInAs, and GaInAsP, with an exploitation for the fabrication of an integrated laser/modulator. Nonplanar epitaxy was also dealt with in an attempt to relate the model to the findings of such structures as butt-coupled waveguides and buried-heterostructure layers.

An evaluation of the different epitaxial growth technologies for optoelectronic applications has shown the advantages of using both MOCVD and CBE for the SAE of GaInAs and GaInAsP-based integrated structures: MOCVD can produce the basic structures, and CBE leads to better uniformity in thickness and composition for SAE regrowth.

Shadow-mask MBE has been developed successfully for application to infrared lead chalcogenide buried-heterostructure lasers, fabricated with only one epitaxial step. Another third of these reports concerned device structures such as visible and IR lasers, vertical-cavity surface-emitting lasers, 1.3 μm SiGe/Si light-emitting diodes, MQW IR modulators, detectors, and self-electrooptic devices.

A recent breakthrough in II-VI semiconductor technology has resulted in blue and blue-green diode lasers that have direct application in displays as well as optical recording and printing. Tremendous progress has been made over the last two years on the issues of doping and interconnection, which are still limiting factors in CW room-temperature operations.

High-quality SiGe/Si heterostructures have been grown by RTCVD, a combination of susceptor-free heating and conventional CVD technology. The absence of nonradiative centers leads to strong photoluminescence (PL) from band-edge bound excitons at 4 K and free excitons at higher temperatures. Even though the alloys have an indirect bandgap, a characteristic feature of the PL is the strong nonphonon mechanism, attributed to the breakdown of momentum conservation due to the alloy randomness. With $Si_{0.8}Ge_{0.2}$ quantum wells, a room-temperature operation of 1.3 μm light-emitting diodes has been reported with an efficiency of 0.1%. Light emission at 1.55 μm has also been reported in a structure with a pure Ge quantum well only several layers thick. Two invited speakers gave a general overview of recent advances in laser diodes for pumping solid-state lasers and fibers. High-power laser diodes with a spectral emission matched with absorption bands of rare-earth ions are now being used as efficient pumping sources for solid-state lasers. With a monolithic surface emitting diode laser design (MOSEL), based on an LP-MOVPE epitaxial process on a nonplanar GaAs substrate, 1.5 kW/cm² at 808 nm under pulsed conditions, and 1 kW/cm² QCW have been demonstrated. 0.98 μm is the optimum wavelength for pumping erbium-doped fiber amplifiers and Er:Yb microlasers emitting at 1.55 μm. Aluminum-free GaInP/GaInAsP/GaInAs 0.98 μm lasers grown by gas-source MBE exhibit threshold current densities as low as 150 A/cm², with an internal quantum efficiency of 90%. Ridge-waveguide lasers launch an output power of up to 100 mW to free space in single-mode operation (CW RT) and 400 mW in multimode. Semiconductor devices based on organic semiconductors have been restricted so far by problems of materials processing. Conjugated polymers offer the combination of excellent materials properties: convenient processibility and tunable electronic properties. Poly (p-phenylenevinylene) (PPV) can be used as the active layer in an electroluminescent device in which a polymer layer is sandwiched between metals, charge injecting electrodes. The emission, just below the bandgap at 2.2 eV is the same as that produced by photoexcitation, and arises from radiative decay of the singlet exciton produced by combination of polarons injected from opposite electrodes. An efficiency of 1% (photons/electrons) can now be achieved through modification of the polymer or through selection of low work-function metals for the electron-injecting electrodes. The proceedings of this symposium will be published in a special issue of *Materials Science and Engineering B*

E-MRS President Peter A. Glasow (right) exchanges greetings with 1993 MRS President S. Thomas Picraux.

https://doi.org/10.1017/S0883769400038562 Published online by Cambridge University Press

before the end of this year. (Report provided by J.P. Hirtz)

Low-Temperature MBE III-V Materials: Physics and Applications (Symposium B)

Chairs: H.J. von Bardeleben, Universities of Paris 6 & 7, France; M.O. Manasreh, Wright Patterson AFB, United States; J.P. Hirtz, Thomson-CSF, Orsay, France.

The subject of III-V epitaxial layers grown by low-temperature molecular beam epitaxy (LTMBE) has seen rapid development in the last three years, particularly in the United States, where the Materials Research Society has already held different symposia devoted to this subject. The interesting aspect of this growth technique is that it allows the growth of layers with extremely high defect concentrations but still of excellent crystallinity. The electrical and optical properties are modified; in particular, highly resistive material can be elaborated, giving rise to many applications. Most results up to now have been obtained for LTMBE GaAs, but this technique can also be applied to all other III-V compounds and alloys.

At the E-MRS meeting, we focused our attention on the following:

- Growth and characterization of undoped highly resistive LTMBE III-V, epitaxial layers; GaAs, GaInAs, AlInAs, InP, and GaP;
- Application of LTMBE III-V layers in microelectronics; MESFETs, HFMTs, and MISFETs; and
- Optoelectronic applications of LTMBE GaAs.

A series of six invited papers gave an overview of the present activity in this field:

- LTMBE GaAs: Present Status and Prospective, by G.L. Wit of AFOSR;
- Point Defects in LTMBE III-V Materials, by P. Hautojävi, University of Helsinki;
- GaAs, AlGaAS, and InGaAs Epilayers containing As Clusters: Metal Semiconductor Composites, by M.R. Melloch, Purdue University, Indiana;
- Extended Defects and Precipitates in LTMBE Grown Materials, by A. Claverie, CEMES/LOE, CNRS Toulouse;
- Optoelectronic Applications of LTMBE III-V Materials, by J.M. Whittaker, University of Michigan; and
- Applications of LTMBE GaAs in Microelectronics, by U.K. Mishra, University of California-Santa Barbara.

As regards the defects in GaAs, interesting new developments on the presence of different types of arsenic antisites as well as vacancy defects and defect clusters have been reported. The report of a study of arsenic implantation and annealing in normal MBE-grown GaAs represented an original and innovative approach to the simulation of LTMBE GaAs, a nonstoichiometric, arsenic-rich material. The 18 papers presented in this symposium will be published together with the proceedings of Symposium A on Semiconductor Materials for Optoelectronic Devices, OEICs and Photonics. (Report provided by H.J. von Bardeleben)

Ion Beam, Plasma, Laser, and Thermally Stimulated Deposition Processes (Symposium C)

Chairs: H. Freller, Siemens, Erlangen, Germany; J.M. Martinez-Duart, Universidad Autonoma, Madrid, Spain; Y. Pauleau, National Polytechnic Institute of Grenoble, France; J. Dieleman, DSA Consultants, Waalre, The Netherlands.

This symposium covered recent trends and progress in the field of deposition processes stimulated by energetic particles provided by ion beams, plasmas, laser beams, or lamps. About 90 participants attended the symposium. The scientific program featured 12 invited speakers and 80 contributed papers (43 oral and 37 poster). The sessions covered many significant topics in sputter-deposition, laser-induced deposition processes, low-energy ion-assisted deposition and ion beam mixing, laser beam and ion-beam-induced surface modifications of materials, microwave plasma-enhanced CVD processes, surface chemistry in CVD and thermally-activated CVD processes.

The symposium started with an excellent invited talk by S. Berg (Uppsala University, Sweden) devoted to large-area selective thin-film deposition by bias sputtering. This process is promising for the selective deposition of, for example, aluminum lines on patterned Si wafers. A new ion beam thinning unit was described by P.B. Barna (Hungarian Academy of Sciences, Budapest, Hungary) and was applied to the study of MgO-Ni interfaces with metal films grown by sputter deposition; this equipment can provide smooth surfaces leading to improved depth resolution in TEM and Auger electron spectroscopy. Other papers focused on the relationship between the properties of sputter-deposited films and experimental deposition conditions, in particular for YBaCuO thin films.

A joint session with Symposium D was devoted to low-energy ion-assisted deposition processes and thermally activated CVD processes. H. Feil (Philips, Eindhoven, The Hague, Netherlands) talked about molecular dynamics simulation of low-energy ion/surface interaction. Important technical and scientific developments were reported by T. Shibata (Tohoku University, Sendai, Japan); the plasma-assisted deposition equipment allows precise control of the ion flux and energy, thereby enabling epitaxially grown Si films to be deposited at temperatures as low as 250°C. D.L. Kwong (University of Texas, Austin, U.S.) emphasized the major applications and advantages of RTCVD technology to ULSI materials processing and device fabrication. The heteroepitaxial growth of $Si_{1-x}Ge_x$ films from SiH_4 and GeH_4 performed at very low pressures and the properties of these films were reported by R. Reif (MIT, Cambridge, U.S.).

Numerous papers dealing with ion-beam-assisted deposition and ion beam mixing were also presented. Hard coatings (TiN), semiconductor films ($FeSi_2$) and also optical coatings (SiO_2) can be produced by these techniques. The use of increasingly sophisticated plasma-enhanced CVD techniques with *in situ* real-time measurements (spectroscopic ellipsometry) of the properties of films is now emerging in advanced technology to produce SiN_x for optical applications and diode AM-LCD, insulating SiO_2 and BN films, $Si_{1-x}C_x$:H films for electroluminescent devices.

The mechanisms involved in tungsten deposition by the H_2 reduction of WF_6 and selectivity loss were described by J.R. Creighton (Sandia National Laboratories, Albuquerque, U.S.); in particular, a reaction mechanism was proposed to explain the first order in H_2 pressure of the H_2 reduction of WF_6 recently found in conventional CVD and laser-induced CVD processes. The chemical reactions and mechanisms in the growth of amorphous hydrogenated Si films were presented and discussed by P. Hess (University of Heidelberg, Germany).

The growing importance of activated deposition techniques in the fabrication process for microelectronic and optoelectronic devices as well as for mechanical components was emphasized during this symposium. The proceedings will appear in 1994 and some papers will be published in a special issue of *Thin Solid Films*. (Report provided by Y. Pauleau)

Advances in Solidification Processes (Symposium F)

Chairs: H. Fredriksson, Royal Institute of Technology, Sweden; H. Jones, University of Sheffield, United Kingdom; G. Lesoult, School of Mines, Nancy, France.

The aim of this symposium was to

bring together metallurgists, physicists, and chemical and mechanical engineers to discuss the use of hydromechanics, thermodynamics, and kinetics in developing and understanding solidification processes. More than 150 people participated in the symposium, and the conference became a forum for the presentation and discussion of a wide range of topics mainly concerning crystallization kinetics, nucleation, and thermodynamics during solidification processes. Metastable solidification processing and the production of metal matrix composites were also discussed together with more conventional casting methods. Numerical and analytical models were presented in order to better describe and simulate different solidification problems. One of the main areas discussed was the simulation of different solidification processes. More than 100 papers were presented, organized into 10 subject areas. Invited speakers and contributors of oral communications and posters presented "research in progress." It was a pleasure to note that many researchers from Japan and the United States participated, made contributions, and presented papers at the conference.

Researchers from both industry and universities participated as well as researchers with different scientific backgrounds. Research in this field seems to be very active and a significant amount of new information was presented, indicating that the research and development will go on for many years. (Report provided by H. Fredriksson)

Materials Aspects of Ion Beam Synthesis: Phase Formation and Modification (Symposium G)

Chairs: P.L.F. Hemment, University of Surrey, Guildford, United Kingdom; Dr. J.A. Kilner, Imperial College, London, United Kingdom.

The best known application of ion beam synthesis is SIMOX technology, in which the nonequilibrium nature of ion implantation is exploited to form silicon-on-insulator (SOI) structures by the implantation of a high dose of high-energy ions. This is the most mature SOI technology, and silicon-processing houses are currently manufacturing high-performance CMOS/SIMOX circuits. The purpose of this symposium was to bring together materials scientists and engineers of like mind in order to stimulate further investigations not only of SIMOX but of other materials systems and applications. The two-day meeting consisted of five sessions with a total of 46 contributed papers from 12 countries plus six invited speakers from Australia, the United States, and Germany.

Topics reflected the wide-ranging interests of the participants, spanning synthesis of silicides, semiconductors, and dielectrics, including papers on electrical, optical, and structural characterization. The main sessions were synthesis of $CoSi_2$, synthesis of $FeSi_2$ and $NiSi_2$, SIMOX, surface and thin film modification, compound formation, and defects and characterization.

In an excellent, wide-ranging review, S. Mantl (Jülich) described recent developments in the science and technology of silicide formation. The contributed papers from the United Kingdom, Germany, and France which followed reflected the high level of activity in this field in Europe. J. Williams (Australia) discussed the phase transformations that occur during high-dose implantation. Contributed papers on Cu clusters in Al, Cu in AlN and formation of SiGe layers followed.

K. Jones (University of Florida, U.S.) reviewed the mechanisms responsible for secondary defect formation in SIMOX materials. Contributed papers described the optical and electrical characterization of the buried oxide.

The symposium was also the closing meeting of a U.K. collaborative project (IED 1777) to develop procedures for the preparation of thin-film SIMOX substrates for advanced fully depleted CMOS devices. (Report provided by P.L.F. Hemment)

Molecular Electronics: Doping and Recognition in Nanostructured Materials (Symposium H)

Chairs: W. Göpel, University of Tübingen; G. Zerbi, Politecnico di Milano, Italy; C. Ziegler, University of Tübingen, Germany.

This symposium was organized jointly by the Eurosensors Steering Committee and the ESPRIT Network of Excellence on Organic Materials for Electronics (NEOME). The aim was to bring together basic science and application-oriented scientists with particular interest in the controlled synthesis and engineering of organic materials.

More than 70 participants followed the seven oral sessions and one poster session with 15 invited and 4 contributed talks as well as 35 posters. The oral sessions concerned sensors, transport phenomena, organic superconductors, materials characterization and synthesis, devices, theory, supramolecules, and film preparation.

Nobel prize winner J.M. Lehn (Strasbourg) presented an overview of the possibilities of utilizing molecular devices. Other highlights included talks by P. Bäuerle (Stuttgart) concerning the design, synthesis, and assembly of new thiophene-based molecular functional units, by U. Neher (Mainz) in the field of photoconductivity in Langmuir-Blodgett films of phthalocyaninato-polysiloxane polymers, by J. Caulfield on a careful study of the Fermi surface topology in BEDT-TTF salts, by R. Friend concerning an overview of optoelectronic devices fabricated with conjugated polymers, and E. Thoden van Velzen on self-assembled monolayers of host molecules on gold.

A committee selected the best three posters: Doping and Stability of Ultrapure α-Oligothiophenes by D. Oeter et al. (Tübingen, 1st prize); Building Up and Structural Study of the First Two-Dimensional Polymer, by D. Lefevre et al. (Saclay, 2nd prize); and Main-Chain Thermotropic Liquid-Crystal Polymers Based on a Substituted Cyanostilbene: Synthesis, Thermooptic Observations and Linear Electrooptic Effect Measurements, by J. Tsibouklis et al. (Durham, 3rd prize).

In addition to the scientific program, an open forum was organized by NEOME to discuss the industrial applications of organic materials with participants from industry. As an introduction, short contributions were presented by Prof. Meijer (University of Eindhoven), Dr. Roth (MPI for Solid State Research, Stuttgart) and Dr. Visser (Philips Eindhoven).

The symposium was intentionally broad in scope and many talks of this general topic were presented. A trend was clearly seen toward careful materials synthesis, assembly, and optimization of properties of well-defined systems with control down to the atomic scale. Performances of electronic devices based on molecular materials were shown. Particular emphasis was put on chemical sensors with the principal potential of broad industrial applications, in which specific recognition sites of molecular materials can be utilized. The stability and reproducibility of interfaces between the inorganic and the organic world are a major concern in any research and application of thin-film structures, in particular if metallic contacts must be prepared for organic layers. Specific problems involving interfaces of molecular materials will therefore be stressed in next year's E-MRS symposium on molecular electronics. (Report provided by C. Ziegler) □

Information for this meeting report came from the E-MRS Newsletter, No. 8, Summer 1993, p. 3–7.