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

FOR THE COMMANDER

Raymond L. Loiselle

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Chief, ESD Lincoln Laboratory Project Office

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

ADVANCED ELECTRONIC TECHNOLOGY

QUARTERLY TECHNICAL SUMMARY REPORT
TO THE
AIR FORCE SYSTEMS COMMAND

1 AUGUST – 31 OCTOBER 1977

ISSUED 21 DECEMBER 1977

LEXINGTON   MASSACHUSETTS

INTRODUCTION

This Quarterly Technical Summary covers the period
1 August through 31 October 1977. It consolidates
the reports of Division 2 (Data Systems) and Divi-
sion 8 (Solid State) on the Advanced Electronic Tech-
nology Program.

CONTENTS

DATA SYSTEMS

DIVISION 2

INTRODUCTION

This section of the report reviews progress during the period
1 August through 31 October 1977 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
Education Technology	Bureau of Mines, ARPA/CTO
Network Speech Processing	OSD-DCA
Digital Voice Processing	AF/ESD
Packet Speech	ARPA/IPTO
Wideband Integrated Voice/Data Technology	ARPA/IPTO
Radar Signal Processing Technology	ARMY/BMDATC
Nuclear Safety Designs	NRC

M. A. Herlin
Head, Division 2

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Associate Head

DIGITAL COMPUTERS
GROUP 23

I. INTRODUCTION

Circuit simulations have led to redesign of the serial/parallel converter which should result in meeting the goal of 1-GHz operation. Wafer fabrication has started for a 65K MNOS memory chip. Test samples of the MOS selection transistors meet specifications.

II. APPLICATIONS

A. Serial/Parallel Converter

The 8-bit serial/parallel converter speed is now limited to 750 MHz by slow on-chip clock transitions. SPICE circuit simulation shows that the transition speed is determined by the charge required to switch the flip-flop clocking transistors and not parasitic load capacitance. The clock waveforms can be improved by modifying the clock driver and reducing flip-flop switched current and transistor size. Adding emitter-followers to the flip-flop and decreasing switched current by a factor of four improves its performance and improves the clock waveforms with no increase in total power dissipation. A new serial/parallel converter circuit with these improvements is now being designed. SPICE simulation indicates the maximum shift rate will be above 1 GHz with present processing parameters.

B. MNOS Capacitor Memory

The mask design and fabrication process definition for a partially decoded 65K MNOS capacitor memory have been completed. The first two masks have been fabricated and a wafer run initiated.

Digit lines in MNOS memory chips made with air isolation between digit mesas tend to be coupled via a surface inversion channel which is produced by charge in the surface oxide and nitride. The coupling can usually be eliminated by biasing the substrate, but for some chips the bias required is unacceptably large. This is a significant yield problem. Etchback experiments followed by electrical tests and SEM examination are being done to find the location of the excessive surface charge.

Experiments in which amorphous Si created by neon implantation is used to isolate Si digit lines in 30×30 MNOS capacitor arrays have been performed. A very high yield of well isolated chips as well as a markedly reduced incidence of capacitor shorting was observed as compared to our present air-isolation process. This process eliminates the digit line shorting due to inversion channel formation and provides a planar surface which is ideal for high-resolution lithography. Futher experiments are required to establish that the neon implant does not degrade the MNOS memory characteristics.

C. MUDPAC (16- $\times$ 16-Bit Serial Multiplier)

Mask layouts for the basic carry-save adder bit have been done and will be incorporated into a test chip. Simulations of the clock driver indicate that a 2-nsec clock period can be achieved with sufficient suppression of ringing on the clock lines. The variable-frequency oscillator has been redesigned to merge it with the multiplexer for the test clock (a slow clock generated off the chip for functional testing). The new design will reduce the delay between the oscillator

and the clock drive lines, which in turn will allow more reliable turnoff of the oscillator at the end of the multiply cycle.

III. IC PROCESSING

A. MNOS Memory Test Devices

Test devices for the 65K MNOS memory chip were designed. The test devices include structures to measure sheet resistance, mesa-field oxide and insulator rotox integrity, metal continuity and bridging. In addition, MOS selection transistors, a 3×3 MNOS array, and a 3×3 array with selection circuits are included for diagnostic purposes. The test devices are arranged on a 30-mil-wide section adjacent to each memory chip so that the test devices can be probed with minimum likelihood of damaging the memory chip. The total chip size, including test devices, is approximately 250 mils square.

B. MNOS Array Selection Transistors

An MOS transistor mask set was designed to permit development of the memory selection transistor process. In addition to the selection transistors, identical in design to those included on the 65K chip, various other devices were included for device and process characterization purposes. A lot of selection transistors was fabricated and tested. The source-drain conductances varied between 1 and 0.8 mmhos, the thresholds between -2.8 and -3.3 V, and the source-drain breakdowns between 45 and 50 V. These values support the general design requirements of the array transistors.

C. Poly-Ox Isolation

The use of recessed oxide spoiler layers to form polysilicon has allowed the use of oxide spoiler layers of up to one micron in thickness, reducing resistor and metal parasitic capacitance to the substrate. In addition, the surfaces of the polycrystalline silicon and the epitaxial single-crystal silicon can be designed coplanar. However, the selective oxidation of the spoiler layer results in an oxide pileup at the edges of the silicon nitride mask resulting in a 3000-Å bump which is replicated in the surface of the poly grown over it. A new technique of selective oxidation has been devised which reduces this bump to a negligible amount and is being applied in the poly-ox process. Process steps have been interchanged to protect the crystalline surface, upon which epi is grown, from the boron channel-stopper implant. This eliminates the potential problems associated with annealing implanted boron damage.

The activation energy, E_a, defined by $J \propto \exp-E_a/kT$, of our doped polysilicon resistor material has been measured to be 0.50 ± 0.05 eV, in agreement with the published results of other workers.

D. Self-Aligned Transistors

In order to achieve even narrower basewidths than our present 2000 Å, devices have been made in which the emitter and base implants are driven in simultaneously with the base width being determined by the faster diffusion of boron compared to arsenic. Transistors have yet to be measured, but computer simulations predict that such a structure should have a thinner base and a more favorable base doping profile than our current transistors, in addition to the advantage of eliminating one of the high-temperature thermal anneal cycles.

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E. Photolithography and Plasma Etching

An automatic photoresist dispenser is being installed. Its design is such that it will eliminate the problem, in our current processing, caused by dried photoresist on the syringe depositing particulates on the wafers and thereby ruining line definition by spacing the mask away from the wafer.

Plasma etching of aluminum with the planetary reactor produces good across-wafer etching uniformity. The metal on one or two wafers from each production run is being plasma etched to check for any unusual problems.

IV. DESIGN, ANALYSIS, AND TESTING

A. MNOS Tester

A static tester to test leakage between digit lines and breakdown voltage from digit lines to substrate has been designed and is being wired. Programs will be written to computer control the tester.

The JFET switches on the dynamic tester are being changed so the digit JFETs will have lower on-resistance. A new sense amplifier has been designed and built which bootstraps stray capacitance making it possible to read with a ramp at 100 kHz instead of the earlier 7 kHz. The MNOS dynamic tester upgrade for the 65K chip is nearly complete. Tester flexibility has been emphasized, including compatibility with various analog switching configurations.

B. Characterizing f_T in the High-Current Falloff Region

It appears that f_T as a function of collector voltage and current can be described by the equation

$$(2\pi f_T)^{-1} = (kT/qI_c)(C_{te} + C_{tc}) + (2\pi f_{Tmax})^{-1} + \tau_{cl} \ln[1 + (I_c/I_{cl})^\gamma]^{1/\gamma}$$

The quantities $(C_{te} + C_{tc})$ and f_{Tmax} describe the low-current behavior of f_T. The last term on the right-hand side of the above expression describes the falloff of f_T at high currents. I_{cl} is the current at which falloff begins. The quantity γ describes the sharpness in the downturn of f_T with current about I_{cl}. Devices measured recently all appear to exhibit a value of $\gamma \approx 4$. τ_{cl} serves to characterize the transistor delay time in the falloff region.

Of the three new parameters I_{cl}, γ, and τ_{cl}, only I_{cl} has been derived from basic theory at the present time. For a uniformly doped epi collector region, I_{cl} is defined as the collector current for which the E-field is constant everywhere in the epi region. In terms of the optical-phonon-scattering limited parameters of velocity, v_{scl} and field, E_{scl}, I_{cl} can be expressed in the form

$$\frac{I_{scl}}{I_{cl}} = 1 + \frac{V_{scl}}{V_{eb} + V_\Phi}$$

where $I_{scl} \equiv qv_{scl} N_d A_\epsilon$ and $V_{scl} = E_{scl} W_{epi}$. Theoretical expressions for the other two parameters are being sought.

C. Measuring f_T in the High-Current Falloff Region

A modified version of the f_T program has been developed and used to make plots of $1/f_T$ vs log collector current. These curves tend to approximate straight lines in the high-current

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f_T falloff region. The straight lines are given by the expression,

$$1/f_T = T_F \log \frac{I_c}{I_0} \qquad (1)$$

where the current turnover, I_0, is the intercept of the $1/f_T$ high-current line with the I_c axis. I_0 as a function of V_{CB} can be represented by:

$$\frac{1}{I_0} = \frac{R_0}{V_{CB} + V_0} + \frac{1}{I_{00}} \qquad (2)$$

where R_0 and I_{00} are experimentally derived parameters. Transistor measurements give reasonably straight lines for $1/f_T$ and $1/I_0$ so that model parameters for I_0 can be determined. Measurements of T_F as a function of V_{CB} have not resulted in good model parameters. The change of T_F with V_{CB} is small so that it may be possible to use a constant value.

Measurements of h_{rb} will be used to evaluate the increase in collector capacitance over this same current range. This will also be compared with measurements made on forward-biased devices using a 1-MHz capacitance bridge. The latter measurement suffers from the effects of decreasing Q as the capacitance increases.

These results are being used to check the validity of the theoretical analysis of the problem and to improve the transistor model used in computer simulations.

D. FABSIM

An ion implantation model was incorporated into FABSIM, the IC fabrication simulation program. Pearson functions model the strongly asymmetric cases of boron in Si and SiO_2, and Half-Gaussian functions are used to model all other cases. The parameters employed to drive these functions are the distribution moments. They are extracted as a function of implant energy, ion type, and substrate from a table of calculated range statistics.

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Several new and useful bridges have been constructed between the VM time-sharing system and the VS batch system during the quarter. As previously reported, VM/CMS users can create VS jobs with the editor and other interactive facilities of VM. When ready for execution, such jobs can be sent to the VSBATCH virtual machine for execution. New facilities make it possible to track the status of these jobs, retrieve their job control language listings, and direct a copy of printed or punched output to the originating VM accounts. These are particularly useful capabilities for program debugging and checkout of deck setup for large batch jobs.

As another aid to microprocessor software development, an INTEL 8080 simulator has been written for the IBM 370/168. In combination with existing cross-assemblers, this simulator gives 8080 programmers access to the high-speed peripherals and utility routines of the 370/168 during program checkout. Although not yet tuned for hardware efficiency, the initial version of the simulator is providing significant efficiencies in user productivity.

The reliability of incoming mail has been improved by the addition of a failsafe procedure. Mail is received from the ARPA Network by a single designated virtual machine (FTP Server) which stores it on file space and internally transfers a copy to the addressee. The transfer mechanism is the VM spooling facility commonly used for communications between virtual machines. The vulnerability of this mechanism is that files sent from one virtual machine, but not yet read by the receiving machine, may be lost during certain system failures. The failsafe procedure includes an automatic receipt when the addressee reads the mail file and a periodic check for loss of spooled files by the FTP Server. Since the mail file received from the Network is held in FTP disk space until internally receipted, it is a simple matter to retransfer all un-receipted mail files after system failures which clear spool files.

SOLID STATE
DIVISION 8

INTRODUCTION

This section of the report summarizes progress during the period
1 August through 31 October 1977. The Solid State Research Re-
port for the same period describes the work of Division 8 in more
detail. Funding is primarily provided by the Air Force, with ad-
tional support provided by the Army, ARPA, NSF, and DOE.

A. L. McWhorter
Head, Division 8

I. Melngailis
Associate Head

DIVISION 8 REPORTS

ON ADVANCED ELECTRONIC TECHNOLOGY

15 August through 15 November 1977

PUBLISHED REPORTS

Journal Articles

JA No.

4694	X-Ray Photoemission Spectroscopy Studies of Sn-Doped Indium-Oxide Films	J. C. C. Fan J. B. Goodenough[*]	J. Appl. Phys. 48, 3524 (1977)
4736	New C.C.D. Programmable Transversal Filter	B. E. Burke W. T. Lindley	Electron. Lett. 13, 521 (1977)
4738	Analysis of the 4-μm $\nu_1 + \nu_3$ Combination Band of SO_2	A. S. Pine G. Dresselhaus B. Palm R. W. Davies[*] S. A. Clough[*]	J. Mol. Spectrosc. 67, 386 (1977)
4744	Vibrational Two-Photon Resonance Linewidths in Liquid Media	S. R. J. Brueck	Chem. Phys. Lett. 50, 516 (1977)
4745	Proton Bombardment in InP	J. P. Donnelly C. E. Hurwitz	Solid-State Electron. 20, 727 (1977)
4748	310-MHz SAW Resonator with Q at the Material Limit	R. C. M. Li	Appl. Phys. Lett. 31, 407 (1977)
4751	Vibrational Energy Relaxation of CH_3F Dissolved in Liquid O_2 and Ar	S. R. J. Brueck T. F. Deutsch R. M. Osgood, Jr.	Chem. Phys. Lett. 51, 339 (1977)
4752	Ion-Implanted n- and p-Type Layers in InP	J. P. Donnelly C. E. Hurwitz	Appl. Phys. Lett. 31, 418 (1977)
4757	High-Efficiency GaAs Shallow-Homojunction Solar Cells	C. O. Bozler J. C. C. Fan	Appl. Phys. Lett. 31, 629 (1977)
4761	High-Sensitivity Infrared Heterodyne Radiometer Using a Tunable-Diode-Laser Local Oscillator	R. T. Ku D. L. Spears	Opt. Lett. 1, 84 (1977)
4766	A New Interferometric Alignment Technique	D. C. Flanders H. I. Smith S. Austin[*]	Appl. Phys. Lett. 31, 426 (1977)
4773	Suppression of Bulk-Scattering Loss at S.A.W.-Resonator Reflectors	R. C. M. Li J. A. Alusow	Electron. Lett. 13, 580 (1977)

[*] Author not at Lincoln Laboratory.

4109	Solar Energy Application of Natural Zeolites	D. I. Tchernev	Proc. 2nd Workshop on The Use of Solar Energy for the Cooling of Buildings, University of California, Los Angeles, 4-6 August 1975, edited by F. and J. W. de Winter (July 1976), pp. 307-319
4362A	Surface State Studies on $SrTiO_3$ Electrodes	J. G. Mavroides	In Semiconductor Liquid-Junction Solar Cells, edited by A. Heller, Proceedings Vol. 77-3 (The Electrochemical Society, Inc., Princeton, New Jersey, 1977), p. 84.
4530	IR Spectroscopy Via Difference-Frequency Generation	A. S. Pine	In Laser Spectroscopy, edited by J. L. Hall and J. L. Carlsten (Springer Series in Optical Sciences, Vol. 7) (Springer-Verlag, New York, 1977)
4559	An Efficient Lensing Element for X-Rays	N. M. Ceglio* H. I. Smith	Proc. VIII Intl. Conf. on X-Ray Optics and Microanalysis, Boston, 22-26 August 1977

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UNPUBLISHED REPORTS

Journal Articles

4710	Micro Fresnel Zone Plates for Coded Imaging Applications	N. M. Ceglio* H. L Smith	Accepted by Rev. Sci. Instrum.
4739A	Measured Compositions and Laser Emission Wavelengths of $Ga_xIn_{1-x}As_yP_{1-y}$ LPE Layers Lattice-Matched to InP Substrates	J. J. Hsieh	Accepted by J. Electron. Mater.
4754	Polarized Vibrational Raman Scattering Lineshape Parameters in Liquid CO and Liquid CO Mixtures	S. R. J. Brueck	Accepted by Chem. Phys. Lett.
4772	GaInAsP/InP Double-Heterostructure Lasers for Fiber Optic Communications	J. J. Hsieh C. C. Shen	Accepted by Fiber Integ. Opt.
4775	Chemisorbed Phases of H_2O on TiO_2 and $SrTiO_3$	V. E. Henrich G. Dresselhaus H. J. Zeiger	Accepted by Solid State Commun.

*Author not at Lincoln Laboratory.

4780	Effect of O_2 Pressure During Deposition on Properties of rf-Sputtered Sn-Doped In_2O_3 Films	J. C. C. Fan F. J. Bachner G. H. Foley*	Accepted by Appl. Phys. Lett.
4784	High-Resistivity Layers in n-InP Produced by Fe Ion Implantation	J. P. Donnelly C. E. Hurwitz	Accepted by Solid-State Electron.

Meeting Speeches[†]

MS No.

4442A	Submicrometer Technology	H. I. Smith	CMSE Colloq., M.I.T. 14 October 1977
4447	Doppler-Limited Infrared Molecular Spectroscopy with a Tunable-Laser Difference-Frequency Converter	A. S. Pine	Fifth Colloq. on High Resolution Molecular Spectroscopy. Tours, France, 19-23 September 1977
4480A	A New Signal Processing Device, the Integrating Correlator	R. W. Ralston D. H. Hurlburt F. J. Leonberger J. H. Cafarella E. Stern	
4545	Filter with Bandwidth Continuously Variable from 5 to 100 MHz	J. Melngailis R. C. Williamson R. H. Domnitz*	
4547	Acoustoelectrically Scanned Gap-Coupled Si-Diode Array/$LiNbO_3$ Imaging Devices	F. J. Leonberger J. H. Cafarella R. W. Ralston E. Stern A. L. McWhorter	1977 Ultrasonics Symp., Phoenix, Arizona, 26-28 October 1977
4548	310-MHz SAW Resonator with Q at the Material Limit	R. C. M. Li	
4560	Case Studies of Successful Surface-Acoustic-Wave Devices	R. C. Williamson	
4501	X-Ray Replication of Submicrometer Linewidth Patterns	H. I. Smith D. C. Flanders	35th Annual Mtg. EMSA, Boston, 22-26 August 1977
4540	Resonant Infrared Four-Wave Mixing in Cryogenic Liquids	S. R. J. Brueck H. Kildal	1977 Fall Mtg. of Optical Society of America, Toronto, Ontario, Canada, 10-14 October 1977

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*Author not at Lincoln Laboratory.

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

4542, A	Recent Advances in Laser Devices	A. Mooradian	9th Intl. Conf. on Solid Devices, Tokyo, Japan, 30-31 August 1977; U.S.-Japan Symp. on Laser Spectroscopy, Hakone, Japan, 4-8 September 1977
4543	Chemisorbed Phases of O_2 on TiO_2 and $SrTiO_3$	V. E. Henrich G. Dresselhaus H. J. Zeiger	24th Natl. Vacuum Symp., Boston, 8-11 November 1977
4544	Surface Photovoltage Experiments on $SrTiO_3$ Electrodes	J. G. Mavroides D. F. Kolesar	
4546	Advances in Narrow-Gap Semiconductor Electrooptical Devices	I. Melngailis	III Intl. Conf. on the Physics of Narrow-Gap Semiconductors, Warsaw, Poland, 12-15 September 1977
4555	Fabrication and Alignment of Submicrometer Structures	H. I. Smith	Colloquium, Sperry Rand Research Center, Sudbury, Massachusetts, 15 August 1977
4561	High-Efficiency GaAs Shallow-Homojunction Solar Cells	J. C. C. Fan C. O. Bozler	1977 Fall Mtg. of Electrochemical Society, Atlanta, Georgia, 9-14 October 1977
4571	Submicrometer Pattern Replication and Alignment Using X-Ray Lithography	D. C. Flanders	Semicon East '77, Boston, 19 September 1977

I. SOLID STATE DEVICE RESEARCH

High-speed gains of up to 12 have been achieved in the 1.15- to 1.25-μm wavelength range with avalanche photodiodes of the quaternary alloy GaInAsP. The low-bias quantum efficiency at 1.15 μm was approximately 45 percent. When biased to yield a gain of about 8, the risetime of the avalanche diode response to a pulse from a GaInAsP/InP laser was less than 200 psec.

CW operation of epitaxially grown $Pb_{1-x}Sn_xTe$ homostructure diode lasers has been achieved for heat-sink temperatures up to 100 K. Relatively large output powers are observed for the x = 0 devices, the maximum obtained being 4.5-mW single-ended output from a LPE homostructure at ~15 K.

The ion implantation of Fe in n-type InP yields high-resistivity layers with $\rho \geqslant 10^7$ Ω-cm. Some diffusion of the implanted Fe occurs during the post-implantation anneal, with the effect being more pronounced on samples implanted at room temperature than in samples implanted at 200 °C.

A high-yield, good-reliability bonding technique has been developed which allows leads to be bonded to small bonding pads on fragile semiconductor materials. The technique provides a simple means of attaching leads to soft crystals without apparent damage, and has allowed 12-element arrays of GHz-bandwidth HgCdTe heterodyne receivers to be fabricated.

II. QUANTUM ELECTRONICS

A MgF_2:Ni laser at 35 K has been operated in the 1.6- to 1.7-μm region, with 1.7 W of CW output power, an absorbed pump power conversion efficiency of 37 percent, and an absorbed pump power threshold of 50 mW. Damped relaxation oscillations leading to true CW operation and lasing up to a crystal temperature of 200 K have been observed.

A mini-TEA CO_2 laser has operated at pulse-repetition rates up to 40 Hz and at pulse output levels to 44 mJ. The laser has been used for frequency doubling by pumping $CdGeAs_2$ crystals, achieving an average pulse-energy conversion efficiency of 18 percent.

Efficient four-wave sum- and difference-frequency generation of the outputs of two CO_2 TEA lasers has been observed in liquid $CO-O_2$ mixtures at 77 K. The potential for efficient frequency tripling of CO_2 laser radiation in SF_6 dissolved in liquid argon has also been examined.

Double-resonance measurements using CO_2 laser excitation have been used to provide evidence for collisionless intramolecular energy transfer in vibrationally excited SF_6. An intramolecular energy transfer time of 3 $\pm$ 1 μsec is inferred for an excess energy of three quanta in the ν_3 mode.

III. MATERIALS RESEARCH

Conversion efficiencies as high as 20 percent have been obtained for single-crystal GaAs shallow-homojunction cells without $Ga_{1-x}Al_xAs$ layers. These cells, which are fabricated by a simplified technique that does not require any vacuum processing steps, utilize an $n^+/p/p^+$ structure with an antireflection coating prepared by anodic oxidation of the n^+ layer.

Ultraviolet photoemission spectroscopy has been used to investigate the chemisorption of O_2 on various surfaces of TiO_2 and $SrTiO_3$, two materials that catalyze the decomposition of water into H_2 and O_2 by photoelectrolysis. Several adsorbed phases are formed; the same initial phase, which is believed to consist of O^{2-} ions, is present on all surfaces for low O_2 exposures.

IV. MICROELECTRONICS

Two approaches are being pursued to build a quasi-optical mixer at submillimeter wavelengths to replace the more conventional approach of embedding a diode in a fundamental waveguide. The first approach is to modify the standard overmoded waveguide diode-wafer package by making a fundamental waveguide insert for use with the package. The second approach uses a long traveling-wave line source set in a corner reflector. Both configurations are being modeled at X-band and are also under construction for submillimeter operation.

An integrated buffer memory having a surface-acoustic-wave (SAW) input and a charge-coupled-device (CCD) output has been designed and is being fabricated. Initial work is being done with a 3.56-μsec-long acoustoelectric interaction region operating at a 100-MHz center frequency with about a 30-MHz bandwidth. The cell size of the CCD has been chosen based on the need to have an effective sampling frequency, which is directly related to cell size, that is sufficiently high to avoid aliasing but not so high that it overlaps the input spectrum.

Fabrication of the 100- $\times$ 400-element CCD imager has continued, and yields based on static testing have averaged 14 percent in recent runs. Dynamic test yields have been somewhat lower due to processing problems which have been corrected. Transfer inefficiencies of 2×10^{-5} and dark currents of 4 nA/cm^2 in the output register have been measured. Single devices have been packaged and operated as imagers in the stare-and-integrate mode in anticipation of evaluating them on the telescope at the GEODSS experimental test system near Socorro, New Mexico.

A test device consisting of an MOS shift register and latch circuits has been made to demonstrate the feasibility of fabricating high-performance n-channel MOS logic devices which are part of a programmable transversal filter that is being developed. The processing techniques are compatible with fabricating the high-speed CCD portion of this device. The shift register has been operated at 8 MHz and as slow as 666 Hz with a high-state output of 10 V. The device has been operated as a true static shift register, and it has been established that a digital reference can be stored in the static latch circuits while a new reference is loaded into the shift register.

Dark current in buried-channel CCDs results from heavy metal contaminants such as gold which are present in unprocessed wafers and are also introduced from the wafer-processing environment. The use of the gettering effect of a high-concentration ($>10^{19}$ cm^{-3}) phosphorous diffusion into the wafer back side, the so-called POGO (pre-oxidation gettering of the other side) process, along with the protection of an oxide layer, has reduced gold trap densities to less than 2×10^{10} cm^{-3} and the dark current in gate-controlled diodes to less than 1 nA/cm^2.

V. SURFACE-WAVE TECHNOLOGY

The precise linear FM response which can be obtained from reflective-array compressors has made possible the realization of large-bandwidth Fourier-transform systems using surface-wave devices. Such systems offer the potential advantages of high speed combined with smaller

size and less power consumption than equivalent digital systems. A 300-point Fourier-transform system with a bandwidth of 10 MHz has been breadboarded for the first phase of the demonstration of the performance of this analog approach. The system is designed for a combination of high precision and wide dynamic range in the Fourier transform.

In gap-coupled acoustoelectric SAW devices, the silicon strip held in close proximity to the surface of the $LiNbO_3$ delay line weakly guides the surface wave and forms an overmoded waveguide. The properties of the modes are modified by the support structure (typically ion-etched posts or rails) which spaces the silicon from the $LiNbO_3$ surface. The resulting coupling and scattering out of the waveguide cause excess loss in acoustoelectric devices. The propagation characteristics of surface waves in delay lines having various types of support structures have been measured by electrostatic and optical probes. The measured mode behavior agrees with a theoretical model, and this understanding has led to modified geometries which yield improved device response.

Encouraging results have been obtained with the acoustoelectric Schottky-diode/$LiNbO_3$ integrating correlator. Good linearity of the integration process has been achieved in correlating biphase modulated codes with 4 µsec chip length and up to 10 msec duration. In these tests, the desired signal was intentionally added to a high-level pseudonoise interference signal, thereby demonstrating a signal-processing gain of 34 dB in the presence of a strong jammer. Long-storage-time diode arrays and application of a reverse bias on the array are essential to linearizing the integration process.

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education technology	materials research	

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 1977. It consolidates the reports of Division 2 (Data Systems) and Division 8 (Solid State) on the Advanced Electronic Technology Program.

DD FORM 1473 EDITION OF 1 NOV 65 IS OBSOLETE
1 JAN 73