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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT
TO THE
AIR FORCE SYSTEMS COMMAND

1 AUGUST — 31 OCTOBER 1981

ISSUED 9 MARCH 1982

LEXINGTON MASSACHUSETTS

INTRODUCTION

This Quarterly Technical Summary covers the period 1 August through 31 October 1981. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

CONTENTS

DATA SYSTEMS

DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 August through 31 October 1981 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs:

Seismic Discrimination	ARPA NMRO
Distributed Sensor Networks	ARPA IPTO
Defense Switched Network Technology	OSD-DCA
Digital Voice Processing	AF ESD
Digital Voice Interoperability Program	AF ESD
Packet Speech Systems Technology	ARPA IPTO
Radar Signal Processing Technology	ARMY BMDATC
Restructurable VLSI	ARPA IPTO
Multi-Dimensional Signal Processing	AF RADC

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DIGITAL INTEGRATED CIRCUITS
GROUP 23

I. INTRODUCTION

Phase 0 integrator wafers have been partially laser programmed. Laser linking and cutting continues to be 100 percent successful. A kinetic model has been developed which fits the data for nitridation of thin oxide films. Silicon gate transistors made with thin nitrided oxide have been shown to be unaffected by 1 Mrad (Si).

II. ADVANCED CIRCUIT DESIGN AND SIMULATION

A. Phase 0 Integrator

Fabrication of several phase 0 integrator restructurable LSI demonstration wafers was completed. Two wafers were mounted in 40-pin hybrid circuit metal headers. One of these was extensively tested for breaks and shorts in the power and interconnect wiring. It was then programmed with the laser into two functioning 4-bit counters, using defect avoidance techniques to work around defective counters and defective wiring. Restructuring of wiring on this wafer using the laser programming equipment under computer control was then successfully demonstrated to program sponsors. The second wafer has been mounted and partially bonded. It will be used to evaluate several interconnect-wiring test algorithms and then connected into a functioning integrator.

This demonstration has shown the need for several features in the phase 1 integrator and FFT designs. These include the ability to isolate faulty regions in the power wiring, to test local interconnect-wiring stubs during wafer probing, and to test global wiring using links to test wires. In addition, it is desirable to be able to test subsections as they are built up net by net during wafer programming, especially on marginal wafers. The parasitic drain diodes at outputs and the clamp diodes at inputs help in testing interconnect wiring as it is formed. Before the complete integrator restructuring can be demonstrated, an autofocus control must be incorporated and the assignment and linking software made operational. The other required change, an improved X-Y table, has recently been installed.

Perhaps the most important result so far is the confirmation, using active circuits, that laser linking and cutting are always successful if positioning accuracy is maintained and that no metal debris problems occur at these power levels.

B. RVLSI Spread Spectrum Integrator

A complete set of reticles, nine levels, has been obtained for the CMOS phase 1 integrator test chip, and processing has proceeded through the first two levels. The test chip is 8.67×9.21 mm and contains 3 integrator cells, 40 clock drivers, and a set of test devices. The integrators have large IO drivers for off-chip connections, and may be scribed and packaged separately for testing. The clock drivers may also be separated into groups of 5 for packaged testing.

The integrator cell, as it will be used for interconnection on the wafer (without the large off-chip IO drivers but with small test pads), is 3.09×1.87 mm and, with the exception of the IO drivers, has the same configuration as the test integrator cell. Therefore, yield and performance data obtained from the test chip will be representative of the integrator cell.

C. FFT for Radar Applications

Mask design for the wafer-scale CMOS FFT is complete. An initial process run has begun in which the FFT reticles will be stepped unshuttered onto a 2-in. wafer. These wafers will be tested for cell functionality, but will not be properly positioned for construction of a wafer-scale device. When the automated masking blades are operational, the FFT reticles will be stepped onto a 3-in. wafer in a manner allowing interconnection between adjacent cells.

Presently we are concentrating on creating the software needed to perform the complex task of interconnecting the 130 individual cells needed to implement the 16-point FFT. The goal is first to create tools of general use which can be used to create and manipulate a data base describing wafer interconnect. These tools will then be used in assigning and linking programs using algorithms specific to the FFT to generate the necessary lists of "makes" and "breaks."

III. RESTRUCTURABLE VLSI TECHNOLOGY

A. Laser-Formed Connections

In yield tests of the laser links, over 1500 VLSI links (see 15 May 1981 QTS) have been attempted with the only failure being due to a large misalignment of the target. The link resistance has averaged $0.7 \pm 0.2\ \Omega$ with half of this being due to the metal lines leading up to the connection, rather than the link itself. Initial tests on 300 of the 100-Å oxide-barrier-protected a-Si RVLSI links suggest they have the same yield as the pure a-Si ones. Also, successful connections have been made on the RVLSI design shrunk latterly by 50 percent to $10\ \mu m \times 10\ \mu m$.

To cut bus lines reliably, it has been found that the a-Si material should not extend beyond the metal line edge. Otherwise, the cutting process pushes metal outward to create a lateral link between the two ends of the metal line through the Si. Removal of the a-Si is self aligned, so it requires only an added etching step.

We are investigating the use of this phenomenon to produce laser-programmable, lateral links with a single layer of metal. We have produced laser-formed links across metal gaps of $3.5\ \mu m$ with a formed link resistance of 3 to 10 Ω. The unformed link resistance was greater than $10^9\ \Omega$.

B. Link Reliability and Structure

Unformed links have now been stressed at 12 V and room temperature for 3000 h with no failures. Formed links have been stressed at 200°C and no voltage for over 300 h. Most of the link resistances have not changed. Some of those which were relatively high initially (0.2 Ω) increased to as high as 0.8 Ω at 150 h and have since decreased. While we do not understand that behavior, it does not seem to indicate any problem.

Unformed links, with and without deposited oxide diffusion barriers (190 Å, both top and bottom), have been stressed at 200°C with no voltage applied. Nearly all the devices without oxide barriers were shorted after 120 h, presumably due to the Al-Si interdiffusion reported previously (15 May 1981 QTS). In sharp contrast, the devices with barriers show a very low failure rate through 1000 h although measurement ambiguities still remain to be resolved.

Sintering experiments were performed at 450°C on link insulator structures with oxide barrier thicknesses of 70 to 130 Å. No shorting was observed in these devices after 30 min., the time which is required for our process. Longer sinters at which device shorting began to occur resulted in an onset time which was consistent with a uniform reduction of silicon dioxide by the aluminum at a rate of 0.44 Å/min. No evidence was seen of premature shorting due to enhanced silicon diffusion through oxide defects, even with the thinnest oxide barriers.

Selected area, Auger, sputter depth-profiling measurements were made on a laser-formed link to examine the link microstructure. At a probe dimension of $0.7\ \mu m$, a uniform composition of nearly equal concentrations of aluminum and silicon was observed plus approximately 10 to 30% oxygen. Since solid aluminum and silicon have a very low mutual solubility, the link microstructure is presumably a two-phase mixture of aluminum and silicon grains. The Auger results suggest a lateral grain size of less than $0.5\ \mu m$. Experiments to determine the current carrying medium in the link are continuing.

C. Laser System

The inexpensive 2-in. travel tables which were fitted to the laser system proved adequate for initial experiments, but are not suitable for fully automatic operation. A more accurate X-Y table system has now been installed which gives micron positional accuracy over a 4-in. travel. This will accommodate the 3-in. wafers and provide the positioning capability necessary for the integrator and FFT systems.

The laser X-Y table is being fitted with a feedback-controlled Z-axis drive to maintain focus despite wafer nonplanarity. Focus is sensed as a *maximization of the mean magnitude of the signal derivative* from the TV camera on the laser microscope.

We have designed and fabricated an I/O bus extender for the Apple computer to accommodate future expansion of the laser programming system.

D. Wafer Carriers

Ceramic wafer carriers for the 1.3- × 1.3-in. phase 0 integrator chips have been fabricated. These are based on an alumina substrate (2.25 in. × 2.25 in. × 0.029 in.) which is metallized (Cr 150 Å /Au 3 μm) on one side and patterned to yield suitable wire-bonding and lead-soldering pads. The leads are chemically etched from Be-Cu sheets and attached by a hard-soldering process (Au-Sn solder). The chips are mounted using frozen epoxy preforms (ECF506 Ablestik Labs). This chip bonding procedure is being compared with conventional bonding procedures. A major problem in the fabrication of wafer carriers is the nonplanarity of ceramic substrates.

IV. SEMICONDUCTOR PROCESSING

A. Lithography

The semiautomatic aperture system, which allows separate images on the same reticle to be printed at arbitrary locations, for the DSW has been installed and is fully functional. It operates with a positional accuracy of ±20 μm, which is quite satisfactory with the blocking borders currently used on the reticle sets. A digital controller was designed and implemented for this system.

B. Dry Etching

The experimental single-wafer parallel-plate reactive ion etching (RIE) system has been built and is undergoing evaluation. Preliminary experiments are encouraging, and detailed study of sidewall anisotropy of the etched work using the SEM is under way. A second RIE system is also under construction which can be used in either the plasma or reactive ion etching mode. This will be used to increase our dry etching capability, particularly for micron-geometry polysilicon definition. Three promising etch gases are being evaluated for anisotropy, undercut, and etch selectivity with respect to gate oxide.

We have plasma etched 1- and 2-μm Al lines with excellent uniformity over 3-in. wafers with BCl_3.

C. Polyimide

First- to second-level-metal contact resistance through vias in polyimide on the laser restructurable link system has been unexpectedly poor. Process modifications introduced to assure compatibility with laser links and CMOS design may be responsible, and a number of test runs are under way to develop a process which will reduce via resistance on future RVLSI runs.

D. CMOS Processing

The yield of CMOS wafers at first-metal test was improved by two process refinements. The standard CVD-SiO_2 film was replaced by reflowed phosphosilicate glass (PSG) which improved step coverage of the polysilicon electrodes, reduced the incidence of erratic contact cuts, and eliminated SiO_2 fractures at polysilicon edges. The PSG is 6% phosphorus by weight as measured by the sheet resistance method;* the glass is reflowed for 30 min. at 1000°C in nitrogen.

*A.C. Adams and S.P. Murarka, J. Electrochem. Soc. 126, 334 (1979).

A new clean has been added to remove remnant photoresist which sometimes exists after the standard strip in an oxygen plasma. A 5-min. dip in a 1:1 solution of H_2SO_4 and H_2O_2 followed by a 10-min. dip in a 12:2:3 solution of H_2O, NH_4OH, and H_2O_2 heated to 85°C removes even heavily implanted resist.

A four-tube diffusion furnace stack was installed to support 3-in. wafer processing, and a CMOS run using 3-in. wafers was initiated.

V. DEVICE THEORY

A. Nitrided Oxide: Kinetics

The experimental data for the growth of the interface nitride films have been fitted to a kinetic model based on the following assumptions:

(1) The growth rate is proportional to the concentration of the nitriding species at the oxide-nitride interface,

(2) The growth rate is proportional to the exponential inverse of the film thickness,

(3) The concentration of the nitriding species at the interface is determined by diffusion through the oxide less incorporation into the growing film, and

(4) The temperature dependence of growth is due to the fact that both the exponential growth and the diffusion are activated processes.

The data appear to fit the model well within the experimental tolerance of the thickness measurements. The temperature dependence is almost completely that of the exponential factor. There are at least three physical processes which have been shown to lead to the proposed thickness dependences on time and temperature: place exchange, wherein a whole column of the film inverts, exposing a new silicon atom from the silicon-nitride interface to the nitride-oxide interface, and two models wherein a silicon atom is caused to move through the film by an electric field generated by electrons which have tunnelled through the nitride film (the maximum film thickness never exceeds about seven layers). We are searching for unique physical justification of a single model.

We now have successful models for the formation of inner and outer nitride films. Very preliminary measurements indicate a substantial (20 percent) concentration of nitrogen in the oxide after vigorous ammoniation. We hope to measure the concentration more precisely and to get some idea of the binding of the nitrogen in order to model the process of how it happens to be there.

B. Nitrided Oxides: Radiation Testing and Electrical Properties

Poly-Si gate n-channel IGFETS using 10-nm nitrided oxides were exposed to 1.5-MeV electrons to a total dose of 1 Mrad (Si) (3×10^{13} electrons cm^{-2}). No degradation of the threshold voltage or channel mobility was measurable after irradiation. This result is significant since poly-gate devices are reported to be "softer" than metal-gate devices. Ring oscillators with stage delays as low as 0.30 ns have been fabricated using this technology (reported in previous quarter). Six of these oscillators were also tested using 1.5-MeV electrons. Four failed at 20 krad (Si) by suffering a loss of most signal amplitude. The oscillator frequency was not affected. The cause of failure could not be well determined from the available test structures; however, published field oxide data say that inversion under the field oxide would be expected at 20 krad (Si), even for hardened devices.

The issue of charge, both fixed and surface state, in both the nitrided oxides and the starting thin oxide films continues to be of concern. The Nicollian and Goetzberger method for determining N_{it},* the surface state density in the silicon band gap, has been used to determine that the density of mid-gap surface states is usually 10^{11} states cm^{-2} eV^{-1} or less in both nitrided oxides and the thin pure oxides. The charge question and effects of anneals are still under study.

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*Bell Syst. Tech. J. 46, 1055 (1967).

COMPUTER SYSTEMS
GROUP 28

A DEC PDP 11/44 computer and the UNIX Operating System were installed during the quarter. As previously reported, the 11/44 will function as a gateway between the Laboratory's Amdahl V/8 central computer, the ARPA Network, and a developing Lincoln Internal Data Link (LIDL). An initial design for the ARPA Network software interface has been prepared.

The requirements for processing power to serve the batch load are not only growing at a faster rate than the interactive load, but now dominate the total. This fact, combined with a decline in the relative power of new commercial processors, dictates a change in the past pattern of serving the Laboratory's batch and interactive computing needs with a single processor operating in alternate modes. A more general solution involving multiple processors in a distributed configuration is probably the direction for future development. The network will be a part of that evaluation. However, to handle a significant increase in batch work in this fiscal year, a small Adjunct Computer will be acquired.

The Adjunct will be compatible with the main system and will process batch work on a full-time schedule. Simple file-sharing communications between the existing Amdahl and the Adjunct will be provided by two-channel connections to direct-access storage devices and a channel-to-channel adapter between the two computers. The Adjunct will also be capable of independent operation so that it can provide special priority service or classified data processing.

The data communications system is undergoing a major reorganization to take full advantage of a new Laboratory telephone system which will be installed next quarter. Generally, terminal equipment presently connected by direct wire to the central facility will remain in place without change. Connections that are part of the new telephone system from remote Laboratory buildings will be able to operate in digital form at higher data rates than those permitted by the current analog system. Even external users accessing the system over telephone company lines will benefit from easier connection procedures.

SOLID STATE

DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 August through 31 October 1981. The Solid State Research Report for the same period describes the work of Division 8 in more detail. Funding is primarily provided by the Air Force, with additional support provided by the Army, DARPA, Navy, NASA, and DOE.

A.L. McWhorter
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I. Melngailis
Associate Head

DIVISION 8 REPORTS
ON ADVANCED ELECTRONIC TECHNOLOGY

15 September through 15 November 1981

PUBLISHED REPORTS

Journal Articles

JA No.			
5152	Transition Temperatures and Heats of Crystallization of Amorphous Ge, Si, and $Ge_{1-x}Si_x$ Alloys Determined by Scanning Calorimetry	J.C.C. Fan C.H. Anderson, Jr.	J. Appl. Phys. 52, 4003 (1981)
5186	Solid-Phase Epitaxial Crystallization of Amorphous Ge on <100> Si	B-Y. Tsaur J.C.C. Fan J.P. Salerno C.H. Anderson, Jr. R.P. Gale F.M. Davis E.F. Kennedy* T.T. Sheng*	J. Electrochem. Soc. *128*, 1947 (1981)
5200	Hydroplane Polishing of Semiconductor Crystals	J.V. Gormley M.J. Manfra A.R. Calawa	Rev. Sci. Instrum. 52, 1256 (1981)
5218	Efficient Si Solar Cells by Low-Temperature Solid-Phase Epitaxy	B-Y. Tsaur G.W. Turner J.C.C. Fan	Appl. Phys. Lett. *39*, 749 (1981)
5219	GaAs Shallow-Homojunction Solar Cells on Ge-Coated Si Substrates	R.P. Gale J.C.C. Fan B-Y. Tsaur G.W. Turner F.M. Davis	IEEE Electron Device Lett. *EDL-2*, 169 (1981)
5222	Shallow PtSi-Si Schottky Barrier Contacts Formed by a Multilayer Metallization Technique	B-Y. Tsaur D.J. Silversmith R.W. Mountain L.S. Hung* S.S. Lau* T.T. Sheng*	J. Appl. Phys. 52, 5243 (1981)

*Author not at Lincoln Laboratory.

JA No.			
5240	Improved Techniques for Growth of Large-Area Single-Crystal Si Sheets Over SiO_2 Using Lateral Epitaxy by Seeded Solidification	B-Y. Tsaur J.C.C. Fan M.W. Geis D.J. Silversmith R.W. Mountain	Appl. Phys. Lett. *39*, 561 (1981)
5245	Mixing of 10-μm Radiation in Room-Temperature Schottky Diodes	P.E. Tannenwald H.R. Fetterman C. Freed C.D. Parker B.J. Clifton R.G. O'Donnell	Opt. Lett. *6*, 481 (1981)
5246	Slider LPE of $Hg_{1-x}Cd_xTe$ Using Mercury Pressure Controlled Growth Solutions	T.C. Harman	J. Electron. Mater. *10*, 1069 (1981)
5247	Remote Probing of the Atmosphere Using a CO_2 DIAL System	D.K. Killinger N. Menyuk	IEEE J. Quantum Electron. *QE-17*, 1917 (1981)
5253	Direct Writing of Refractory Metal Thin Film Structures by Laser Photodeposition	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	J. Electrochem. Soc. *128*, 2039 (1981)

Meeting Speeches

MS No.			
5230A	[illegible]	H. A. Haus* [illegible] [illegible] [illegible]	Proc. SPIE, Vol. 269: *Integrated Optics* (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981), pp. 55-59
5358A	[illegible]	[illegible]	*Proceedings of the Symposium on Materials and New Processing Technologies for Photovoltaics* (The Electrochemical Society, Pennington, New Jersey, 1981), p. 304
5525	[illegible]	[illegible]	Proc. Fifteenth IEEE Photovoltaic Specialists Conference — 1981, Orlando, Florida, 12-15 May 1981, pp. 432-436

* [illegible]

MS No.			
5531	GaAs Shallow-Homojunction Solar Cells on Epitaxial Ge Grown on Si Substrates	R.P. Gale B-Y. Tsaur J.C.C. Fan F.M. Davis G.W. Turner	Proc. Fifteenth IEEE Photovoltaic Specialists Conference — 1981, Orlando, Florida, 12-15 May 1981, pp. 1051-1055
5532	Cathodoluminescence Analysis of Polycrystalline GaAs	J.P. Salerno R.P. Gale J.C.C. Fan	Proc. Fifteenth IEEE Photovoltaic Specialists Conference — 1981, Orlando, Florida, 12-15 May 1981, pp. 1174-1178
5533	GaAs Shallow-Homojunction Concentrator Solar Cells	G.W. Turner J.C.C. Fan R.L. Chapman R.P. Gale	Proc. Fifteenth IEEE Photovoltaic Specialists Conference — 1981, Orlando, Florida, 12-15 May 1981, pp. 151-155
5563	Sputtered Films for Wavelength-Selective Applications	J.C.C. Fan	Thin Solid Films *80*, 125 (1981)
5619	High-Performance GaInAsP/InP Avalanche Photodetectors	V. Diadiuk S.H. Groves C.E. Hurwitz G.W. Iseler	Proc. SPIE, Vol. 272: *High Speed Photodetectors* (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981), pp. 17-21
5620	Intracavity Loss Modulation of GaInAsP Lasers	D.Z. Tsang J.N. Walpole S.H. Groves J.J. Hsieh* J.P. Donnelly	Proc. SPIE, Vol. 269: *Integrated Optics* (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981), pp. 81-83
5632A	InP Optoelectronic Mixers	A.G. Foyt F.J. Leonberger R.C. Williamson	Proc. SPIE, Vol. 269: *Integrated Optics* (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981), pp. 109-114
5640	Guided-Wave Electro-Optic Analog-to-Digital Converter	F.J. Leonberger	Proc. SPIE, Vol. 269: *Integrated Optics* (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981), pp. 64-68
5672	Junction Formation by Solid-Phase Epitaxy: A Novel Low-Temperature Technique for Efficient Si Solar Cells	B-Y. Tsaur G.W. Turner J.C.C. Fan	Proc. Fifteenth IEEE Photovoltaic Specialists Conference — 1981, Orlando, Florida, 12-15 May 1981, pp. 257-258

*Author not at Lincoln Laboratory.

MS No.			
5696	Applications of InP Photoconductive Switches	F.J. Leonberger	Proc. SPIE, Vol. 272: *High Speed Photodetectors* (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981), pp. 58-63
5726	Thin-Film GaAs Solar Cells	J.C.C. Fan C.O. Bozler R.W. McClelland	Proc. Fifteenth IEEE Photovoltaic Specialists Conference — 1981, Orlando, Florida, 12-15 May 1981, pp. 666-672
5783	A New CCD Parallel Processing Architecture	A.M. Chiang	*CMU Conference on VLSI Systems and Computations* (Computer Science Press, Rockville, Maryland, 1981), p. 408

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UNPUBLISHED REPORTS

Journal Articles

JA No.			
5209	Solar Photovoltaic Cells	J.C.C. Fan	Accepted by *Kirk-Othemer Encyclopedia of Chemical Technology*
5244	Optical Technique for Measurements of Submonolayer Adsorbed Films	V. Daneu R.M. Osgood, Jr. D.J. Ehrlich	Accepted by Opt. Lett.
5249	Laser Microreaction for Deposition of Doped Silicon Films	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	Accepted by Appl. Phys. Lett.
5261	Techniques for Electron Beam Testing and Restructuring Integrated Circuits	D.C. Shaver	Accepted by J. Vac. Sci. Technol.
5262	A Novel Anisotropic Dry Etching Technique	M.W. Geis G.A. Lincoln N. Efremow W.J. Piacentini	Accepted by J. Vac. Sci. Technol.
5263	Sub-Doppler Submillimeter Spectroscopy Using Molecular Beams	W.A.M. Blumberg D.D. Peck H.R. Fetterman	Accepted by Appl. Phys. Lett.

JA No.			
5264	Cryogenic Operation of Submillimeter Quasioptical Mixers	P.F. Goldsmith* H.R. Fetterman B.J. Clifton C.D. Parker N.R. Erickson*	Accepted by Intl. J. Infrared and Millimeter Waves
5269	The Permeable Base Transistor and Its Application to Logic Circuits	C.O. Bozler G.D. Alley	Accepted by Proc. IEEE
5270	Production and Annealing of Ion-Bombardment Damage in Silicides of Pt, Pd and Ni	B-Y. Tsaur C.H. Anderson, Jr.	Accepted by J. Appl. Phys.
5276	N-Channel Deep-Depletion MOSFETs Fabricated in Zone-Melting-Recrystallized Polysilicon Films on SiO_2	B-Y. Tsaur M.W. Geis J.C.C. Fan D.J. Silversmith R.W. Mountain	Accepted by Appl. Phys. Lett.
5279	Zone-Melting Recrystallization of Encapsulated Silicon Films on SiO_2 — Morphology and Crystallography	M.W. Geis H.I. Smith* B-Y. Tsaur J.C.C. Fan E.W. Maby* D.A. Antoniadis	Accepted by Appl. Phys. Lett.
5291	Electrical Properties of Laser Chemically Doped Silicon	T.F. Deutsch D.J. Ehrlich D.D. Rathman D.J. Silversmith R.M. Osgood, Jr.	Accepted by Appl. Phys. Lett.

Meeting Speeches†

MS No.			
5608A	Comparative Sensitivity of Dual-Laser and Single-Laser Remote Sensing of Atmospheric Species	D.K. Killinger N. Menyuk	1981 Annual Optical Society of America Mtg., Kissimmee, Florida, 26-30 October 1981
5707D	Microreactions Using Laser Beams	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	1981 Annual Optical Society of America Mtg., Kissimmee, Florida, 26-30 October 1981

*Author not at Lincoln Laboratory.

†Titles of Meeting Speeches are listed for information only. No copies are available for distribution.

MS No.			
5653A	Linewidth Characteristics of (GaAl)As Semiconductor Diode Lasers	A. Mooradian D. Welford M.W. Fleming	Workshop on "Optical Processing Elements," London, England, 17-18 September 1981
5695	SAW Convolvers for Spread-Spectrum Communications	I. Yao	1981 Natl. Electronics Conf., Chicago, Illinois, 26-28 October 1981
5707B	Laser Microchemistry for Electronics	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	Fifth Intl. Thin Films Congress, Herzlia-on-Sea, Israel, 21-25 September 1981
5707C	Laser Photodeposition	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	Amer. Vac. Soc. Natl. Symp., Anaheim, California, 3-6 November 1981
5707E	Laser Microphotochemistry for Electronics	D.J. Ehrlich R.M. Osgood, Jr. T.F. Deutsch	IEEE Local Chapter Mtg., Waltham, Massachusetts, 14 October 1981
5717A	High Quality MOSFETs on Silicon Films Prepared by Zone-Melting Recrystallization of Encapsulated Polysilicon on SiO_2	B-Y. Tsaur	Seminar, Hughes Research Laboratory, Malibu, California, 24 July 1981
5717B	Growth of Large-Area Device-Quality Si Sheets on Insulators	B-Y. Tsaur	Materials Science and Engineering Seminar, Cornell University, Ithaca, New York, 10 September 1981
5717C	Preparation of High-Quality Silicon Films on Insulators by Zone-Melting Recrystallization	B-Y. Tsaur	Seminar, RCA, Princeton, New Jersey, 1 October 1981
5720	Laser-Photochemical Techniques for VLSI Processing	D.J. Silversmith D.J. Ehrlich T.F. Deutsch R.M. Osgood, Jr.	VLSI Technology Symp., Maui, Hawaii, 9-12 September 1981
5724	Monolithic Integrated Receiver Technology for the Millimeter and Submillimeter Wave Regions	B.J. Clifton	Accepted by Proc. Eighth Biennial Cornell Electrical Engineering Conf., Cornell University, Ithaca, New York, 11-13 August 1981

MS No.			
5751	Experimental and Theoretical Analysis of Temperature Dependence of Wideband SAW RAC Devices on Quartz	D.M. Boroson D.E. Oates	1981 Ultrasonics Symposium, Chicago, Illinois, 14-16 October 1981
5752	High Performance Elastic Convolver with Extended Time-Bandwidth Product	I. Yao	1981 Ultrasonics Symposium, Chicago, Illinois, 14-16 October 1981
5755	Compact Multiple-Channel SAW Sliding-Window Spectrum Analyzer	D.R. Arsenault V.S. Dolat	1981 Ultrasonics Symposium, Chicago, Illinois, 14-16 October 1981
5756	A SAW Tapped Delay Line with Short (15-ns) Pedestal of Delay and High (110 dB) Feedthrough Isolation	D.E. Oates R.W. Ralston	1981 Ultrasonics Symposium, Chicago, Illinois, 14-16 October 1981
5753	Slider LPE of $Hg_{1-x}Cd_xTe$ Using Mercury Pressure Controlled Growth Solutions	T.C. Harman	U.S. Workshop on the Physics and Chemistry of Mercury Cadmium Telluride, Minneapolis, Minnesota, 28-30 October 1981
5796	Research at the Limits of Microstructure Fabrication	D.C. Flanders	Microcircuit Engineering '81, Lausanne, Switzerland, 28-30 September 1981
5804	High-Speed Electrooptical Signal Processing Devices	F.J. Leonberger	Integrated Optical Technologies for Sensing and Signal Processing, M.I.T., 22 September 1981
5831	Integrated Optical Devices for Temperature Sensing	L.M. Johnson	Integrated Optical Technologies for Sensing and Signal Processing, M.I.T., 22 September 1981
5804A	High-Speed Electrooptical Signal Processing Devices	F.J. Leonberger	Optics and Quantum Electronics Seminar, M.I.T., 14 October 1981
5807	Monolithic Integrated Receiver Technology for the Millimeter Wave Region	B.J. Clifton R.A. Murphy G.D. Alley	Ninth DARPA/Tri-Service Millimeter Wave Conf., Huntsville, Alabama, 20-22 October 1981
5821	The Development of Monolithic Circuits for Millimeter Wave Systems	A. Chu W.E. Courtney L.J. Mahoney M.E. Elta J.P. Donnelly C.O. Bozler	Ninth DARPA/Tri-Service Millimeter Wave Conf., Huntsville, Alabama, 20-22 October 1981
5809	*Theory and Status of High Performance Heterodyne Detectors*	D.L. Spears	SPIE 25th Annual Intl. Tech. Symp., San Diego, California, 26 August 1981

MS No.			
5813	Electrooptics and Optical Signal-Processing Devices	R.C. Williamson	NATO Panel III Mtg., Lincoln Laboratory, 28 August 1981
5829	Analog processing with Superconducting Circuits	E. Stern	Workshop on Josephson Digital Devices, Circuits, and Systems, Waterville Valley, New Hampshire, 10 September 1981
5848	GaAs Microwave Device Packaging Concepts	W. Macropoulus	IEEE Boston Chapter Mtg. on Components, Hybrids and Manufacturing Technology, Lincoln Laboratory, 14 October 1981
5850	Laser Remote Sensing of Jet Aircraft Exhaust Using a CO_2 LIDAR	D.K. Killinger N. Menyuk	DoD Mtg. on Optical Radar Systems, Naval Surface Weapons Center, Silver Springs, Maryland, 20-22 October 1981

SOLID STATE

DIVISION 8

I. SOLID STATE DEVICE RESEARCH

The series combination of a semiconductor-diode gain element and an optical fiber has been operated inside an external cavity with an output at a single wavelength and a linewidth which was less than the measurement limit of 1.7×10^{-5} nm. The work is aimed toward demonstrating the feasibility of coupling semiconductor-diode lasers in parallel by using optical fibers and thus verifying the concept of a semiconductor laser system with average power up to the order of kilowatts.

InP optoelectronic switches have been fabricated which have fast response times (<100 ps) and high electron mobility (~1000 cm^2/V-s) following proton bombardment and anneal. These devices are well suited for high-speed sampling and mixing applications, especially those which require the absence of a DC offset and/or a high degree of isolation between the local oscillator and output. Other applications, such as optical detection, could make use of the high speed of these devices.

Hole diffusion lengths in n-InP of 12 μm have been determined by measuring the increase in collection efficiency of an InP avalanche photodiode as a function of reverse bias. This diffusion length is nearly an order of magnitude greater than the previously reported values measured by surface photovoltage and electron-beam-induced-current (EBIC) techniques.

A 4-bit, 275-MS/s guided-wave electrooptic analog-to-digital converter has been demonstrated. The device consists of a mode-locked Nd: YAG laser, an array of Ti-diffused $LiNbO_3$ interferometric modulators, a Ge avalanche photodiode, and a special high-speed Si integrated circuit.

Planar Hg-diffused $Hg_{0.824}Cd_{0.176}Te$ photodiodes have been fabricated and operated at 20 K with cutoff wavelengths of over 30 μm and response times of less than 0.6 ns at a wavelength of 20 μm. These devices are being developed for use as wide-bandwidth heterodyne receivers at 28 μm for astrophysical applications.

II. QUANTUM ELECTRONICS

Remote sensing measurements of the toxic compounds hydrazine, unsymmetrical dimethylhydrazine (UDMH), and monomethylhydrazine (MMH) have been carried out using LIDAR returns from a diffusely reflecting target located 2.7 km from the laboratory. The results indicate that atmospheric fluctuation is the dominant factor limiting the detection sensitivity of these compounds over ranges between 0.5 and 5 km.

Raman measurements of the stress in silicon-on-sapphire device structures have been carried out with an approximately 1-μm spatial resolution. The measurements indicate substantial reduction of the stress near the edges of 6-μm-wide structures.

A planar antenna has been designed which will serve as a subarray element in an imaging array intended for operation over the range 140 to 700 GHz. Scale-model measurements have been carried out at X-band which show that the radiation pattern of the antenna is suitable for such an array.

III. MATERIALS RESEARCH

In Si films prepared by zone-melting recrystallization of polycrystalline Si on SiO_2-coated fused quartz and sapphire substrates, the carrier mobilities are significantly influenced by stress which occurs because the thermal expansion coefficient of Si is much higher than that of fused quartz and less than that of sapphire. Because the films on SiO_2-coated fused quartz are under strong tensile stress, the electron Hall mobilities in these films are about 75 percent higher than those in films recrystallized on SiO_2-coated Si, and the electron mobilities in n-channel MOSFETs fabricated in the films on fused quartz are even higher than those in similar devices fabricated in bulk Si single crystals.

Single crystals of InP that are dislocation-free up to a diameter of about 20 mm have been grown by the liquid-encapsulated Czochralski technique, without impurity doping, by increasing the thickness of the B_2O_3 encapsulant layer to reduce the radial temperature gradients in the growing boule. X-ray topography and CO_2 laser transmission studies have shown that impurity-doped LEC crystals contain prominent growth striations, probably produced by random convection currents in the melt, that are associated with abrupt changes in dopant concentration.

The lateral vapor-phase epitaxial growth of InP over insulating films on (100) InP substrates has been studied as a function of orientation in the plane of the substrate. Significant lateral growth is found to occur for non-low-index directions because the growing layers are bounded by intersecting low-index facets that form corners which act as nucleation sites.

Good electrical activation of Se-implanted GaAs has been obtained by using a simple graphite strip heater for transient annealing at temperatures between 900° and 1140°C. From the decrease in sheet resistivity and increase in sheet carrier concentration observed over this temperature range, it is probable that still better activation can be achieved by annealing at higher temperatures either with a better encapsulant or in an atmosphere with controlled arsenic vapor pressure.

Since the usefulness of transition-metal silicides for a variety of applications in Si integrated circuit technology depends on their sensitivity to ion bombardment, sheet resistance measurements on polycrystalline films of seven silicides have been used to study the production of damage by Ar^+-ion bombardment. The sensitivity of the compounds to bombardment increases in the following order: Pd_2Si, Pt_2Si, PdSi, Ni_2Si, PtSi, NiSi, $NiSi_2$; the heat of formation per metal atom, which is believed to be correlated with the degree of covalent bonding, increases in the same order.

IV. MICROELECTRONICS

A novel etching technique has been developed which is similar to reactive ion etching, but allows the independent control of the energetic ions and the chemically reactive flux. The technique, called ion-beam assisted etching (IBAE), provides high etching rates and the ability to etch a variety of structures. By using argon ions and a reactive flux of Cl_2, GaAs surfaces etched by IBAE can be made of sufficient quality for many device applications.

IBAE has been used to etch the channel for a recessed-gate, GaAs MESFET. A 250-μm-wide device with a 1.3-μm gate has a transconductance of 30 mS. This value of transconductance, which compares favorably with devices whose gate recess was etched by conventional techniques, indicates that IBAE has the potential to be an important processing technique for GaAs microwave devices.

V. ANALOG DEVICE TECHNOLOGY

Surface-acoustic-wave technology, which was recently used to demonstrate short-pedestal-of-delay filters, has been extended to provide wideband (≈100 MHz) multipath simulators. Edge-bonded input transducers give both large (>1:2) fractional bandwidth and high (>100 dB) feedthrough isolation. Split-finger interdigital output transducers are apodized and random-phase encoded to provide a noise-like impulse response.

An elastic convolver with time-bandwidth product of 2200 has been demonstrated which incorporates a parabolic-horn acoustic beamwidth compressor for high efficiency (−69-dBm efficiency factor), a dual-track configuration with orthogonal transducers for self-convolution suppression (< −43 dB), a simplified output-combiner circuit for temporal uniformity (±0.5 dB, ±5°), and a chirped-transducer design for low spectral phase distortion (< ±30°). This low-cost, compact device can provide programmable matched filtering of minimum-shift-keyed wideband spread-spectrum signals within 0.15 dB of ideal performance.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ESD-TR-81-330
2. GOVT ACCESSION NO.: AD-A114 319
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): Advanced Electronic Technology
5. TYPE OF REPORT & PERIOD COVERED: Quarterly Technical Summary, 1 August – 31 October 1981
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): Alan J. McLaughlin and Alan L. McWhorter
8. CONTRACT OR GRANT NUMBER(s): F19628-80-C-0002
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Lincoln Laboratory, M.I.T., P.O. Box 73, Lexington, MA 02173
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Program Element No. 63250F, Project No. 649L
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Systems Command, USAF, Andrews AFB, Washington, DC 20331
12. REPORT DATE: 15 November 1981
13. NUMBER OF PAGES: 25
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Electronic Systems Division, Hanscom AFB, MA 01731
15. SECURITY CLASS. (of this report): Unclassified

15a. DECLASSIFICATION DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

None

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

digital computers	solid state devices	quantum electronics
integrated circuitry	materials research	microelectronics
computer systems	laser research	analog device technology

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Quarterly Technical Summary covers the period 1 August through 31 October 1981. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

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