(NASA-CR-161345) HIGH DENSITY CIRCUIT TECHNOLOGY Quarterly Progress Report, 13 Jul. - 13 Oct. 1979 (Mississippi State Univ., Mississippi State.) 17 p
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QUARTERLY REPORT

July 13, 1979 - October 13, 1979

Contract NAS8-33448

(NASA-CR-161345) HIGH DENSITY CIRCUIT TECHNOLOGY Quarterly Report, 13 Jul. - 13 Oct. 1979 [redacted] (Mississippi State Univ., Mississippi State.) 17 p [redacted]
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HIGH DENSITY

CIRCUIT TECHNOLOGY

by

Thomas E. Wade
Principal Investigator

Microelectronics Research Laboratory
Mississippi State University
Department of Electrical Engineering
Mississippi State, Mississippi 39762

QUARTERLY REPORT

July 13, 1979 - October 13, 1979

Contract NAS8-33448

HIGH DENSITY CIRCUIT TECHNOLOGY

Prepared for

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

by

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Mississippi State University
Department of Electrical Engineering
Mississippi State, Mississippi 39762

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I. INTRODUCTION

Progress has been accomplished in all of the proposed areas as listed under the Scope of Work, Exhibit A, Contract NAS8-33448. Some delays have been experienced due to metal deposition equipment malfunctions and start-up procedures associated with the Mississippi State Microelectronics Research Laboratory. It is felt that many of these problems have been eliminated to the extent that normal progress will be rendered during the next contract quarter. This is especially true since a full time processing technician has recently been hired to assist in these and other endeavors.

In accordance with the contracts "Report Requirements" section which states "quarterly reports shall be in narrative form, and brief and informal in content", the following research areas of emphasis will be addressed.

II. MULTI-LEVEL METAL TECHNIQUE

This study is a continuation of last years NASA contact effort (J. D. Trotter, T. E. Wade, J. D. Gassaway, "Trends and Techniques for Space Base Electronics", NASA Contract NAS8-26749, June, 1979). In addition to heat treatment studies and the use of phosphosilicate glass as a dielectric (T. E. Wade, Special Report, "Post Heat Treatment Effects on Double Layer Metal Structures for VLSI Applications," NASA Contract NAS8-26749, November, 1979), several wafers having first level patterned metal were sent to the West Coast for processing. In these semiconductor houses, the wafers had dielectric materials deposited on them of C.V.D. silicon dioxide (vapox), silicon nitride and polyimide (GAF and Hitachi versions) after which via's were realized as per the M.S.F.C. test pattern. These wafers were received from the West Coast after the termination of last years contract. Prior to depositing the second layer metal, the wafers will have to be back-sputtered in-situ to eliminate the Al_2O_3 present on the first layer metal in the via's. Final processing of these wafers is anticipated to take place at M.S.F.C. using their new back-sputtering capability (to be installed within the next quarters effort).

During the first quarter, polyimide materials have been received from two different companies, Hitachi and Dupont, for experimental and comparative studies. Some Hitachi materials were obtained from M.S.F.C. personnel (thanks to Mr. Donald Routh) while additional materials and information have been ordered from the company. Dupont has forwarded their polyimide (PI-2550) and thinner, but their adhesion promoter has been back logged. This should be arriving soon. Attempts will also be made to acquire some G.A.F. polyimide material for comparative studies. Initial studies (i.e., vendors info, literature and preliminary experiments) indicate the Hitachi P. I.Q. to be superior polyimide over the others, however, it is much too early to draw definite conclusions.

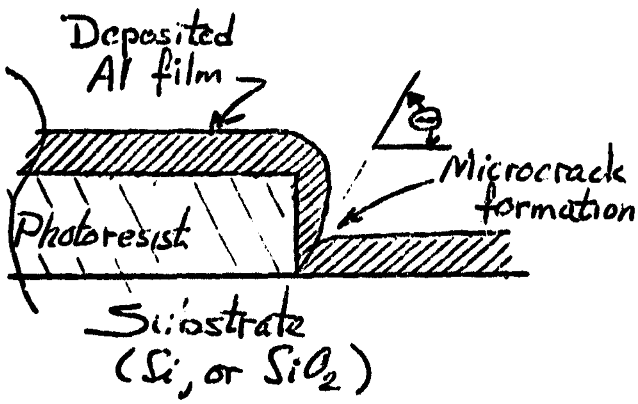
Hopefully, before the termination of this contract, Mississippi State's Microelectronics Research Laboratory will have the capability of depositing silicon nitride as a dielectric using the Unipak VIII Epitaxial Reactor. This reactor is well on its way to becoming operational, with anticipated completion date of December, 1979. As of to date, the machine has been installed, most of the plumbing (water, vent, gases , etc.) has been complete, and some system checks have been accomplished.

A problem experienced during the first quarter of this contract was with the metal deposition system. A short in the d.c. sputter gun resulting from an accumulation of aluminum on one side of the gun caused the gun's power supply to fail. Attempts to repair this by local technicians were unsuccessful (due to inability to monitor sequential timing of power SCR's and poor documentation), and hence the 2.5 Kw power supply had to be sent to the West Coast for repair.

Other laboratory activities involved in during the past quarter included a complete replumbing of gas lines in the laboratory. For wafer processing during our "Fundamentals of LSI" course last Spring, gases such as nitrogen, oxygen, air, etc. were supplied to those locations in the laboratory where required in some what of a temporary arrangement. Beginning with this academic school year, all temporary lines were dismantled and replaced with permanent lines to our gas bottle closets with all stainless steel runs placed in the ceiling, etc. This replumbing task is essentially complete for primary gases. The complete replumbing activity should be completed in the near future, depending on the receipt of parts now on order.

III. METAL LIFT-OFF TECHNIQUES

A review of the literature indicates that sputtered aluminum films may be successfully patterned using the lift-off technique provided the substrate surface temperature remains low (<100°C) and the atmospheric pressure in the chamber is relatively high at the time of sputtering. If these conditions are met, aluminum films which exceed the photoresist in thickness can be successfully deposited without reduction in pattern width. Also, the slope of the side walls of metallized aluminum patterns is controlled by the argon pressure during sputtering in the following manner. As illustrated below, the aluminum films grows perpendicular to the sidewalls of the photoresist pattern and the substrate surface,



respectively. The films contact each other near the photoresist pattern edges, but do not fuse together since they have different growth directions (at low temperatures), resulting in a microcrack formation. A suitable stripper can then penetrate through the microcrack to dissolve the photoresist.

The slope, θ, of the resulting metal pattern is a function of (1) the metal deposition rate on the photoresist sidewalls, V_p, and (2) the deposition rate normal to the substrate, V_s, and can be expressed as

$$\theta = \tan^{-1}\left(\frac{V_s}{V_p}\right) .$$

At low argon pressure in the chamber, V_s is large and V_p is small since most deposited atoms fall on the substrate surface (directly from the target). Whereas, for higher argon pressure in the chamber, V_p increases due to an increased number of collisions metal atoms have with argon ions. Thus, slope angle for metal line side walls, θ, decreases as the argon pressure increases.

At least three additional metal lift-off techniques have been researched as reported in the literature (i.e. conventional, use of auxiliary layer, multiple wall self-aligned, etc.)

IV. DRY PROCESSING EQUIPMENT EVALUATION

With the assistance of former colleagues who are presently located on the West Coast, a list of primary vendors for dry processing equipment have been compiled and is attached to this report. Letters of inquiry and/or telephone contact have been forwarded to most companies on this list, several of which have responded with equipment literature and/or specification sheets. It is anticipated that after reviewal of the vendors literature, equipment can be identified which has the potential of meeting the needs of M.S.F.C.'s objectives, and at a later date a demonstration and evaluation of such equipment can be undertaken.

A prototype parallel plate plasma etch machine has been identified for either purchase at a much reduced price or donated to the Microelectronics Research Laboratory at M.S.U. If this machine is acquired, it probably will not arrive until the first of next year. It is hoped that delivery and installation of this etcher is such that experimental studies may be reported during this contract period.

A considerable amount of material has been collected via personal contacts, library studies, vendor's info, etc. as related to the physics of plasma processing. This material will be reviewed and essential portions presented in the final report of this contract.

V. FUTURE TRENDS IN VLSI FABRICATION TECHNIQUES

An extensive study is underway to evaluate present and future trends. These incorporate the following broad areas:

A. Lithography, with emphasis on optical (contact, projection and proximity), electron beam, x-ray, D.S.W. (direct-step-on-the-wafer), testing and analysis thereof.

B. Processes as related to devices, namely CMOS, VMOS, CMOS on sapphire, fast TTL, SOS, GaAs devices, I^2L, n-MOS, etc.

C. Processes as related to fabrication, as low pressure C.V.D., high pressure oxidation, resist materials, etc.

D. Also, proposed materials and areas as metal silicide interconnection technology, refractory metal gate processes, laser annealing (of ion-implanted or lattice damage, of amorphous or poly, etc.)

Report of these findings will be presented in the final report.

VI. M.S.U. MICROELECTRONICS RESEARCH LABORATORY

Thanks principally to NASA M.S.F.C.'s early support, the Micro-electronics Research Laboratory at M.S.U. shows promise of becoming a prominent research and teaching facility. Last Spring, a Unipak VIII epitaxial reactor was received and is now almost operational. It is anticipated that in addition to growing epitaxial layers, polysilicon and silicon nitride capabilities will be realized. This past summer, two Kasper 100·Kev ion implantors (one will be used for parts) were received and installation of one of these is presently underway. As mentioned early, it is hoped that the parallel plate plasma etcher can be acquired this year and used for this contract effort.

A new full time laboratory fabrication technician has been hired and reported to work this month (October, 1979). Mrs. Becky Hamilton has had fifteen years of processing experience in major semiconductor companies on the West Coast. She will make a tremendous contribution to our overall microelectronics effort.

VII. PROPOSED WORK FOR NEXT QUARTER

It is anticipated that for next quarter, a continuation of work began this quarter will be undertaken with considerable more emphasis on laboratory experimental studies as related to double layer metal processing and the metal lift-off techniques. Back ordered supplies should be forthcoming in the next few weeks and the laboratory facilities should also be in working order.

Trips to the International Electron Devices Meeting in Washington D.C. are planned, as well as possible a trip to the West Coast to attend the Materials Research Corporations conference and school on Sputtering and Plasma Etching.

VIII. PROBLEMS AREAS

As indicated, this quarters problems have been experienced with failures of the metallization system power supply and sputter gun. These have been corrected. Also, replumbing of laboratory gas runs and alterations in equipment location have hampered laboratory experimentation in addition to long delays in receiving ordered supplies (as Shipley photo resist, Dupont polyimide coupler, sputter gun holders, etc.).

IX. DRY PROCESSING VENDORS

A. Plasma Etch Vendors

1. Tegal, Inc.
   528 Weddell Dr.
   Sunnyvale, California 94086
   (408)744-0872 Contact: Phil Crabtree

   Barrel and "in-line" parallel plate reactors both with end point detectors.

2. LFE
   2920 San Xsidro Way
   Santa Clara, California 95051
   (408)727-2360 Contact: Ken Scow

   Barrel and small parallel plate reactors also, an "in-line" 5 wafer system

3. D-W Industries (part of Kasper Instruments)
   844 Del Rey
   Sunnyvale, California 94086
   (408)733-9800 Contact: Berl Bragg

   Parallel Plate batch system only

4. Dionex (Formerly I.P.C.)
   3115? San Benito Street
   Hayward, California 94544
   (415)489-3030 Contact: Wayne Landman

   Parallel plate batch and barrel equipment

5. Applied Materials
   3050 Bower Avenue
   Santa Clara, California 94051
   (408)249-5555 Contact: Steve Corlett

   Plasma nitride deposition and etch systems. Also new types of plasma oxide etchers being developed by a group headed by Robert Anglin

6. E. T. Systems
   2378C Walsh Avenue
   Santa Clara, California ?5050
   (408)984-230C Contact: Clint Graves

   Planar Aluminum, poly, nitride batch etchers

B. Reactive ION Etchers

Varian
375 Distel Circle
Los Altos, California 94022
(415)966-1110 Contact: Louis Kunz

Still in development

C. ION Beam Milling

VEECO
599 N. Mathilda Avenue, Suite 140
Sunnyvale, California 94086
(608)732-2330

In production

D. Plasma Deposition Vendors

1. Tegal (see above)
2. L.F.E. (see above)
3. AMT (see above)
4. Pacific-Western Systems
   855 Maude Avenue
   Mountain View, California
   (415)961-8861 Contact: Norm Lewis

   Both nitride and oxide plasma deposition

E. Low Pressure CVD Vendors (Oxide, Nitride, Poly)

1. Thermco
   1465 N. Batauia Street
   Orange, California 92668
   (714)639-2340

2. Advance Crystal Science
   2995 Copper Road
   Santa Clara, California 95051
   (40_)733-3633 Contact: Roger McKinley

3. Tylan Corporation
   4203 Spencer Street
   Torrance, CA 90503

4. ASM/America
   2328A Walsh Avenue
   Santa Clara, California 95050
   (408)727-2323 Contact: Ing-Marie Helmer

F. Sputter Deposition System AL, Al, Al/Si, Al/Si/Cu, Silicides, etc.

1. Perkin-Elmer
   361 Willow Street
   San Jose, California 95110
   (408)249-5540 Ext. 270 Contact: David Tam

2. C.P.A. Inc.
   725 Kifer Road
   Sunnyvale, California 94086
   (408)733-9823 Contact: Ed Wilder

3. Varian (see above)

4. MRC
   1101 San Antonio Road
   Mt. View, California 94040
   (415)964-7272 Contact: Dick Walker

QUARTERLY

FINANCIAL REPORT

FOR

NASA Contract NAS8-33448

July 13, 1979 - October 13, 1979

Prepared for

George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Submitted by

Thomas E. Wade
Principal Investigator

COST ANALYSIS OF __SEARCH PROJECTS

CONTRACT 30-45-0210607-235 PROJECT TITLE NASA Contract NAS8-33448

DATE THIS REPORT July 13, 1979 THROUGH July 31, 1979

	EXPENDITURES THIS MONTH	EXPENDITURES TO DATE	OUTSTANDING COMMITMENTS	FREE BALANCE	TOTAL PROPOSED BUDGET
A. PERSONNEL SERVICES (1) Professional				14,205.00	$14,205
(2) Graduate Assistants				4,500.00	4,500
(3) Undergraduate Assistants				500.00	500
(4) Technical					
(5) TOTAL PERSONNEL SERVICES				19,205.00	19,205
B. MATERIALS AND SUPPLIES	50.00	50.00		3,150.00	3,200
C. EQUIPMENT					
D. TRAVEL				2,000.00	2,000
E. EMPLOYEE BENEFITS				2,463.00	2,463
F. OTHER (Specify) PUBLICATION COSTS				300.00	300
G. TOTAL DIRECT EXPENDITURES	50.00	50.00		27,118.00	27,168
H. INDIRECT COST 45.0% of A(5)				8,642.00	8,642
I. TOTAL EXPENDITURES	50.00	50.00		35,760.00	$35,810

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COST ANALYSIS OF . .SEARCH PROJECTS

CONTRACT 30-45-0210607-235 PROJECT TITLE NASA Contract NAS8-33448

DATE THIS REPORT August 1, 1979 THROUGH August 31, 1979

	EXPENDITURES THIS MONTH	EXPENDITURES TO DATE	OUTSTANDING COMMITMENTS	FREE BALANCE	TOTAL PROPOSED BUDGET
A. PERSONNEL SERVICES (1) Professional	1,835.47	1,835.47		12,369.53	$14,205
(2) Graduate Assistants				4,500.00	4,500
(3) Undergraduate Assistants				500.00	500
(4) Technical					
(5) TOTAL PERSONNEL SERVICES	1,835.47	1,835.47		17,369.53	19,205
B. MATERIALS AND SUPPLIES	465.48	515.48		2,684.52	3,200
C. EQUIPMENT					
D. TRAVEL				2,000.00	2,0[illegible]
E. EMPLOYEE BENEFITS				2,463.00	2,463
F. OTHER (Specify) PUBLICATION COSTS				300.00	300
G. TOTAL DIRECT EXPENDITURES	2,300.95	2,350.95		24,817.05	27,168
H. INDIRECT COST 45.0% of A(5)	825.96	825.96		7,816.04	[illegible],642
I. TOTAL EXPENDITURES	3,126.91	3,176.91		32,633.09	$35,810

COST ANALYSIS OF ..SEARCH PROJECTS

CONTRACT 30-45-0210607-235 PROJECT TITLE NASA Contract NAS8-32449

DATE THIS REPORT September 1, 1979 THROUGH September 30, 19 79

	EXPENDITURES THIS MONTH	EXPENDITURES TO DATE	OUTSTANDING COMMITMENTS	FREE BALANCE	TOTAL PROPOSED BUDGET
A. PERSONNEL SERVICES (1) Professional	1,037.89	2,873.36		11,331.64	$14,205
(2) Graduate Assistants				4,500.00	4,500
(3) Undergraduate Assistants	247.95	247.95		252.05	500
(4) Technical					
(5) TOTAL PERSONNEL SERVICES	1,285.84	3,121.31		16,083.69	19,205
B. MATERIALS AND SUPPLIES	43.42	558.90		2,641.10	3,200
C. EQUIPMENT					
D. TRAVEL				2,000.00	[illegible]
E. EMPLOYEE BENEFITS				2,463.00	[illegible]
F. OTHER (Specify) PUBLICATION COSTS				300.00	[illegible]
G. TOTAL DIRECT EXPENDITURES	1,329.26	3,680.21		[illegible]	27,168
H. INDIRECT COST 45.0% of A(5)	578.63	1,404.59		7,237.41	[illegible]
I. TOTAL EXPENDITURES	1,907.89	5,084.80		30,725.20	[illegible]