Japanese Scientists Predict 3D SOI Circuits Within Next Few Years

Two-dimensional SOI (silicon-on-insulator) circuits are expected to be available in the next 24 months and three-dimensional versions will be available in the early 1990s, according to *Electronic Week* (April 8, 1985), which summarized developments in this area described at the conference of the Japan Society of Applied Physics held in April.

Four developments by Japanese firms were presented, including papers by MRS members Nobuo Sasaki, a leader of the SOI group at Fujitsu Ltd., and Yoichi Akasaki, manager of the VLSI Process Technology Group at Mitsubishi Electric Co.'s LSI R&D Laboratory.

Mitsubishi's work on an experimental 1.1-kilogate array fabricated in laser-recrytallized silicon on a silicon dioxide insulating layer was reported, whose performance is near that of CMOS circuits fabricated on standard substrates. In an identical laser-recrystallization method, integrated-circuit fabrication technology was used to deposit a 500-Å nonreflecting thin film of silicon nitride on the polysilicon layer. A 5-μm-wide silicon nitride stripe with a center-to-center pitch of 15 μm was etched, and the layer was recrystallized by a raster scan with a 20-W beam tracing a line 100 μm wide.

NEC Corporation reported using a method to get a temperature profile suitable for laser annealing polycrystalline on a silicon dioxide substrate by scanning the wafer with a split laser beam.

Fujitsu fabricated a three-level CMOS static RAM in a substrate and two successive SOI layers. The cross-coupled inverters in the basic cell consist of two-p-channel transistors on the substrate, two-n-channel transfers on the first SOI layer and two-n-channel transfer-gate transistors on the second SOI layer.

Matsushita Electric Industrial Co. reported a three-level circuit using amorphous silicon and laser-beam recrystallized SOI on a semiconductor substrate. Eight optical sensors on the amorphous-silicon top layer, CMOS circuits on the SOI layer that convert the sensor signal to zero or one, and eight CMOS SRAMs on the substrate were included.

New Process for Refractory Metals Developed by Sandia

Sandia National Laboratories engineers have developed a new chemical milling process that has produced excellent results in machining molybdenum and is expected to be useful for other refractory metals and noble metals. The Electropulse Chemical Machining (EPCM) process uses pulses of direct current rather than a continuous current as in standard electrochemical machining. This results in etch rates an order of magnitude higher than those existing methods have achieved and an improved surface finish.

As current density approaches a maximum of 4300 amp/ft^2 the etch rate on a single-sided workpiece will reach 240 microinches per minute, compared to 12 microinches per minute reached by using the standard method.

Test apparatus consisted of a variable direct current power supply connected through a pulse generator to the reaction cell. The reaction cell consisted of a Pyrex electrolyte chamber with ⅛-in. thick walls and a cathode made of 5-mil rolled stainless steel stock cut into plates measuring 2 in. x 4 in. Temperature and stirring were adjustable from a central control console.

The test material was 1-mil thick rolled molybdenum stock, cut to approximately 2 in. square and coated with a 150 microinch thickness of photoresist polymer.

The reaction cell contained 750 ml of a combination etchant/electrolyte consisting of 128 g/l of potassium ferricyanide and 16.3 g/l of sodium hydroxide, maintained at a temperature of 30° C. Tests were performed using constant voltage (3-9 Vdc) and pulsed voltage (3-19 Vdc, 1 pulse per second).

Analysis of data from the experimental series showed that molybdenum was dissolved into the solution without being deposited on the cathode surfaces and without leaving "whiskers" on the machined part. A nonconductive coating of smut formed on the workpiece, but was washed off during each "off" cycle of the voltage pulsing sequence. It was shown that reproduction of lines and features to 2 mils can be achieved repeatedly, with superior contour definition and edge configuration.

Other advantages achieved with EPCM in this type of application are greater longevity for resists and masks, a reduction in formation of harmful reaction products, lower average current requirements, and suitability of using cheaper and weaker etchants. Some disadvantages through use of the applied electrical field are lateral etching and the rounding of corners. These, however, are correctable. The process also requires use of an etchant that will dissolve the reaction products when no field is applied, then attack the workpiece when electrically activated.

MRC Advances Silicide Target Technology

Materials Research Corporation has developed a process for producing silicide compound targets that results in purity, density, and homogeneity typically found only in metal sputtering targets.

The new Ultragrade™ process synthesizes the silicide compound from Marz™ grade silicon and refractory metals and the compound is then powdered and pressed into shape. The resulting powder is less reactive than powder produced by conventional elemental powder processing techniques. Final purity of 99.99% is achieved through use of a new vacuum processing technology.

The advantage of the process is the ability to form sputtering targets of compound silicides in excess of 95% theoretical density to whatever stoichiometry is needed for the particular process. The increase in density permits the target material to exhibit high physical integrity at high sputtering power levels, regardless of shape. The process permits consistent and constant deposition, and opens up a wide range of possibilities for depositing from a single compound target in production usage of high-quality silicides for VLSI.

MRS MATERIALS RESEARCH SOCIETY

Stephen Hsu, leader of the Tribology Group at the National Bureau of Standards, has been named chief of the Inorganic Materials Division of the NBS Center for Materials Science. Activities of the Division span research, measurement science, standards, reference materials, and fundamental concepts related to the physics, chemistry, structure, processing, and performance of ceramics, glasses, and other inorganic materials.

The Signal UOP Research Center in Des Plaines, Illinois, has changed its name to Signal Research Center Inc. to reflect its expanded role as the central research laboratory for The Signal Companies, Inc. Signal has grown by more than 60% in the past two years, and restructured itself as a high-technology and engineering company serving a broad range of industries, including aerospace, automotive, energy and electronics. Dr. Mary L. Good has been named president and director of research for the Center.

G. D. W. Smith has been named recipient of the Vanadium Award by the Institute of Metals (UK) along with T. D. Mottishaw for their paper, "Microalloyed pearlite steels for the wire industry: mechanisms of alloy element redistribution and strengthening processes in Cr-V eutectoid steels." The paper was presented at the HSLA Conference in Philadelphia, October 1983. Smith is a member of the **MRS BULLETIN** Editorial Board.

MRS member George Lester was one of 24 researchers honored recently by the Signal Research Center for career achievements. Lester is the author of 39 patents.

Ferranti Offers Brochure on Laser Systems

A new brochure illustrating a range of lasers and turnkey laser systems has been published by Ferranti Industrial Electronics. The literature describes applications for Ferranti lasers with a power range from 2W up to 10kW.

Copies of the brochure, "The Power to Put Lasers to Work," are available from Ferranti plc, Professional Components Department, Dunsinane Avenue, Dundee, DD2 3PN, England.

(continued on the next page)

CERN Continues to Support LHC as U.S. Government Hesitates on Proposed SSC

Debate on the future of the proposed Superconducting Super Collider (SSC) continues to flourish both in the United States and abroad, according to two recent reports in *Science*. In April, the House Science and Technology Committee issued a report to the DoE indicating that it would not support funding of the SSC until sufficient work has been done on the magnet system. The Committee cited its concern for potential failure and cost overruns. The current cost estimate is $6 billion. The Committee indicated that "the basic issue facing the SSC for the next several years is not when and where the SSC will be built, rather the issue is whether or not the SSC should be built." The Committee further criticized the program for its "lack of industrial and foreign participation." (*Science*, April 19, 1985)

European physicists, however, continue to show concern for the SSC (*Science*, May 24, 1985), as they continue to seek international support for construction of the Large Hadron Collider (LHC) at CERN in Geneva. CERN realizes the importance of U.S. support for this $1 billion project, and argues that the LHC would be capable of carrying out the same hadron/hadron collision investigations as the proposed SSC but at a fraction of the cost.

The LHC would provide a collision energy of 18 TeV, compared to the 40 TeV range anticipated for the SSC. The Europeans contend that 40 TeV only increases the equivalent center of mass energy for hadron collisions by 50%, although some physicists reluctantly admit that even this small increase could be sufficient to lead to discoveries beyond the reach of the LHC.

At present the potential of SSC construction is leading the European research community to explore some alternative avenues for funding and/or compromise. Japan and Canada could be new sources of support, and both have indicated interest in participating in either the SSC or LHC. Japan even expressed interest in a package deal in which U.S. involvement in the LHC would lead to European support for a large-scale R&D program into accelerator techniques based in the United States.

(For an opinion from a U.S. scientist's viewpoint, see George Pake's Plenary Address form the 1985 MRS Spring Meeting, "The Material Foundations of Modern Scientific and Technological Advances," **MRS BULLETIN**, Vol. X, No. 3.)

Four Meetings Address Materials Issues in Asia

Three recently conducted conferences and one upcoming event illustrate the range of on-going activities of the Asian research community in various fields of materials research. The annual conference of the Chinese Society for Materials was held March 6-7, 1985 at the National Taiwan University, Taipei, Taiwan, China. Dr. Frederick Seitz of Rockefeller University was guest speaker and presented the C. H. Lu Medal to C. T. Wei.

The 2nd International Symposium on VLSI Technology, Systems, and Applications was held May 8-10 at the Lai Lai Sheraton Hotel, Taipei. The symposium was sponsored by the Industrial Technology Research Institute and the National Science Council, Taiwan, China.

The 4th Asia-Pacific Corrosion Control Conference (APCCC) was held shortly thereafter, May 25-31 in Tokyo. The 3rd APCCC was held two years ago in Taipei.

Coming up September 2-3, 1985 is the 1985 Electronic Device and Materials Symposium (EDMS) and Semiconductor Technology Workshop, which will be held at the National Chiao Tung University, Hsinchu, Taiwan. The workshop, sponsored by the University, will focus on VLSI, CAD/CAM, and GaAs technology.

New Ceramic Production Technique Yields Very High-Field Varistor

Scientists at Sandia National Laboratory have developed a technique which produces ceramic variable resisitors that can be made to regulate voltages up to 100 times greater than previously possible. In the process, the microscopic structure of the ceramic is controlled so that the grain size is smaller, resulting in more grain boundaries and higher switching voltages.

The conventional fabricating process relies on mechanical stirring of the oxide powders and high-temperature sintering. The new Sandia method uses chemical precipitation and ion exchange techniques to make very fine, highly reactive zinc-manganese-cobalt-bismuth powders that are sintered at a relatively low temperature, producing ceramic material with submicron-sized grains. The new material can have switching voltages ranging from 20 to 100 kV/cm of material.

"Very high-field varistors will permit size reductions and new capabilities for many Sandia device designs," according to Cliff Ballard, supervisor of the Ceramic Components Development Division, "and their usefulness probably will spill over into the commercial sector. However, we feel the real accomplishments here are our ability to analyze the factors that control electro-ceramic performance, and then to use that knowledge to design new micro-architectures required to meet specific technological needs. These capabilities will have long-term significance in this field."

The process involved dissolving zinc, manganese, and cobalt chlorides in an aqueous solution and then adding sodium hydroxide, which initiates a chemical reaction that allows very homogeneous particles of zinc, manganese, and cobalt to grow and then settle out of a solution as solids. This hydroxide powder is changed to an organic material by reacting it with oxalic acid, and calcining the mixture to 600°C to drive off volatile materials. The result is a very uniform powder mixture with grains of a predetermined shape and size.

Next, an acidic solution of bismuth ions is poured over the powder. The ions react with grain surfaces, leaving a very thin bismuth coating. A 400°C calcining operation drives off excess water and other volatiles to produce a well-balanced mixture of zinc, manganese, and cobalt oxide powders that can be pressed into usable shape.

The final sintering occurs at temperatures between 700°C and 760°C, and a ceramic that is only 10% porous results.

Bruce Tuttle is team leader for the varistor development project. The new process for making small-grained ceramic material was developed by Robert A. Dosch, with assistance from Robert Brooks. Both are members of MRS. Other key researchers involved on the project are MRS member Timothy Gardner and MRS First Vice President Gordon Pike.

Gordon Pike

Pike Named Division Supervisor at Sandia

Sandia National Laboratories has announced the promotion of Gordon Pike to supervisor of the Electronic Properties of Materials Division. This is the same group in which he has worked since 1978. Pike's division is involved with a variety of materials and processing techniques. Research areas include photoconductivity of insulating polymers, surface and bulk dielectric breakdown of inorganic insulators, thin metal films for multilayer microcircuits, amorphous metal alloy films, ion-implanted polycrystalline silicon for VLSI, electronic properties of semiconductor grain boundaries, and ceramic zinc oxide varistors. In addition to conducting fundamental research on these topics, the staff works with related engineering applications divisions. Pike is First Vice President and President-Elect of the Materials Research Society.

14 SHORT COURSES
On
ADVANCED MATERIALS RESEARCH TECHNIQUES

Sponsored by the Materials Research Society in conjunction with the 1985 Fall Meeting, Boston, Massachusetts.

Make plans now to round out your week in Boston at the MRS Fall Meeting by attending an MRS short course. Look for details and registration information in the mail and register early.

Friday, December 6, (One-Day Courses)

Ion Implantation and Rapid Thermal Annealing
Instructor: T. E. Seidel, J. C. Schumaker Co.

Deep Level Transient Spectroscopy
Instructor: C. E. Barnes, Aerospace Corporation

Sol-Gel Processing of Glass
Instructor: C. Jeffrey Brinker, Sandia National Laboratories

Applications of Reflection Electron Diffraction to Epitaxial Growth
Instructor: P. I. Cohen, University of Minnesota

Saturday, December 7 (One-Day Course)

Ion Beam Modification of Non-Semiconductors
Instructor: J. K. Hirvonen, SPIRE, Inc.

Friday-Saturday, December 6-7 (Two-Day Courses)

Surface and Thin Film Analysis
Instructors: Leonard C. Feldman, AT&T Bell Laboratories
James W. Mayer, Cornell University

Liquid Phase Epitaxy Techniques
Instructor: L. R. Dawson, Sandia National Laboratories

Vapor Phase Epitaxy
Instructors: Herbert M. Cox, Bell Communications Research
P. D. Dapkus, University of Southern California

Molecular Beam Epitaxy
Instructor: Gary W. Wicks, Cornell University

Vacuum Technology
Instructor: Mars H. Hablanian, Varian Vacuum Division

Materials Aspects of Silicon Devices
Instructors: Subhash Mahajan, Carnegie-Mellon University
K. S. SreeHarsha, San Jose State University

Electronic Properties of Amorphous Semiconductors
Instructor: David Adler, Massachusetts Institute of Technology

Processing-Microstructure-Mechanical Property Relationships in Metals
Instructor: Kenneth H. Eckelmeyer, Sandia National Laboratories

Films and Coatings for Engineering Applications
Instructor: Don Mattox, Sandia National Laboratories

The MRS Short Course Program is an activity of the MRS Education Committee.

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