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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT
TO THE
AIR FORCE SYSTEMS COMMAND

1 NOVEMBER 1980 - 31 JANUARY 1981

ISSUED 29 MAY 1981

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FOR THE COMMANDER

Raymond L. Loebell

Raymond L. Loebell, Lt. Col., USAF
Chief, ESD Lincoln Laboratory Project Office

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INTRODUCTION

This Quarterly Technical Summary covers the period 1 November 1980 through 31 January 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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DATA SYSTEMS DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period 1 November 1980 through 31 January 1981 on Data Systems. Separate reports describing other work of Division 2 are issued for the following programs:

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

A.J. McLaughlin
Head, Division 2
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DIGITAL INTEGRATED CIRCUITS

GROUP 23

I. INTRODUCTION

An argon laser has been used to form reproducible, low-resistance connections between two levels of metal separated by insulating amorphous silicon. The design has been completed for a large-area feasibility demonstration which will permit restructuring of a multiplicity of gate array chips on a single wafer using the laser for both link addition and deletion. A metallurgical change directly associated with fatigue from write/erase cycling of MNOS capacitors has been established for the first time using a silicon etch technique.

II. ADVANCED CIRCUIT DESIGN AND SIMULATION

A. Restructurable VLSI (RVLSI) Test Circuit

Design of the large-area RVLSI circuit is almost complete, and tapes for the two reticle types required will soon be sent for pattern generation. Most of the wafer will be stepped with gate arrays previously used in the CMOS test chip. At the wafer periphery, images containing wafer-scale pads and test devices will be stepped separately using the DSW machine. Two-level interconnect metal with sites for laser-formed vias and disconnects will be placed symmetrically surrounding each gate array and stitched together to form continuous wafer length lines using the DSW machine.

B. Design of Basic Integrator Cell for RVLSI Spread-Spectrum Integrator

Layout of a custom CMOS version of the basic cell for the spread-spectrum integrator has begun. This cell has four 10-bit buffered counters

and means for write and read accessing serially by word.

III. RVLSI TECHNOLOGY

A. Laser-Formed Vias

Current experiments with laser-formed connections for RVLSI applications indicate that best results are obtained with the following structure: 1 μm of base thermal oxide, 0.5 μm of Al alloy first metal, 0.5 to 1.0 μm of sputtered amorphous silicon insulator, and 0.75 μm of Al alloy second metal. Using an argon laser with a range of 2 to 4 W peak power and 5-ms pulses, connection resistances of 0.3 ohm were observed with no failures in several hundred tests. It has proved significantly more difficult to form vias in CVD SiO_2 and polyimide than in amorphous Si. The process dynamics of link formation is presently under study.

B. Link Test Wafer Design

A design has been completed for the RVLSI laser link node to be used in the initial feasibility demonstration of large-area laser restructuring. This structure, which is conservative in its approach, will employ links on 50- μm spacings. The design allows for (1) laser connections at the link node, (2) cutting of first or second metal bus lines, and (3) disconnecting the node from the buses (to cut a connection already made or to isolate a damaged node). A test wafer implementation of this structure has been designed and is currently being produced. It contains a range of devices varying from simple 3-by-3 blocks of the link structures to a complex full-wafer wiring grid involving tens of thousands of link pads. Testing schemes to locate errors in an unprogrammed link

node grid are employed in some sections of this system. This wafer should provide the test data necessary to determine the feasibility of using this technique in an operational RVLSI wafer programming system.

C. X-Y Table for Laser Restructuring

An Apple II Plus computer has been interfaced to the X-Y table in order to provide a programmable position controller. The table is moved by two DC stepping motors that can step in increments of 3.125 μm . The computer controller will eventually be connected to the VAX computer to obtain data files which contain the link locations generated from test and routing programs. The controller has an absolute position display which may be set to any zero location. It also includes feedback to provide a continuous check on the translator modules which drive the stepping motors.

IV. SEMICONDUCTOR PROCESSING

A. Lithography

The direct step-on wafer printer is now integrated into photolithography processing. Previous difficulties with machine stability and level-to-level misregistration have been largely eliminated. Excellent resolution and registration are now being obtained, and our confidence level is high enough that a majority of new circuit patterns are being made for use with the DSW. We have also demonstrated the ability to mix levels stepped on the DSW with those produced by a normal mask aligner.

B. Reactive Ion Etching

A reactive ion etching system has been assembled from spare parts and is undergoing evaluation. Initial etching of polyimide, using

aluminum as the mask, has produced excellent results. Lines and spaces 2 μm wide were etched in 1.75- μm -thick polyimide at a rate of 1700 $\text{\AA}/\text{min}$. using 100-percent oxygen. The resulting sidewalls were vertical, and undercut was essentially zero. Investigations of silicon etching in CF_4 and SF_6 are proceeding.

C. Polyimide Implant Mask

Continued investigation of polyimide as a high-temperature ion-implant mask shows minimal deformation at high doses and current levels for boron, phosphorus, and arsenic. It is readily stripped in oxygen plasma, and its stopping power has been confirmed to follow the published curves for KTFR.

D. CMOS Process Development

Problems with polysilicon gate undercut and adhesion of resist to polysilicon have been essentially eliminated by the use of the DSW. An additional mask for threshold adjustment by ion implantation appears desirable in order to obtain adequate threshold control.

E. Silicon Epitaxy by Lateral Growth Over Oxide

A CVD process is being developed to laterally grow single-crystal silicon over SiO_2 bar structures. Such a process could be used to fabricate two-level silicon devices. To date, we have determined the dependence of the lateral growth rate on the standard deposition parameters and have grown single-crystal silicon over 20- μm -wide oxide strips. The next task is to evaluate the electronic properties of the overgrown silicon.

F. Thermal Nitridation

Ellipsometer measurements of the sandwich structure produced by nitriding thin (100- $\text{\AA}$) oxide films in ammonia at 1200°C typically show

an interface film of 20-Å silicon nitride, an intermediate layer of SiO₂ containing less than 10-percent silicon nitride of 95 Å, and an outer layer of silicon nitride converted from oxide of 5 to 10 Å. A model of the kinetics of this process is being developed.

Several transistor runs have been completed and indicate that, without further treatment, the nitride-silicon interface results in reduction of channel mobility by a factor of 2 compared with oxide devices fabricated in the same run.

V. DEVICE THEORY, TEST, AND MODELING

A. CMOS Design Rule Checker

The design rule check program for our CMOS process has been modified to perform additional tests. It currently separates mask areas into 19 different component classifications and then makes 58 design rule checks. A printed job-output summary is provided which gives the number of elements in each component category and in each error category. In spite of these added features, program improvements have reduced the CPU time required to evaluate the CMOS test-chip mask set to 6 min. from the previously reported 20 min. Documentation has been made available describing the use of the program and it is expected to handle efficiently any new mask sets designed with the same rules.

B. The Role of Defects in the Fatigue Mechanism of MNOS Devices

An etch technique has been developed that can be used to reveal the role of defects in the fatigue and ultimate failure mechanism in MNOS devices. Native-oxide MNOS capacitors with various histories of stress (up to 3×10^8 Write/

Erase cycles) were stripped of metal, and etched in 6-1-1 silicon etch until the dielectrics were fully removed. Etch-pit size and density in the silicon can be correlated with the electrical history of each device. In particular, above 10^8 cycles (in deep fatigue) there is a marked change in etch-pit size, indicating that a metallurgical change at the silicon-dielectric interface is produced during fatigue.

C. Photodepopulation Spectroscopy of MNOS Diodes

A preliminary set of photodepopulation experiments has been carried out on MNOS diode devices in which either a net-positive or net-negative charge had been stored. There is now clear evidence of a hole trap and an electron trap, both with energy levels located close to the mid-gap of the silicon nitride.

D. Optical Probe

An optical method has been devised to "probe" or measure the state of internal nodes in MOS digital integrated circuits. The depletion region surrounding the drain or output diffusion of some chosen inverter or gate is illuminated by a small spot of light, producing a photocurrent. If the inverter pulldown transistor is off, the entire photocurrent must flow through the pullup device to the V_{dd} supply; if it is on, most of the current will follow the lower-impedance path through it to the V_{ss} supply. The light is modulated so that the small V_{ss} photocurrent can be detected as an AC signal.*

Initial experiments with the optical probe involved passing mechanically chopped light through a small aperture in the illumination path of a metallurgical microscope. Node states were successfully measured throughout a commercial MSI polysilicon-gate CMOS chip. Measurements

*This scheme has apparently been used at the VLSI Cooperative Laboratories; see Y. Tarui, IEEE J. Solid-State Circuits SC-15, 386 (1980).

were not possible on an NMOS DARPA Multi-Project Chip (MPC) because of a fabrication peculiarity that may well be removable: the die-bond package-to-substrate connection is not ohmic, but instead a diode with zero-bias leakage resistance of about 0.5 Mohm. Photocurrent flowing through this high-impedance path modulates the substrate potential and, thus, the back-gate

bias of every conducting enhancement load device on the chip, producing significant substrate-to- V_{ss} current amplification and masking the desired primary photocurrent. An unsintered metal contact to the back side of a chip greatly reduced contact resistance, but still left an unacceptable level of current gain, probably because of localized or "spreading" resistance.

COMPUTER SYSTEMS GROUP 28

The Amdahl 470V/7 central processor was upgraded during this quarter to a Model V/8. The upgrade, consisting of the replacement of approximately 50 boards, was completed in a single day without significant incident. The principal changes were a decrease in cycle time by a factor of about 10 percent, and a doubling of high-speed cache memory size to 64K bytes. No user software conversion was required. For those programs with relatively sequential reference patterns, the improvement is close to 10 percent, while those that also benefit from the larger cache enjoy improvement of the order of 20 percent. Other changes in the central system involve reconfiguration of the data channels to handle additional equipment, and the installation of an IBM 3274 Display Controller.

Initial support has been provided for the Information International COMp80 plotting system to produce high-quality masters for direct conversion to text-only viewgraphs. Either horizontal or vertical formats using Times Roman font are available on 8½ by 11-in paper. Source files

prepared using a standard text editor on the Amdahl time-sharing system are translated to a tape that drives the COMp80. The early response to this new service has generated plans for providing additional fonts, including both Greek and mathematical symbols.

In related investigations, a word processor has been linked to the central computer. Specifically, a MICOM has been connected to the Amdahl V/8 over internal telephone lines. As an input device, the MICOM loses some of its effectiveness because of its inability to transmit special characters, such as lines or Greek letters. As an output device, it can provide high-quality local copy for small documents.

A new IBM PASCAL Compiler has replaced the version from London Imperial College. Among the benefits of the new system are interactive debugging facilities, code optimization, and availability under both of the Laboratory's operating systems, VSI and VM/370/CMS. For the most part, older programs, which did not elect to take advantage of these new capabilities, were converted simply by recompiling.

SOLID STATE DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period 1 November 1980 through 31 January 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
Head, Division 8

I. Melngailis
Associate Head

DIVISION 8 REPORTS
ON ADVANCED ELECTRONIC TECHNOLOGY

15 November 1980 through 15 February 1981

PUBLISHED REPORTS

Journal Articles

JA No.

4972	Liquid-Phase Epitaxy	J. J. Hsieh	Chapter 6 in <u>Handbook on Semiconductors</u> , Vol. 3, edited by S. P. Keller (North-Holland, Amsterdam, 1980), pp. 415-497
5053	Spectral Intensities of the 4- μ m $\nu_4 + \nu_3$ Combination Band of SO ₂	A. S. Pine M. Dang-Nhu*	J. Mol. Spectrosc. <u>84</u> , 132 (1980)
5076	Formation of the XeBr Exciplex by Xe-Br ₂ (D') Collisions	D. J. Ehrlich R. M. Osgood, Jr.	J. Chem. Phys. <u>73</u> , 3038 (1980)
5083	Laser Microphotochemistry for Use in Solid-State Electronics	D. J. Ehrlich R. M. Osgood, Jr. T. F. Deutsch	IEEE J. Quantum Electron. <u>QE-16</u> , 1233 (1980)
5084	Laser Sources and Detectors for Guided Wave Optical Signal Processing	L. Melngailis	Opt. Eng. <u>19</u> , 941 (1980)
5088	Energy-Dependent Electron-Energy-Loss Spectroscopy: Application to the Surface and Bulk Electronic Structure of MgO	V. E. Henrich* G. Dresselhaus* H. J. Zeiger	Phys. Rev. B <u>22</u> , 4764 (1980)
5120	Avalanche Multiplication and Noise Characteristics of Low-Dark-Current GaInAsP/InP Avalanche Photodetectors	V. Diadiuk S. H. Groves C. E. Hurwitz	Appl. Phys. Lett. <u>37</u> , 807 (1980)
5123	Orientational and Electronic Contributions to the Third-Order Susceptibilities of Cryogenic Liquids	H. Kildal S. R. J. Brueck	J. Chem. Phys. <u>73</u> , 4951 (1980)
5127	Heteroepitaxy of Ge _{1-x} Si _x on Si by Transient Heating of Ge-Coated Si Substrates	J. C. C. Fan R. P. Gale F. M. Davis G. H. Foley	Appl. Phys. Lett. <u>37</u> , 1024 (1980)

* Author not † Lincoln Laboratory.

JA No.

- | | | | |
|------|---|---|---|
| 5135 | High-Performance Quasi-Optical GaAs Monolithic Mixer at 110 GHz | B. J. Clifton
G. D. Alley
R. A. Murphy
L. H. Mroczkowski | IEEE Trans. Electron Devices <u>ED-28</u> , 155 (1981) |
| 5136 | Submillimeter Heterodyne Detection of Interstellar Carbon Monoxide at 434 Micrometers | H. R. Fetterman
G. A. Koepf*
P. F. Goldsmith*
B. J. Clifton
D. Buhl*
N. R. Erickson*
D. D. Peck
N. McAvoy*
P. E. Tannenwald | Science <u>211</u> , 580 (1981) |
| 5167 | Spectral Characteristics of External-Cavity Controlled Semiconductor Lasers | M. W. Fleming
A. Mooradian | IEEE J. Quantum Electron. <u>QE-17</u> , 44 (1981) |
| 5171 | Transferable Single-Crystal Semiconductor Films | C. O. Rozler | In Physics News in 1980, P. F. Schewe, Ed. (American Institute of Physics, New York, 1980), pp. 39-40 |
| 5178 | Laser Microchemistry: Applications in Semiconductor Processing | T. F. Deutsch
R. M. Osgood, Jr.
D. J. Ehrlich | In Physics News in 1980, P. F. Schewe, Ed. (American Institute of Physics, New York, 1980), pp. 70-71 |
| 5180 | ν_3 Vibrational Ladder of SF ₆ | C. W. Patterson*
B. J. Krohn*
A. S. Pine | Opt. Lett. <u>6</u> , 39 (1981) |

* * * * *

UNPUBLISHED REPORTS

Journal ArticlesJA No.

- | | | | |
|------|---|--|----------------------------|
| 5145 | Laser Induced Dielectric Breakdown in Cryogenic Liquids | S. R. J. Brueck
H. Kildal | Accepted by J. Appl. Phys. |
| 5154 | Thermal Expansion of NdP ₅ O ₁₄ | W. E. Barch
S. R. Chinn
W. K. Zwicker* | Accepted by J. Appl. Phys. |
| 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 | Accepted by Opt. Lett. |

* Author not at Lincoln Laboratory.

JA No.

- | | | | |
|------|---|---|----------------------------------|
| 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* | Accepted by Astrophys. J. |
| 5160 | Transmission Electron Microscopy and Ion Channeling Studies of Heteroepitaxial $\text{Ge}_{1-x}\text{Si}_x$ Films Produced by Transient Heating | B-Y. Tsaur
J. C. C. Fan
T. T. Sheng* | Accepted by Appl. Phys. Lett. |
| 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 | Accepted by Appl. Phys. Lett. |
| 5165 | UV Photolysis of Van der Waals Molecular Films | D. J. Ehrlich
R. M. Osgood, Jr. | Accepted by Chem. Phys. Lett. |
| 5168 | Anodic Dissolution Technique for Preparing Large Area GaAs Samples for Transmission Electron Microscopy | J. P. Salerno
J. C. C. Fan
R. P. Gale | Accepted by J. Electrochem. Soc. |
| 5170 | Solid-Phase Heteroepitaxy of Ge on $\langle 100 \rangle$ Si | B-Y. Tsaur
J. C. C. Fan
R. P. Gale | Accepted by Appl. Phys. Lett. |
| 5173 | Intracavity Loss Modulation of GaInAsP Diode Lasers | D. Z. Tsang
J. N. Walpole
S. H. Groves
J. J. Hsieh
J. P. Donnelly | Accepted by Appl. Phys. Lett. |
| 5177 | Laser Photochemical Microalloying for Etching of Aluminum Thin Films | D. J. Ehrlich
R. M. Osgood, Jr.
T. F. Deutsch | Accepted by Appl. Phys. Lett. |
| 5179 | Explosive Crystallization of Amorphous Germanium | H. J. Leamy*
W. L. Brown*
G. K. Celler*
G. Foti*
G. H. Gilmer*
J. C. C. Fan | Accepted by Appl. Phys. Lett. |
| 5191 | Fundamental Line Broadening of Single Mode (GaAl)As Diode Lasers | M. W. Fleming
A. Mooradian | Accepted by Appl. Phys. Lett. |
| 5192 | On the Use of AsH_3 in the MBE Growth of GaAs | A. R. Calawa | Accepted by Appl. Phys. Lett. |

* Author not at Lincoln Laboratory.

JA No.

- 5201 Low Loss GaAs Optical Waveguides Formed by Lateral Epitaxial Growth over Oxide
- F. J. Leonberger
C. O. Bozler
R. W. McClelland
I. Melngailis

Accepted by Appl. Phys. Lett.

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
- 5427 Optical Measurement of Phase Boundary Dynamics During Laser Crystallization of Amorphous Ge Films
- R. L. Chapman
J. C. C. Fan
H. J. Zeiger
R. P. Gale
- 5428 TEM Investigation of the Microstructure in Laser-Crystallized Ge Films
- R. P. Gale
J. C. C. Fan
R. L. Chapman
H. J. Zeiger
- 5429 Scanning Cathodoluminescence Microscopy of Grain Boundaries in GaAs
- J. P. Salerno
R. P. Gale
J. C. C. Fan
J. Vaughan†
- 5461 Origins of High Spatial Resolution in Photochemical, Direct-Write Laser Processing
- D. J. Ehrlich
T. F. Deutsch
R. M. Osgood, Jr.
- 5538A Lateral Epitaxy by Seeded Solidification for Growth of Single-Crystal Si Films on Insulators
- J. C. C. Fan
M. W. Geis
B-Y. Tsaur
- 5596 Explosive Crystallization of Amorphous Germanium Films
- H. J. Leamy†
W. L. Brown†
G. K. Celler†
G. Foti†
G. H. Gilmer†
J. C. C. Fan
- 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
- 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

Materials Research Society
Mtg., Boston, 16-21 November 1980

IEEE Intl. Electron Devices
Mtg., Washington, DC,
8-10 December 1980

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

† Author not at Lincoln Laboratory.

MS No.

5145A	The Permeable Base Transistor	C. O. Bozler	Seminar, University of Illinois, Champaign/Urbana, 6 November 1980
5152B	Laser Induced Photochemical Reactions for Electronic Device Fabrication	D. J. Ehrlich T. F. Deutsch R. M. Osgood, Jr.	Seminar, M.I.T., 10 February 1981
5232A	Tunable Solid-State Ultraviolet Lasers	D. J. Ehrlich P. F. Moulton R. M. Osgood, Jr.	LASERS '80, New Orleans, Louisiana, 15-19 December 1980
5379A	Resonance-Line Lasers and Their Applications	R. M. Osgood, Jr. D. J. Ehrlich T. F. Deutsch G. C. Turk* J. E. Travis*	
5477	Tunable Transition-Metal Lasers	P. F. Moulton A. Mooradian	
5264C	Recent Advances in Tunable Lasers	A. Mooradian	Seminar, Goddard Space Flight Center, Greenbelt, Maryland, 26 January 1981
5354	A TDI CCD Hybrid Sensor Mosaic for Satellite Surveillance	B. E. Burke W. H. McGonagle R. W. Mountain D. J. Silversmith	GOMAC '80, Houston, Texas, 19-21 November 1980
5355	A High Speed Digitally Programmable CCD Transversal Filter	A. M. Chiang B. E. Burke	
5411A	Applications of Microstructures in Physics and Chemistry	D. C. Flanders	Microstructures Seminar, State University of New York, Albany, 2 December 1980
5433	Electromagnetic Long-Line Effects in SAW Convolvers	E. L. Adler	1980 Ultrasonics Symposium, Boston, 3-7 November 1980
5434	The Effect of Acoustic Dispersion and Attenuation on SAW Convolver Performance	E. L. Adler J. H. Cafarella	
5435	Attenuating Thin Films for SAW Devices	A. C. Anderson V. S. Dolat	
5436	Self-Aligning SAW Chirp-Fourier-Transform System	D. R. Arsenault V. S. Dolat	

* Author not at Lincoln Laboratory.

MS No.

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, Boston, 3-7 November 1980
5438	Temperature-Stable RAC	D. E. Oates D. M. Boroson	
5439	An Acoustoelectric Burst-Waveform Processor	S. A. Reible I. Yao	
5440	Nonlinear Coupled-Mode Interactions of Surface Acoustic Waves	N. P. Vlannes A. Bers	
5441	High Performance Elastic Convolver with Parabolic Horns	I. Yao	
5448	Hybrid Convolver/Binary Signal Processor Achieves High Processing Gain	R. P. Baker J. H. Cafarella	
5449	The Impact of Convolver Characteristics on System Performance	E. Stern	
5489	A Closed-Form Analysis of Reflective-Array Gratings	P. V. Wright H. A. Haus*	IEDM '80, Washington, DC, 8-10 December 1980
5457	Recent Experimental Results on Permeable Base Transistors	G. D. Alley C. O. Bozler D. C. Flanders R. A. Murphy W. T. Lindley	
5498B	On the MBE Growth of High Purity GaAs	A. R. Calawa	American Vacuum Society Mtg., Waltham, Massachusetts, 14 January 1981
5529	High-Speed Electrooptical Signal Processing Devices	F. J. Leonberger	Boston Section IEEE Chapter on Quantum Electronics, GTE, Waltham, Massachusetts, 18 November 1980
5538B, C, D, E	Preparation of Thin Single-Crystal Films on Insulators	J. C. C. Fan	Xerox Corporation Colloq., Webster, New York, 20 January 1981; Seminar, Stanford University, California, 9 February 1981; Seminar, University of California, Berkeley, 11 February 1981; Seminar, University of California, Los Angeles, 13 February 1981
5551	Optical Techniques for Signal Processing	R. C. Williamson	Electrooptics/Laser '80, Boston, 19 November 1980

* Author not at Lincoln Laboratory.

MS No.

5556	Surface-Acoustic-Wave Signal-Processing Devices	R. W. Ralston	Seminar on Solid-State Physics, Yale University, 16 January 1981
5557, A, B	Transition-Metal Ion in Tunable Lasers	P. F. Moulton A. Mouradian	Topical Meeting on Infrared Lasers, Los Angeles, California, 4 December 1980; Seminar, IBM, San Jose, California, 5 December 1980; Seminar, Purdue University, 8 December 1980
5558	Electron Beam Testing and Restructuring of Integrated Circuits	D. C. Shaver	Second Caltech Conf. on VLSI, Pasadena, California 19-21 January 1981
5576	Surface-Acoustic-Wave Signal Processing in a Digital Age	R. C. Williamson	University of Maine, Orono, 18 November 1980; John Carroll University, Cleveland, Ohio, 9 December 1980; Penn. State University and Central Pennsylvania IEEE, State College, 10 December 1980; Washington Section IEEE, Washington, DC, 21 January 1981; Los Angeles Section IEEE, Irvine, California, 27 January 1981

SOLID STATE DIVISION 8

I. SOLID STATE DEVICE RESEARCH

The spectral dependence of the optical absorption introduced in InP and GaInAsP by proton bombardment has been measured as a function of dose. The induced absorption, which increases nearly linearly with dose, extends well beyond the band edge and decreases approximately exponentially with wavelength over a broad range. A short 420°C anneal reduces this bombardment-induced absorption by more than a factor of 10.

The optical absorption coefficient corresponding to electronic transitions between the valence and conduction bands in HgCdTe has been measured at photon energies well above the energy gap. Excellent agreement with the Kane theory was found using a matrix element $P = 7.5 \times 10^{-8}$ eV-cm. At a photon energy hc/λ about 1.2 times the HgCdTe gap energy E_g , the absorption coefficient is equal to $3/\lambda$ for $0.02 < E_g < 0.4$ eV.

A study has been made of the etching technique used to delineate the active GaInAsP layer in GaInAsP/InP double-heterostructure lasers. It was found that careful control of etch solution composition and etch time was necessary to obtain accurate measurement of active layer thickness.

A new method has been demonstrated for the prevention of thermal etching or decomposition of InP substrates prior to liquid-phase epitaxial (LPE) growth. With this method, the substrate is stored in the growth tube at room temperature during the pregrowth bake and then is transferred to the LPE slider shortly before growth. This method allows both high-purity ($n \approx 1 \times 10^{15} \text{ cm}^{-3}$) and excellent surface morphology

to be simultaneously and reproducibly obtained for both InP and GaInAsP LPE-grown layers.

II. QUANTUM ELECTRONICS

The temporal correlation and measurement error of a dual-laser differential-absorption LIDAR (DIAL) system has been measured and compared with theory. Also, the improvement in measurement accuracy of a dual-laser DIAL compared with a single-laser DIAL system has been determined.

A CW Ni:MgO laser has been operated with up to 10.3 W of TEM₀₀-mode output power, and tuning has been demonstrated near 1.31 and 1.38 μm over small-wavelength regions.

A technique has been devised in order to perform the disconnect function in microelectronic circuits: regions of thin aluminum interconnects are first microalloyed with Zn atoms using a laser photochemical-heating technique, and then the alloyed regions are etched away with a mild acetic acid solution.

In order to characterize thin molecular films adsorbed onto insulators and semiconductors, a reflectometry technique has been developed in which the adsorbent is prepared as a thin, almost antireflecting layer on some appropriate substrate. The large fractional change in reflectivity thus obtainable provides a convenient diagnostic tool for laser photochemical processing.

III. MATERIALS RESEARCH

A new method, named the LESS technique (lateral epitaxy by seeded solidification), has been used to grow single-crystal Si films over insulating layers on single-crystal Si substrates. After narrow stripes have been opened in the insulating layer to expose the substrate, an amorphous or polycrystalline Si film is deposited over

the entire surface, and graphite strip heaters are employed for zone melting the film. By means of this technique, continuous single-crystal Si films have been obtained over SiO₂ layers with stripe openings spaced 50 or 500 μm apart, and single-crystal growth extending as far as 4 mm over Si₃N₄ has been observed.

A one-step technique has been developed for preparing heteroepitaxial Ge films of good crystal quality by deposition of vacuum-evaporated Ge on heated Si single-crystal substrates. Such Ge films, the best of which were obtained by deposition on $\langle 100 \rangle$ Si substrates heated to 550°C, are of interest as potential substrates for the chemical-vapor deposition of GaAs films for shallow-homojunction solar cells.

The crystal quality of heteroepitaxial Ge_{1-x}Si_x films produced by transient heating of Ge-coated Si substrates has been studied by using transmission electron microscopy and ⁴He ion channeling. The results obtained by the two techniques, which are in good agreement, reveal a high density of misfit dislocations near the alloy-Si interface, with a much lower density of inclined dislocations propagating up toward the surface.

IV. MICROELECTRONICS

The performance of a time-integrating correlator in which the multiplication and integration of many samples of two wideband surface-acoustic-wave (SAW) inputs take place in a charge-coupled device (CCD) has been evaluated for the correlation of 20-MHz-bandwidth spread-spectrum signal buried in band-limited Gaussian noise. By using a second CCD chip as an analog delay line to permit cancellation of fixed-pattern noise, a signal-processing gain in excess of 30 dB and a dynamic range of 48 dB have been achieved.

Three focal-plane mosaics consisting of five 100- $\times$ 400-element CCD imager chips mounted on a hybrid substrate have been assembled with the positional accuracy required by an advanced moving-target indicator sensor system used in the GEODSS (Ground-based Electro-Optical Deep Space Surveillance) Program.

A GaAs monolithic-integrated-circuit mixer module, which has a double-sideband (DSB) mixer noise temperature of 339 K and a conversion loss of 3.8 dB at 110 GHz when operated at 300 K, has been evaluated at 77 K. The cooled mixer module has a DSB noise temperature of 50 K, the lowest reported for mixers at 110 GHz, and a conversion loss of 4.5 dB.

The lateral growth of single-crystal silicon over the edge of a thin SiO₂ bar structure on a single-crystal silicon substrate using the reduction of silane in hydrogen has been investigated. Lateral-to-vertical growth ratios much greater than 1 have been achieved for appropriate growth conditions. The observed growth phenomena can be explained in terms of the differences of the lateral and vertical partial-pressure gradients of the silane gas.

The resistivity of tungsten films deposited on GaAs has been found to decrease with increasing annealing temperature, and to reach a minimum value 3.5 times the theoretical lower limit for an annealing temperature of 750°C. For anneals above 750°C, the resistivity increases because of a reaction between tungsten and GaAs. The barrier heights for annealed W-GaAs Schottky barriers are comparable to the barrier heights obtained for Ti-W Schottky barriers on GaAs, and are greater than those for any other metal annealed at these temperatures on GaAs.

Shallow PtSi-Si Schottky-barrier contacts have been formed by heat treatment at 500°C of structures prepared by vacuum deposition of thin

alternating Pt and Si layers on n-type (100) Si substrates. This new technique permits the formation of shallow contacts without placing any limitations on the thickness of the PtSi layer. The characteristics of diodes formed by this process are superior to those of conventional diodes formed by heat treatment of structures prepared by depositing a single Pt layer on Si.

V. ANALOG DEVICE TECHNOLOGY

A hybrid MNOS/CCD circuit has been fabricated which is capable of nonvolatile storage and subsequent nondestructive readout of sampled analog data. A linear dynamic range of 34 dB has been measured 10 min. after writing. After storage times of 100 h, stored signals are attenuated to 60 percent of their initial amplitude but with no loss of linearity. This device provides direct

long-term storage of analog data and avoids the need for analog-to-digital conversion and digital memory.

An improved 4-ary elastic convolver has been demonstrated which incorporates a parabolic-horn acoustic beamwidth compressor for high efficiency, a dual-track configuration with orthogonal transducers for self-convolution suppression, and narrow metal-film waveguides for low phase distortion. The time-bandwidth product of this convolver is 930, the self-convolution suppression exceeds 45 dB over the entire passband, and the phase distortion is less than $\pm 35^\circ$. This low-cost, compact device can provide programmable matched filtering of minimum-shift-keyed wideband spread-spectrum signals within 0.5 dB of ideal performance.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19 REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 18 ESD-TR-81-4	2. GOVT ACCESSION NO. AD-A102144	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) 6 Advanced Electronic Technology.		5. TYPE OF REPORT & PERIOD COVERED 9 Quarterly Technical Summary rept. 1 November 1980 - 31 January 1981
7. AUTHOR(s) 10 Alan J. McLaughlin Alan L. McWhorter		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS Lincoln Laboratory, M.I.T. P.O. Box 73 Lexington, MA 02173 16 649L		8. CONTRACT OR GRANT NUMBER(s) 15 F19628-80-C-0002
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Systems Command, USAF Andrews AFB Washington, DC 20331		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Program Element No. 63250F Project No. 649L
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Electronic Systems Division Hanscom AFB Bedford, MA 01731 12 23		11. REPORT DATE 11 15 February 1981
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		12. NUMBER OF PAGES 28
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		13. SECURITY CLASS. (of this report) Unclassified
18. SUPPLEMENTARY NOTES None		15a. DECLASSIFICATION DOWNGRADING SCHEDULE
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
digital computers integrated circuitry computer systems	solid state devices materials research laser research	quantum electronics microelectronics analog device technology
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
This Quarterly Technical Summary covers the period 1 November 1980 through 31 January 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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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)