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This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT
TO THE
AIR FORCE SYSTEMS COMMAND

1 FEBRUARY – 30 APRIL 1981

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LEXINGTON MASSACHUSETTS

INTRODUCTION

This Quarterly Technical Summary covers the period 1 February through 30 April 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 February through 30 April 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
Network Speech Systems 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

The CMOS process has been debugged, and 4-bit counters have been built and successfully tested. A restructurable VLSI demonstration wafer which uses that counter is in process, and cell layouts are finished for two whole-wafer RVLSI designs. The laser-link insulator has been modified to allow higher temperature processing. Thin oxynitride gate transistors have shown excellent radiation resistance.

II. ADVANCED CIRCUIT DESIGN AND SIMULATION

A. Restructurable VLSI Demonstration Wafer

The design and layout of a demonstration wafer for the restructurable VLSI project continues. This wafer will consist of a 7×7 array of customizable CMOS gate-array chips surrounded by chips containing test devices and off-wafer bonding pads. Each gate array contains a 4-bit counter like the one on the CMOS test chip discussed in Sec. IV. A matrix of two-level metal interconnect with laser-formable links will be located in channels between the chips. This design has been finished through the contact cut layer, and wafer processing has begun.

The functional tester has been modified to test the 4-bit counter. The tester was originally built for ECL, so voltage levels had to be changed. Counters on the CMOS test chip were successfully tested at a 1-MHz clock rate.

B. RVLSI Spread Spectrum Integrator

The 5-μm design rules have been used to design an integrator cell on the Calma system. The cell contains four 10-bit counters, two 4-stage shift registers, and input and output buffers and drivers. The design contains about 1900 transistors. The complete integrator will use 64 of these cells wired together with laser-programmed restructurable interconnect.

The Lincoln Laboratory design rule check program has been extremely effective in simplifying the layout task. Spacing errors are easily found without the necessity of a meticulous part-by-part inspection.

C. FFT for Radar Applications

Design of a restructurable wafer-scale system for performing 16-point FFTs at a data rate of up to 16 MHz is completed through transistor specification. The system consists of a fully populated array of 32 radix-two butterfly elements, each consisting of four multipliers and six adder/subtracters. Sixteen-bit, serial arithmetic is employed throughout. The use of serial arithmetic simplifies intercellular communication and promotes pipelining of operations. Mask design for the first experiment is now under way.

III. RESTRUCTURABLE VLSI TECHNOLOGY

A. Production of Laser-Formed Vias

We have now made vias with amorphous Si insulator from three different sources. Sputtered, e-beam evaporated, and plasma-deposited a-Si all produce excellent connections.

We have reduced the laser pulse length to 1 ms instead of 5 ms. The resulting connections are equally good, with essentially 100% yield, and the probability of a short through the underlying 1 μm of SiO_2 is reduced to near zero.

First samples of the RVLSI laser-link test wafer have been received (see 15 February 1981 AET QTS). Initial tests of the 20 × 20-μm^2 pads indicate that the laser connections which have been formed are as good as those on the larger test structures used to date. Chains of five vias have been tested, and resistances $<<1\ \Omega$ have been obtained. Work is continuing on these structures.

B. Via Reliability

Shorting is observed in laser-link insulator structures consisting of a-Si sandwiched between layers of Al-Si-Cu after short anneals at 350°C with e-beam deposited a-Si and 425°C with sputter-deposited a-Si. Etchback and SEM analysis indicates rapid dissolution of a-Si in Al and Al counterdiffusion to produce the shorts. The driving force for this process is the decrease in Si free energy when Si goes from the amorphous state to form crystallites embedded in the Al film. To control this failure mode, we have added thin (about 200 Å) nitride or oxide barriers to prevent Si and Al interdiffusion. The dielectric barriers also substantially reduce link insulator leakage and improve the insulator breakdown voltage. Good laser links are formed with these barrier structures, and work is now under way to evaluate their yield and reliability. Thicker dielectric barriers will also be investigated.

C. Mechanism of Laser Formed Vias

We have monitored the .eflected laser light during via formation. Intensity peaks occur which we identify with melting of each of the three layers. By simultaneously measuring the first- to second-metal resistance, we find that initiation of electrical contact coincides with melting of the a-Si insulator.

Etchback and SEM examinations of laser-programmed links indicate that virtually all of the material in the laser-formed crater is Si. This strongly suggests that the links are composed of a metal-Si-metal sandwich structure where the Si is highly doped with Al (a p-type dopant) to provide low resistivity and low metal-to-Si contact resistance. Further experiments are planned to clarify the nature of the contact.

D. Laser Table Positioning Controller and Interface

The design and fabrication of a controller/interface for the Apple computer and the X and Y table have been completed. Programs have been written in Basic to address the X and Y table and provide laser pulse control.

IV. SEMICONDUCTOR PROCESSING

A. Lithography

The direct-step-on-wafer system has now achieved adequate throughput to handle our needs and its reliability seems satisfactory. Design of a semiautomatic reticle aperture system for the DSW is under way. This will permit use of reticles containing a number of images which can be separately exposed by independent control of the position of each of the four masking aperture blades, thus achieving multicircuit capability on the wafer with a minimum number of reticles. The aperture system is to be built as a direct retrofit to the existing DSW machine.

B. Reactive Ion Etching (RIE)

The experimental RIE system has been completed and been used to etch polyimide, silicon, polysilicon, and thermox using various etch gases. Oxygen etches polyimide very well, producing vertical sidewalls in thick sections and can produce submicron geometries for ion implant masking. Evaluation of several fluorine-containing gases at various pressures has revealed that SF_6 will etch polysilicon on thermox with a 25:1 etch rate preference for polysilicon. There is some undercut with good anisotropy in the poly. Also, this gas appears to etch single-crystal silicon with excellent smoothness and anisotropy. Material evaluation will continue in an attempt to develop a wide repertoire of etching capability.*

C. CMOS Test Chip

The 5-μm CMOS process is now well established. After adjusting implant conditions to avoid ion penetration through the poly Si gate, threshold control seems to be good. We will continue fabricating test-chip runs, along with the products discussed in Sec. II, in order to gain experience and optimize various details of the process.

The first run containing 4-bit counters (see Sec. II-A) had a low yield of about 25% due to metal-poly insulator defects. The next run, now partially tested, looks much better with a yield of around 60%.

D. Thermal Nitride

Analysis of the nitridation data indicates that the rate of nitridation of thin oxide films is proportional to the ammonia concentration and inversely proportional to the film thickness. The exact temperature dependence has not yet been determined.

A group of metal gate transistors were irradiated with up to ±4 V on the gate. The dose was 1 Mrad (Si) of 1.5-MeV electrons. Many of the transistors were virtually unchanged both in gain and threshold, although some were damaged catastrophically, probably in handling.

V. DEVICE THEORY

Jahn-Teller Effect as the Mechanism for the Strong Coupling of Defect Electron-Lattice Systems in Covalent Insulators

When degenerate electronic levels of a defect are partially occupied, the lattice in the vicinity of the defect will distort in such a manner as to reduce the order of the degeneracy and lower the overall energy of the defect electron-lattice system. This distortion is known as the Jahn-Teller effect. In order to describe the nature of the defects that produce deep-level states in covalent semiconductors and insulators, it is important to understand the lattice relaxations and distortions that occur around the defect and their intimate connection with defect electronic states. Reported here is an examination of the Jahn-Teller effect as applied to the N_4^+ defect (see 15 November 1978 AET QTS) in silicon nitride.

The N_4^+ defect in silicon nitride is a singly charged nitrogen atom bonded to four silicon atoms in a tetrahedral arrangement. When an electron is trapped on an N_4^+ defect ($N_4^+ + e^- \rightarrow N_4^0$), a local distortion in the lattice may occur due to the Jahn-Teller effect. The tetrahedral symmetry (T_d) of the lattice about the N_4 defect is distorted into a trigonal symmetry (C_{3V}) with the principal axis lying in the direction of one of the four bonding orbitals of the N_4^+ defect. As a result of this distortion, the silicon atom lying along the principal axis of the trigonal symmetry tends to move along the axis *away* from the nitrogen atom and the other three silicon atoms, while the nitrogen atom tends to move in the opposite direction toward the plane formed by these other three silicon atoms. In other words, the trigonal distortion of the N_4^0 defect state tends to produce a silicon atom with a dangling bond (on which the captured electron principally resides) and a nitrogen atom which is normally bonded to three silicon atoms in a trigonal coplanar arrangement.

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*T.O. Herndon, R.L. Burke, and J.F. Howard, "Plasma Etching of Aluminum (for Multilevel Metal)," University/Government/Industry Microelectronics Symposium, Mississippi State University, May 1981.

COMPUTER SYSTEMS
GROUP 28

A pair of Benson-Varian 9211 Printer Plotters were installed during the quarter and are undergoing acceptance testing. These units are connected directly on-line in much the same manner as a line printer. Graphic output is produced on 11-in. fanfold paper by an electrostatic process at a resolution of 200 points per inch. User software support is provided by the Laboratory's common graphics interface package known as GRILL.

Vector output from this system is sorted and converted to raster format by a Benson-Varian Graphware 1000 Controller. Several format problems associated with this process are still to be resolved. Although the quality of the output cannot be expected to equal that of the COMp 80 CRT Plotter, the results are very satisfactory for many applications. Of particular interest to users is the fact that the direct on-line connection permits faster turnaround times, and the unit cost of output produced by the Benson-Varian Plotters is less than that of the COMp 80.

The initial components of the Lincoln Internal Data Link (LIDL) have been delivered by AUSCOM, Inc. and are installed on the Central Computer System. The basic function of LIDL is that of geographically extending the access capabilities of a data channel of the Amdahl 470 Computer. The AUSCOM equipment, which is located in the computer room and directly attached to an Amdahl data channel, performs the interfacing function.

On the inboard or Amdahl side, it responds to all channel communications protocol addressing and signalling as though it were a standard device controller. On the outboard side, it can be programmed to respond to a variety of communications protocols and standards such as the IEEE 488 Instrumentation Bus, the DEC Q-Bus or Unibus, or the EIA RS232 Interface Standard. Remotely located devices connected via LIDL will be addressed and controlled by the central system as though they were standard, locally attached, input/output units. Equipment checkout and software development for LIDL are in progress.

Continued demand for remote terminal connections has required the installation of a third IBM 3705 Communications Controller, and a fifth IBM 3270 Type Controller. There are now 340 devices operating at speeds up to 4800 baud through the 3705's. Most of these devices are directly connected to the system, but 25 ports are assigned to modem pools for communications over the telephone system to remote locations. The five 3270 Type Controllers now support more than 130 alphanumeric display terminals. The maintenance and extension of these communications systems require a significant sustained effort.

SOLID STATE
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 February through 30 April 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.

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DIVISION 8 REPORTS
ON ADVANCED ELECTRONIC TECHNOLOGY

15 February through 15 May 1981

PUBLISHED REPORTS

Journal Articles

JA No.	Title	Authors	Citation
5071	Phase Diagram for LPE Growth of GaInAsP Layers Lattice Matched to InP Substrates	J. J. Hsieh	IEEE J. Quantum Electron. QE-17, 118 (1981)
5140	Balloon-Borne Laser Heterodyne Radiometer for Measurements of Stratospheric Trace Species	R. T. Menzies* C. W. Rutledge* R. A. Zanteson* D. L. Spears	Appl. Opt. 20, 536 (1981)
5144	Low Dark-Current, High Gain GaInAs/InP Avalanche Photodetectors	V. Diadiuk S. H. Groves C. E. Hurwitz G. W. Iseler	IEEE J. Quantum Electron. QE-17, 260 (1981)
5145	Laser-Induced Dielectric Breakdown in Cryogenic Liquids	S. R. J. Brueck H. Kildal	J. Appl. Phys. 52, 1004 (1981)
5150	Gain Spectra in GaInAsP/InP Proton-Bombarded Stripe-Geometry DH Lasers	J. N. Walpole T. A. Lind J. J. Hsieh J. P. Donnelly	IEEE J. Quantum Electron. QE-17, 186 (1981)
5156	High-Resolution Double-Resonance Spectroscopy of $2\nu_3 \leftarrow \nu_3$ Transitions in SF_6	C. W. Patterson* R. S. McDowell* P. F. Moulton A. Mooradian	Opt. Lett. 6, 93 (1981)
5159	Detection of the $J = 6 \rightarrow 5$ Transition of Carbon Monoxide	P. F. Goldsmith* N. R. Erickson* H. R. Fetterman B. J. Clifton D. D. Peck P. E. Tannenwald G. A. Koepf* D. Buhl* N. McAvoy*	Astrophys. J. 243, L79 (1981)
5160	Transmission Electron Microscopy and Ion-Channeling Studies of Heteroepitaxial $Ge_{1-x}Si_x$ Films Produced by Transient Heating	B-Y. Tsaur J. C. C. Fan T. T. Sheng*	Appl. Phys. Lett. 38, 447 (1981)

* Author not at Lincoln Laboratory.

JA No.			
5163	Efficient Si Solar Cells by Laser Photochemical Doping	T. F. Deutsch J. C. C. Fan G. W. Turner R. L. Chapman D. J. Ehrlich R. M. Osgood, Jr.	Appl. Phys. Lett. 38, 144 (1981)
5164	Lateral Epitaxy by Seeded Solidification for Growth of Single-Crystal Si Films on Insulators	J. C. C. Fan M. W. Geis B-Y. Tsaur	Appl. Phys. Lett. 38, 365 (1981)
5170	Solid-Phase Heteroepitaxy of Ge on <100> Si	B-Y. Tsaur J. C. C. Fan R. P. Gale	Appl. Phys. Lett. 38, 176 (1981)
5173	Intracavity Loss Modulation of GaInAsP Diode Lasers	D. Z. Tsang J. N. Walpole S. H. Groves J. J. Hsieh J. P. Donnelly	Appl. Phys. Lett. 38, 120 (1981)
5177	Laser Photochemical Microalloying for Etching of Aluminum Thin Films	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	Appl. Phys. Lett. 38, 399 (1981)
5179	Explosive Crystallization of Amorphous Germanium	H. J. Leamy* W. L. Brown* G. K. Celler* G. Foti* G. H. Gilmer* J. C. C. Fan	Appl. Phys. Lett. 38, 137 (1981)
5191	Fundamental Line Broadening of Single-Mode (GaAl)As Diode Lasers	M. W. Fleming A. Mooradian	Appl. Phys. Lett. 38, 511 (1981)
5201	Low-Loss GaAs Optical Waveguides Formed by Lateral Epitaxial Growth over Oxide	F. J. Leonberger C. O. Bozler R. W. McClelland I. Melngailis	Appl. Phys. Lett. 38, 313 (1981)

Meeting Speeches

MS No.			
4779D	Beam Annealing of Ion-Implanted GaAs and InP	J. C. C. Fan R. L. Chapman J. P. Donnelly G. W. Turner C. O. Bozler	Proc. MRS Annual Mtg. 1980: Laser and Electron-Beam Solid Interactions and Materials Processing (Elsevier North-Holland, New York, 1981), pp. 261-274

* Author not at Lincoln Laboratory.

MS No.			
5127B	Recent Advances in High Efficiency, Low-Cost GaAs Solar Cells	J. C. C. Fan C. O. Bozler R. P. Gale R. W. McClelland R. L. Chapman G. W. Turner H. J. Zeiger	Proc. IEEE Intl. Electron Devices Mtg., Washington, DC, 8-10 December 1980, pp. 534-537
5196	Electrode Band Structure and Interface States in Photoelectrochemical Cells	J. G. Mavroides J. C. C. Fan H. J. Zeiger	In ACS Symposium Series, No. 146, "Photoeffects at Semiconductor-Electrolyte Interfaces," A. J. Nozik, Ed. (American Chemical Society, New York, 1981), pp. 217-230
5394	Nonlinear Optics of Cryogenic Liquids	S. R. J. Brueck H. Kildal	Proceedings of the Sergio Porto Memorial Conference (Springer-Verlag, Heidelberg, 1981), p. 147
5427	Measurement of Phase Boundary Dynamics During Scanned Laser Crystallization of Amorphous Ge Films	R. L. Chapman J. C. C. Fan H. J. Zeiger R. P. Gale	Proc. MRS Annual Mtg. 1980: Laser and Electron-Beam Solid Interactions and Materials Processing (Elsevier North-Holland, New York, 1981), pp. 81-88
5433	Electromagnetic Long-Line Effects in Surface Wave Convolvers	E. L. Adler*	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 82-87
5434	The Effect of Acoustic Dispersion and Attenuation on SAW Convolver Performance	E. L. Adler* J. H. Cafarella	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 1-4
5435	Attenuating Thin Films for SAW Devices	A. C. Anderson V. S. Dolat W. T. Brogan	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 442-445
5436	Self-Aligning Bilateral Chirp-Transform System	D. R. Arsenault V. S. Dolat	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 220-225
5437	$LiNbO_3$ Surface-Acoustic-Wave Edge-Bonded Transducers on ST Quartz and <001>-Cut GaAs	D. E. Oates R. A. Becker	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 367-370
5438	Temperature-Stable RAC	D. E. Oates D. M. Boroson	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 272-276
5439	An Acoustoelectric Burst-Waveform Processor	S. A. Reible L. Yao	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 133-138

* Author not at Lincoln Laboratory.

MS No.			
5440	Nonlinearly Coupled Modes of Surface Acoustic Waves	N. P. Vlannes* A. Bers*	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 356-361
5441	High Performance Elastic Convolver with Parabolic Horns	I. Yao	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 37-42
5448	Hybrid Convolver/Binary Signal Processor Achieves High Processing Gain	R. P. Baker J. H. Cafarella	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 5-9
5462	Detectors for the 1.1-1.6 μm Wavelength Region	C. E. Hurwitz	Proc. SPIE Vol. 239: Guided-Wave Optical and Surface Acoustic Wave Devices, Systems and Applications (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981), pp. 33-41
5479	State-of-the-Art in Coherent Near-mm Detectors	P. E. Tannenwald	Proc. SPIE Vol. 259: Millimeter Optics (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981), pp. 2-4
5489	A Closed-Form Analysis of Reflective-Array Gratings	P. V. Wright H. A. Haus*	1980 Ultrasonics Symposium Proceedings (IEEE, New York, 1980), pp. 282-287
5530	GaAs Monolithic Circuit for Millimeter-Wave Receiver Application	A. Chu W. E. Courtney L. J. Mahoney G. A. Lincoln W. Macropoulos R. W. Sudbury W. T. Lindley	1981 IEEE Intl. Solid-State Circuits Conf., Digest of Technical Papers, Vol. XXIV, New York, New York, 18-20 February 1981, pp. 144-145
5538	Lateral Epitaxy by Seeded Solidification for Growth of Single-Crystal Si Films on Insulators	J. C. C. Fan M. W. Geis B-Y. Tsaur	Proc. 1980 IEEE Intl. Electron Devices Mtg., Washington, DC, 8-10 December 1980, p. 845
5567	Pulsed Plasma Source for X-Ray Lithography	S. M. Matthews* R. Stringfield* I. Roth* R. Cooper* N. P. Economou D. C. Flanders	Proc. SPIE Vol. 275: Semiconductor Microlithography VI (Society of Photo-Optical Instrumentation Engineers, Bellingham, Washington, 1981)
5596	Explosive Crystallization of Amorphous Ge Films	H. J. Leamy* W. L. Brown* G. K. Celler* G. Foti* G. H. Gilmer* J. C. C. Fan	Proc. MRS Annual Mtg. 1980: Laser and Electron-Beam Solid Interactions and Materials Processing (Elsevier North-Holland, New York, 1981), p. 89

* Author not at Lincoln Laboratory.

UNPUBLISHED REPORTS

Journal Articles

JA No.			
5166	Detectors for the 1.1-1.6 μm Wavelength Region	C. E. Hurwitz	Accepted by Opt. Eng.
5185	Heteroepitaxy of Vacuum-Evaporated Ge Films on Single-Crystal Si	B-Y. Tsaur M. W. Geis J. C. C. Fan R. P. Gale	Accepted by Appl. Phys. Lett.
5189	The Electro-Optic Application of InP	A. G. Foyt	Accepted by J. Cryst. Growth
5195	n^+-InP Growth over InGaAs by Liquid Phase Epitaxy	S. H. Groves M. C. Plonko	Accepted by Appl. Phys. Lett.
5200	Hydroplane Polishing of Semiconductor Crystals	J. V. Gormley M. J. Manfra A. R. Calawa	Accepted by Rev. Sci. Instrum.
5215	Optical Properties of Proton Bombarded InP and GaInAsP	F. J. Leonberger J. N. Walpole J. P. Donnelly	Accepted by IEEE J. Quantum Electron.
5220	Spatially Delineated Growth of Metal Films via Photochemical Prenucleation	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	Accepted by Appl. Phys. Lett.
5227	Transient Annealing of Arsenic-Implanted Silicon Using a Graphite Strip-Heater	B-Y. Tsaur J. P. Donnelly J. C. C. Fan M. W. Geis	Accepted by Appl. Phys. Lett.
5229	Effect of Turbulence Induced Correlation on DIAL Measurement Errors	D. K. Killinger N. Menyuk	Accepted by Appl. Phys. Lett.
5230	Temporal Correlation Measurements of Pulsed Dual CO_2 LIDAR Returns	N. Menyuk D. K. Killinger	Accepted by Opt. Lett.
5242	MNOS/CCD Nonvolatile Analog Memory	R. S. Withers D. J. Silversmith R. W. Mountain	Accepted by IEEE Electron Dev. Lett.
5251	Sputtered Films for Wavelength-Selective Applications	J. C. C. Fan	Accepted by Thin Solid Films

Meeting Speeches*

MS No.			
4584E	New Developments and Applications of Submillimeter Heterodyne Detectors	H. R. Fetterman	Seminar, University of California, Los Angeles, 18 March 1981
5134A	Excimer Excitation of Lasers Via Bound-Free and Free-Bound Transitions	R. M. Osgood, Jr.	Seminar, University of Florida, Gainesville, 13 April 1981
5161B	The Permeable Base Transistor	C. O. Bozler	Seminar, Greater Boston IEEE Chapter, Lincoln Laboratory, 23 April 1981
5230A	Picosecond Optical Sampling	H. A. Haus†, S. T. Kirsch†, K. Mathyssek†, F. J. Leonberger	SPIE Los Angeles Technical Symp., North Hollywood, California, 9-13 February 1981
5619	High-Performance GaInAsP/InP Avalanche Photodetectors	V. Diadiuk, S. H. Groves, C. E. Hurwitz, G. W. Iseler	SPIE Los Angeles Technical Symp., North Hollywood, California, 9-13 February 1981
5620	Intracavity Loss Modulation of GaInAsP Lasers	D. Z. Tsang, J. N. Walpole, S. H. Groves, J. J. Hsieh, J. P. Donnelly	SPIE Los Angeles Technical Symp., North Hollywood, California, 9-13 February 1981
5632	InP Optoelectronic Mixers	A. G. Foyt, F. J. Leonberger, R. C. Williamson	SPIE Los Angeles Technical Symp., North Hollywood, California, 9-13 February 1981
5640	Guided-Wave Electrooptic Analog to Digital Converter	F. J. Leonberger	SPIE Los Angeles Technical Symp., North Hollywood, California, 9-13 February 1981
5236G	Direct-Write Laser Processing for Microelectronics	R. M. Osgood, Jr., D. J. Ehrlich, T. F. Deutsch	Topical Mtg., IEEE Chapter on Quantum Electronics, Washington, DC, 21 April 1981
5528A	Transferable Single-Crystal Films Using the CLEFT Process	C. O. Bozler	Industrial Liaison Program Symp., M.I.T., 16 April 1981
5607A	Laser Photochemical Techniques	T. F. Deutsch	Industrial Liaison Program Symp., M.I.T., 16 April 1981
5633	Novel Junction Formation Techniques	B-Y. Tsaur	Industrial Liaison Program Symp., M.I.T., 16 April 1981

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

† Author not at Lincoln Laboratory.

MS No.			
5638	Large-Grained or Single-Crystal Films on Amorphous Substrates	M. W. Geis	Industrial Liaison Program Symp., M.I.T., 16 April 1981
5644	Tomorrow's Solar Cell Technology	J. C. C. Fan	
5645	Gallium Arsenide Solar Cells: Material Growth	R. P. Gale	
5646	Gallium Arsenide Solar Cells: Cell Fabrication	G. W. Turner	
5548	Low Loss $LiNbO_3$ Waveguide Bends with Coherent Coupling	L. M. Johnson F. J. Leonberger	Third Intl. Conf. on Integrated Optics and Optical Fiber Communication, San Francisco, California, 27-29 April 1981
5552	An Integrated Optical Temperature Sensor	L. M. Johnson F. J. Leonberger G. W. Pratt, Jr.*	
5568	Repetitive Q-Switching of Semiconductor Diode Lasers	D. Z. Tsang J. N. Walpole	
5578	Progress in Long-Wavelength Sources and Detectors	C. E. Hurwitz	
5556A	Surface-Acoustic-Wave Signal-Processing Devices	R. W. Ralston	Chicago IEEE Group on Sonics and Ultrasonics, Chicago, Illinois, 2 February 1981
5569	Interband Magneto-Optical Studies in $In_{1-x}Ga_xAs_yP_{1-y}$ Semiconducting Alloys	K. Alavi* R. L. Aggarwal* S. H. Groves	American Physical Society Mtg., Phoenix, Arizona, 16-20 March 1981
5573	Precision Collisional Lineshapes by Difference-Frequency Laser Spectroscopy	A. S. Pine	SPIE Technical Symposium East '81, Washington, DC, 20-24 April 1981
5678	Liquid Phase Epitaxial Growth of $Hg_{1-x}Cd_xTe$ from Te-Rich Solutions	T. C. Harman	
5696	Applications of InP Photoconductive Switches	F. J. Leonberger	
5597	The Role of the GaAs Substrate in Device Performance	R. A. Murphy	GaAs Workshop, Wakefield, Massachusetts, 11 March 1981
5607B	Pulsed UV Laser Doping of Semiconductors	T. F. Deutsch	Laser Workshop, M.I.T., 4-5 May 1981

* Author not at Lincoln Laboratory.

MS No.			
5609A	Divalent Transition-Metal Solid State Lasers	P. F. Moulton A. Mooradian	Topical Mtg. on Tunable Laser Sources, Keystone, Colorado, 1-3 April 1981
5641	Frequency-Doubled Mini-TEA CO_2 Laser System for Remote Sensing	N. Menyuk P. F. Moulton D. K. Killinger	
5620A	Intracavity Loss Modulation of GaInAsP Lasers	D. Z. Tsang J. N. Walpole S. H. Groves J. J. Hsieh J. P. Donnelly	Optics and Quantum Electronics Seminar, M.I.T., 18 March 1981

SOLID STATE
DIVISION 8

I. SOLID STATE DEVICE RESEARCH

GaInAsP/InP diode lasers have been fabricated with an intracavity electroabsorption modulator. The additional loss produced by operating the modulator near maximum reverse bias increased the laser threshold by a factor of as much as 2.9 relative to the threshold with the modulator open-circuited. Large depth of modulation of the laser output has been achieved at frequencies up to 2.5 GHz, the system measurement limit.

InP optoelectronic switches have been shown to have potential performance advantages over conventional diode bridges as electronic mixers. These advantages include isolation of local oscillator and signal, simplicity of construction, and linearity from low frequencies into the gigahertz range. Mixer operation has been demonstrated at 100 MHz, and calculations indicate good performance into the gigahertz range with existing InP technology and GaAs laser sources.

II. QUANTUM ELECTRONICS

A preliminary study, including laboratory measurements, has been made to test the capability of a dual-laser differential absorption LIDAR system for the remote sensing of hydrazine, monomethylhydrazine, and unsymmetrical dimethylhydrazine, which are used as aircraft and missile propellants. The results indicate that a detection sensitivity of 10 to 100 parts per billion in the atmosphere over a range of several kilometers should be achieved with these molecules.

Two GaAlAs double-heterostructure semiconductor diode lasers, each in a separate external cavity, have been heterodyned. Broadly tunable (10 nm), single longitudinal mode operation, with a spectral linewidth less than 15 kHz, has been observed for the first time.

The characteristic times for thermalization to the lattice temperature of electrons excited to the upper noncentral conduction-band minima of GaAs and InP have been measured using a four-wave mixing technique. Relaxation times of 1.1 ps for GaAs and 0.3 ps for InP at a lattice temperature of 300 K are obtained. Measurements of the nonresonant third-order susceptibility in these materials show that it is dominated by bound electron contributions and is insensitive to the free carrier concentration.

III. MATERIALS RESEARCH

Shallow-homojunction GaAs solar cells have been fabricated from single-crystal GaAs epilayers grown by chemical vapor deposition on Si substrates that were coated with a thin epilayer of vacuum-evaporated Ge to enhance GaAs nucleation. These cells, which have conversion efficiencies of 12 percent (AM1), are the first reported GaAs devices fabricated on Si substrates.

Cathodoluminescence, excited by the electron beam of a scanning electron microscope, has been utilized for nondestructive characterization of the optoelectronic properties of polycrystalline GaAs doped with Zn at the concentration level ($\sim 10^{19}$ cm^{-3}) used for the substrates of GaAs shallow-homojunction solar cells. By employing cathodoluminescence imaging and using spectral analysis to determine local carrier concentrations and diffusion lengths, it has been found that grain boundaries in this material differ significantly in their effects on nonradiative recombination and impurity distribution.

A simple transient annealing technique, which should be useful for large-scale semiconductor processing, has been developed for removal of ion-implantation damage in Si. For samples implanted with As at concentrations below the equilibrium solubility limit, annealing at 900° to 1000°C for only 10 s on a graphite strip heater results in electrical activation comparable to that obtained by a conventional furnace anneal at 1000°C for 30 min., but with negligible dopant redistribution.

A simplified version of the LESS technique (Lateral Epitaxy by Seeded Solidification) has been developed for the growth of single-crystal Si films over insulators. Films grown over SiO_2 by the new method, which uses a stationary graphite strip for transient heating, are comparable in crystal quality to the films obtained by the original method, which uses both a stationary and a movable heater.

IV. MICROELECTRONICS

The technique of charge skimming has been investigated for use with the CCD imager developed for the GEODSS (Ground-based Electro-Optical Deep Space Surveillance) Program as a means of increasing the sensitivity of the sensor for daylight sky surveillance, an application characterized by high background and low contrast. To demonstrate the capability of this technique, the final transfer stage of a CCD array has been operated with a signal of approximately 3,700 electrons electrically added to an optically induced background of 400,000 elec[illegible].

A metallization technique, in which alternating films of silicon and a refractory metal are deposited from a multi-hearth electron-beam source without breaking vacuum, has been used to investigate the formation of refractory-metal silicides. Although $TaSi_2$ and $MoSi_2$ are readily formed by this technique, the chemistry of vacuum-deposited tungsten films results in an isolating oxide between the tungsten and silicon films that prevents the formation of WSi_2 up to 1000°C. This property of tungsten makes it inherently useful for buried-metal films in silicon devices.

The high-accuracy alignment capability of scanning electron-beam lithography systems has been applied to FET device patterns with submicrometer feature sizes. A multistep alignment procedure is used which involves coarse registration to large alignment marks viewed at low magnification, followed by high-resolution alignment using a set of small alignment marks imaged at high magnification.

V. ANALOG DEVICE TECHNOLOGY

Tests on MNOS/CCD analog memory chips indicate that the devices can withstand at least 10^6 erase/write cycles before the onset of degradation in writing and retention characteristics. Fixed-pattern noise is the major source of error in the memory and is caused by threshold voltage variations both in the thin-oxide (memory) dielectric (~40 mV) and in the thick-oxide (nonmemory) dielectric (~25 mV). The device also functions as a binary/analog memory correlator, with well over 40 dB of linear dynamic range demonstrated in the correlation of 15-bit M-sequences.

As part of an effort to utilize superconducting circuits to produce very wideband analog-signal processors, a design analysis has been carried out for tapped-delay-line filters made with superconducting waveguiding structures. The constraints on delay and bandwidth set by conductor loss, dielectric loss, dispersion, crosstalk, and current technology have been determined for microstrip, stripline, and coplanar waveguides. Matched filters with time-bandwidth products of over 1000 and with bandwidths of 2 to 20 GHz appear feasible.

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