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Computer Control and Data Management in an LSI Fabrication Facility

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Prepared by Sandia Laboratories, Albuquerque, New Mexico 87185
and Livermore, California 94550 for the United States Department
of Energy under Contract DE-AC04-76DP00789

Printed June 1980

Sandia National Laboratories

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Printed in the United States of America

Available from
National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Price: Printed Copy ~~\$4~~ Microfiche \$3

5.00

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SAND80-0810
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IN AN LSI FABRICATION FACILITY

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A B S T R A C T

A minicomputer system is used to control diffusion furnaces, monitor temperatures, provide operator instructions for each processing step, and record detailed process histories for wafer lots fabricated in the Sandia Semiconductor Development Laboratory. The system provides a complete data base for laboratory operations, a variety of displays describing equipment status, scheduling and utilization summaries for equipment, wafer and mask inventories, and laboratory management information. The wafer lot history includes a record indicating the operator, time, date, and specification recipe for each process step, special notes summarizing process deviations, results of inspection steps, and in-line capacitance, oxide thickness, or resistivity measurements.

Introduction

In recent years many system design groups and laboratories have developed in-house integrated circuit (IC) fabrication capabilities because of the limited availability of commercial resources. This has been especially true for government laboratories requiring small numbers of hi-rel, custom circuits for use in military and satellite applications with severe operational environmental constraints. Because the fabrication of these low-volume custom ICs usually deviates from the commercial vendor mainstream production and hence attracts limited vendor interest, Sandia has developed a state-of-the-art Semiconductor Development Laboratory (SDL) for technology development and prototype circuit fabrication. The SDL supports fabrication for a variety of silicon technologies such as metal and silicon gate CMOS, MNOS nonvolatile memory, high-frequency bipolar, and solar cell devices.

The laboratory is contained in a vertical laminar flow clean area comprised of two sections: 2,500 square feet of Class 100 and 3,000 square feet of Class 10,000. A plan of the laboratory showing the equipment locations and area usage is shown in Figure 1. A list of major equipment contained in the laboratory is provided in the Table.

In addition to careful selection of the basic equipment and layout of the laboratory, many of the laboratory objectives could be efficiently met only by the use of computer control with extensive data acquisition and processing. The laboratory equipment selection was based on cost, versatility, ease of use, size, and the availability of automatic control with optional digital/analog input and output interfaces.

After evaluating the limited automated diffusion furnace systems available during laboratory planning and careful analysis of the special requirements for computer usage in the laboratory, a decision was made to develop the computer system in-house rather than purchase a turnkey system for subsequent modification. This decision was

based, in part, on the continuously evolving laboratory requirements for an R&D facility, proprietary restrictions associated with available software, lack of software documentation, and absence of an adequate data base organization to support an entire integrated circuit fabrication laboratory. In addition, production costs, the critical dependence of successful completion of a wafer lot on each process step, and lack of experience with automated control dictated that an initial manual backup capability be provided for the computer control to prevent loss of a wafer lot as a result of computer failure. A backup file storage system was also to be provided for a duplicate record of the entire laboratory data base to prevent loss of information caused by computer system failure.

The remainder of the report describes the computer system and is divided into five basic sections describing (1) the computer hardware, (2) software, (3) system operation, (4) system experience, and (5) present expansion.

Computer Hardware

The initial computer control system selected was a Hewlett-Packard 21MX computer system with 32 K words of memory and an HP7905 7.5 million word disc storage unit. This system was subsequently expanded to include 224 K words of memory, an HP7906 10 million word disc, and an HP2631 printer. Operator interaction with the system occurs via seven HP2640 CRT terminals.

The HP2640 terminals, with an 80-character by 26-line screen, have at least 5,000 words of memory to permit storage of 3 display pages and allow the user to scan each page for items of interest. Most program displays are segmented "pages" of 20 lines each. This provides one or two lines for a header, 20 lines for display, and a line for an operator's response if required. The operations room contains an HP2648 system terminal and HP2631 printer; the remainder of the terminals and printers are strategically located throughout the clean room and staff areas. Terminals in special locations

preferentially access information associated with equipment located nearby.

The HP21MX computer is connected by a data link to a remote microelectronics computer network for long-term file storage and complex data manipulations. The remote file backup system is part of a larger microelectronics computer network composed of a VARIAN 75 and seven HP 2100 series minicomputers and graphical data displays on direct-view storage tubes (DVST) as shown in Figure 2. Communication links are provided to a DEC System 10 IC design system and a scientific computer network consisting of Control Data 6600 and 7600 computers. In addition to the Hewlett-Packard minicomputer used for the SDL control and data management, the other HP minicomputers are used to control automatic testing equipment and acquire data for characterizing integrated circuits fabricated in the laboratory.

The HP21MX computer is interfaced to 17 tubes of the Lindberg diffusion furnaces system for temperature set point, gas system valve actuation, and boat loader actuation. The interface to a Doric Model 220 A/D scanner provides temperature monitoring via a Lindberg microelectronics signal conditioning interface.

Software

During initial system planning, several basic software development objectives were established. The system was to employ (1) a standard real-time executive operating system, (2) a computer access security system, (3) a high-level programming language, (4) modular programming, (5) easily maintainable software, (6) an optimized operator interface, (7) a hierarchical sequence for information display, and (8) a backup data base to prevent information loss in the event of computer hardware failure.

The original operating monitor selected for the computer system was the Hewlett-Packard RTE-II (real-time executive) operating system.

The present RTE-IV-B system provides fast disc access and supports the use of large FORTRAN programs.

The computer security system objective was met by implementing a five-level software security system to limit access to authorized personnel and to limit initiation of critical processing equipment or modification of data records. As the security level increases, additional capabilities are enabled. The lowest level of access provides a read-only capability for processing and recipe information. The second level provides an additional write capability for adding information to the lot histories. The third level of security allows processes to be added to the data base, and the fourth security level allows changes in operation of the furnace equipment and access to report functions and critical operations files. The highest level of security used by the system development programmer allows access to all processing files and the entire data base.

All software programs were written in a modular structure using FORTRAN. Assembly language was used only for the hardware interface driver routines. The use of the modular structure and FORTRAN programming tends to minimize problems encountered in modifying the programs as the requirements change.

Operator interaction with the system is accomplished by running a number of separate programs under the control of the real-time operating system. Each program generates a CRT display, asks the operator the appropriate questions, processes the operator responses, generates or modifies the data base files, and branches to the next program.

All programs were initially developed as discrete entities and required an operator to call each program as needed. While this mode was necessary, program linking was needed to transfer blocks of data from one program to another. The H-P RTE system "Class I/O" was used to buffer information into an area of protected memory and then pass the location to the called program. The called program reads this

buffer into a storage area and releases the system area for use by another program.

Programs can be used in a hierarchical sequence. At the highest level, programs are available for determining laboratory equipment status or the status of wafer lots in fabrication. The next lower level provides individual lot history information, and the lowest level provides detailed recipe information for each step in the lot history. In this sequence, a device-lot history is the group of process recipes required to manufacture an integrated circuit, and each process recipe defines a unique set of operations performed on the wafer lot.

The laboratory data base is composed of a number of logical units containing sequential files. All files are formatted in 80-character ASCII variable-length records.

Backup for the data base system files is supported in two modes consisting of local and remote disc files. Dual files are locally maintained on both removable and nonremovable disc platters. A duplicate remote file is provided on the microelectronics computer system via file transfer over 9600 baud communication lines.

Although a number of programs support system operation, the following list of program acronym and definitions represents the major system programs:

1. DEFT-- A program for defining the list of process recipe steps used for new devices, lots, or sublots.
- 2 DDEF-- A program for displaying the device history and operator options for listing the next process, starting a furnace, or signaling the completion of a step.

3. PDEF-- A program defining the process recipes. Two types of process recipes are used in the system--a documentation process (i.e., an acid clean for the silicon wafers) and processes used in conjunction with the computer/equipment interfaces to automatically control the equipment.
4. TUBE-- A program changing tube temperatures and displaying the operational status of the diffusion furnace.
5. TMPR-- A program for monitoring the temperature profile of the furnace tubes. The monitoring employs six thermocouples located in the quartz process tube, a Doric 220/A/D scanner, and an Intel 8080 microprocessor/HP interface.
6. RPRT-- A program for generating management, operational, process, and device yield reports.
7. DSPL-- A program used to determine the queue of wafer lots at specified process stations.
8. INVN-- A program for maintaining the inventory of silicon slices. Inventories are adjusted automatically when a new device lot is defined by calling this program.
9. NEXT-- A program which determines the next available device/lot code available for definition.
10. STAT2-- A program for generating reports of the devices/lots not started on hold, or in processing. The report lists the operator, total

number of steps and completed step numbers for the past 6 days.

11. EXPS-- A program listing the recommended exposure time as a function of photoresist type.

The above programs are available from all system interactive terminals. The following special programs are available only from a central operations system terminal:

1. TMPF-- A program for monitoring each diffusion furnace tube temperature profile at a selected time interval and adjusting three motorized set point controllers via the Lindberg interface to improve the profile.
2. CLEAN-- A program for initiating an HCl/O₂ gas clean cycle for furnace tubes at selected times and dates.
3. EDT01-- A program (H-P system software) for editing data base files.
4. FMG01-- A system file manager program (H-P system software) for manipulating or purging data base files from the system.

In addition to the above programs, several special software/interface diagnostic programs were developed. These programs are used to sequentially exercise all interface links (e.g., decrease each furnace tube temperature set point by 50°C and return to the original setting) to verify correct operation.

System Operation

Although a number of options are available for use by operators in the laboratory, typical operation during wafer lot processing occurs as follows:

The operator initially presses the return key on the CRT terminal and enters an assigned four-digit security identification code. The program processes the ID code to determine the user's security level, initials, and the last time the user operated the system. The first time the operator signs on the system each day a "message of the day" is displayed. These messages contain special instructions or assignments and can be interrogated by the user later by keying in the appropriate acronym.

The operator then enters a six-character, alphanumeric device lot code or presses the space bar and return. If the device lot code is entered, an automatic call to program DDEF is implemented. DDEF displays the sequence of process recipe steps for the wafer lot requested. The operator is asked if all lines are to be printed or only the particular lines corresponding to the processing recipe steps being performed. If the complete process recipe is requested, the display shown in Figure 3 is obtained. Each device/lot contains a header with information for the wafer lot identification, technology type, wafer lot number, description of the device, and engineer responsible for that design. Typical processing sequence information consists of a step number, a specification number, an abbreviated description of the process step to be performed, operator's initials, completion time and date, the number of wafers processed through that step, and notes. For manual steps, the operator must perform the processing operation described and indicate to the computer that the step has been performed and the number of wafers processed through that step. The computer automatically enters the operator's initials, the time and date the particular step was completed, and number of wafers. If notes are to be added at the end of the process page, the program places an asterisk in the notes column. For

automatic steps such as high-temperature furnace operations, the operator loads the wafer boats onto a paddle and indicates to the computer that the step is ready to be performed. The computer performs a number of automatic checks including verifying that all previous steps have been signed off, verifying the operation is being performed in the proper tube, and checking for the correct tube temperature. After verifying these conditions, the computer controls the appropriate gasses, inserts the wafer boat, times the appropriate high-temperature cycle, and ramps the furnace temperature as required by the process recipe. After completion of the operation, the computer enters the operator's initials, the time and completion date for that particular step, the number of wafers, and the furnace tube number in the notes column.

At the end of the process recipe listing, a series of labeled notes are provided to the operator by the engineer. (Refer to Figure 3.) These notes provide special processing instructions and are referenced in the abbreviated process recipe description for the appropriate processing step. Following the notes, a series of comments corresponding to recipe steps is added during processing by the operator. These notes are of arbitrary length and contain either information the operator considers important for later problem diagnosis or the results of in-line process measurements.

Process recipes can be referenced by the operator at any time. A typical recipe for a scrub and acid clean sequence is shown in Figure 4. The operator obtains this display by typing PDEF and the unique six-digit specification identification number. In addition to several introductory lines describing the process, the definition date, and process designer, typical recipes contain several notes describing the equipment, material, and chemicals used, and settings for timers or switches. Processing instructions are described in sufficient detail to allow operators familiar with laboratory equipment to successfully complete the sequence of steps. Since each process recipe is described with a unique identification number and even minor changes in the recipe requires a change in the alpha suffix,

precise accounting and indefinite storage of accurate processing recipe libraries is ensured.

During laboratory operation, a number of auxiliary status displays are available. Several typical displays are shown in Figure 5.

System Experience

The computer control/data management system has been in continuous use for approximately 4 years and is the only method used by all SDL personnel. Due to the system's excellent hardware/software reliability, no paper travelers or process descriptions are used within the facility to back up the computer system. The system has experienced approximately three hardware outages per year of less than 2 hours each, based on a 24-hour, 5-day usage schedule. One single hardware failure of about 1 day's length has occurred. This excellent uptime record is due both to the routine, once-per-month, preventive maintenance service and the quick service call response provided by the computer manufacturer.

The conceptual system decision for programming all software in a standard language for subsequent ease of modification has proven to be a major factor in the successful system use by the line personnel. After the original concepts were programmed and implemented, many modifications became apparent which would significantly increase the usefulness of the system. The response time of the system to a request for information became a key factor in the use of the system by line personnel; if the system was cumbersome in its response, its acceptance was poor. Specifically, two modifications were made to the original software which significantly improved the system's response time. The number of nonessential operator keystrokes was reduced to a minimum to allow quick access to the desired information or data entry point. Secondly, after an initial training period, the software was modified to reduce the amount of program-generated descriptive text, which the typical user saw many times during the workday. In addition to this text being redundant and losing its

value, the operator was required to wait while the information was displayed. The ability to rapidly change the system software ensured its acceptance by the operating personnel. During the system's use, a number of modifications to existing programs and several new programs were suggested. If these modifications and new programs had not been easily adapted to the software, the system would have become less functional with time.

When sizing the original system hardware, the number of disc files (lot listings, process descriptions, program files, report and data files, etc.) required was underestimated. Subsequently, in addition to more than doubling system disc storage from 7.5 to 17.5 megabytes, the disc resident time of completed lot histories was reduced to less than 3 months before historical storage on magnetic tape. These actions created sufficient disc storage to allow redundant storage on separate disc packs of key process and lot information and prevented a significant loss of information on one occasion due to a defective disc pack unit.

In addition to increasing the amount of disc storage, four major areas of hardware expansion have occurred which required a significant reprogramming effort. A display-only TV terminal similar to that used in many airport facilities for displaying flight information was added to display commonly needed information to line personnel (tube status, process queues, etc.), thus reducing the load on available interactive terminals. A microprocessor-memory system was interfaced between the central computer and slow data-generating peripherals not designed for polling operation. The microcomputer controls the peripherals, logs data, and passes the data to the central computer on command, thus freeing the central computer for more critical operations. A telephone modem was also added to allow remote interrogation of the system. Finally a high-speed printer was added to output the many reports and historical lot listings required by the line engineering staff.

The SDL computer control/data management system has not been a static entity but has seen a significant evolution of both hardware and software during the 4 years of use. Without the ability to implement such changes, the rapidly changing requirement of a semiconductor fabrication line would render any such system obsolete in a short number of years.

Present Expansion

Two major areas of revision of the computer control/data management system are planned within the SDL: the staged replacement of 17 analog furnace tubes with 24 Direct Digital Control (DDC) furnace tubes and the addition of programs and equipment necessary for automatic in-process data acquisition and plotting. Both changes will result in a number of complex, new, automatic decision-making programs.

The staged replacement of the existing 17 tubes of analog* furnaces with 24 tubes of Bruce Industrial Control's DDC furnaces is an excellent example of the versatility of the Sandia software. Initially, eight tubes of Bruce DDC furnaces will be installed while the operation of 14 of the original analog tubes is maintained. The addition of the Bruce DDC furnaces requires an additional high-speed I/O multiplexer and 12 major new software programs. However, both types of software must be operational during the interim period and appear transparent to the line personnel.

A new series of programs is also being added which will accept information automatically taken by in-line measurement instruments or entered via an interactive message terminal, log the data in various line control files and the traditional lot history file, and generate line control plots. These line-control data files may also be used by separate programs to issue line-control deviation warning reports to responsible line personnel.

The original software was deliberately designed to accept only incoming data (lot history data), generate reports using this data, and

provide open loop furnace equipment control with no process decisions. As experience was obtained, the goal was to determine which measurements, reports, and decisions could effectively be made automatically and to include these advanced system features when the appropriate line equipment became available. The addition of the DDC furnaces and automatic measuring equipment in conjunction with the associated closed-loop programs will be a large step forward in the automation of the process facility.

Summary

A minicomputer control and data management system has been developed to control diffusion furnace operations, provide detailed instructions for manual processing steps, and maintain detailed device/lot histories in the Semiconductor Development Laboratory. The system has evolved over a 4-year period and has been used continuously. Excellent operating experience has supported the initial decision to develop and maintain the custom software in-house.

Figure 1. SEMICONDUCTOR DEVELOPMENT LABORATORY

Figure 2. MICROELECTRONIC AUTOMATION NETWORK

DEVICE NUMBER-- B1310A RUN TYPE IS DEVELOPMENT
 DEVICE DESCRIPTION IS SI/W-SI GATE AND WAS DEFINED 11/ 2/79
 BY JJC AND ASSIGNED TO EKL
 FOR 24 WAFERS
 REMARKS W1-17,C1-7 ARE 3-6 OHM-CM, N-PH, (100), MONSANTO

NEXT STEP	PROCESS	OPTR	COMPLETION	NO.	
OPRN NO.		INIT	TIME DATE	WFRS	NOTES
1 1106BA	CLEAN;A+C	EKL	9:42 11/ 6/79	24	0
2 3102AB	100,15.M,90.M,DRY/STM;A+C	EKL	11:31 11/ 6/79	24	9
3 5105AA	HR100,LEVI;A	EKL	14:49 11/ 6/79	17	0
4 5124AA	TX-100;A+C	EKL	14:49 11/ 6/79	24	0
5 5111AA	ETCH,HPO+1M;A+C	EKL	14:50 11/ 6/79	24	* 0
6 1100AA	CLEAN;A+C	EKL	8:40 11/ 7/79	24	0
7 3107AB	000,60.M;A+C	EKL	9:44 11/ 7/79	24	6
8 4503BH	P-WELL IMPL;A+C1	LG	13:28 11/ 7/79	18	0
9 5111BB	ETCH,4M;A+C	EKL	14:38 11/ 7/79	24	0
10 1106AA	CLEAN;A+C	EKL	14:49 11/ 7/79	24	0
11 3105AC	200,4.H,4.H;A+C	EKL	0:51 11/ 8/79	24	10
12 5105AA	HR100,LEV2;A	EKL	10:35 11/ 8/79	17	0
13 9200AA	INSPECTION;A	EKL	10:35 11/ 8/79	17	0
14 5124AA	TX-100;A+C2	EKL	10:49 11/ 8/79	18	0
15 5111AA	ETCH,HPO+1M;A+C2	EKL	10:49 11/ 8/79	18	* 0
NEXT PAGE?(Y OR N): Y					
16 9200AA	INSPECTION;A	EKL	13:17 11/ 8/79	17	0
17 1100AA	CLEAN;A+C	EKL	14: 6 11/ 8/79	24	0
18 3111AA	050,25.M,P+ ;A+C	EKL	14:35 11/ 8/79	24	1
19 5112AA	ETCH B-GLASS;A+C	EKL	16: 0 11/ 8/79	24	0
20 3102DB	900,10.M,2.M;A+C	EKL	16:15 11/ 8/79	24	3
21 5112AA	STAIN REMOVAL;A+C	EKL	8:53 11/ 9/79	24	0
22 3107AF	000,30.M;A+C	EKL	9:26 11/ 9/79	24	6
23 5111AA	ETCH,HPO+1M;A+C	EKL	14:45 11/ 9/79	24	* 0
24 1106AA	CLEAN;A+C	EKL	9: 6 11/12/79	24	0
25 3102CC	000,15.M,60.M;A+C	EKL	10.25 11/12/79	24	6
26 2106CA	C02-H2 OXIDE,5.5KA;A+C	EKL	13.26 11/12/79	24	* 0
27 9103AA	FIELD OX THICK;C1	EKL	13:27 11/12/79	1	* 0
28 5105AA	HR100,LEV3;A	EKL	14:30 11/12/79	17	0
29 9200AA	INSPECTION;A	EKL	14:30 11/12/79	17	0
30 5124AA	TX-100;A+C	EKL	14:53 11/12/79	24	0
31 5111AA	ETCH,HPO+1M;A+C	EKL	14:53 11/12/79	24	* 0
32 9200AA	INSPECTION;A	EKL	16:19 11/12/79	17	0
33 1100AA	CLEAN;A+C	EKL	8:48 11/13/79	24	0
34 3107AC	000,90.M;A+C	EKL	10:22 11/13/79	24	0
35 9105AB	GATE OX THICK;C1,C3	EKL	10:28 11/13/79	2	* 0
86 1117AA	712D STRIP;A	:	/ /		
87 3100AA	SINTER;A	:	/ /		
88 2151BA	P-GL,6.5-9KA,NOTE 5;A+C9	:	/ /		
89 9103AA	OXIDE MEAS;C9	:	/ /		
90 5107AA	MN150,LEV9;A	:	/ /		
91 5122AA	PHOS/HF ETCH;A	:	/ /		
92 1117AA	712D STRIP;A	:	/ /		
93 1107AA	SCRUB;A	:	/ /		
94 9200AA	FINAL INSPECT-DLW;A	:	/ /		

(This figure continued on next page)

NEXT PAGE?(Y OR N): Y

N-NOTE 1: CONTACT J. CLEMENT BEFORE PLASMA ETCHING

N-NOTE 2: USE A ZERO DEGREE IMPLANT

N-NOTE 3: USE A ZERO DEGREE IMPLANT WITH A BEAM CURRENT OF LESS

N- THAN 25 MICRO AMPS

N-NOTE 4: ADD A BLANK CONTROL WAFER C8

N-NOTE 5: ADD A BLANK CONTROL WAFER C9

N-NOTE 6: CLEAN IN SPECIAL AU BEAKERS AND BOATS, 80C H2S04 ONLY, NO H202

N-NOTE 7: USE A SPECIAL BOE BEAKER - NOT THE STANDARD TANK

*- 1 LOT 1994, SN 088635

*- 5 ETCH TIME=8.4 MIN

*- 15 ETCH TIME=5.2 MIN

*- 23 ETCH TIME=4.0 MIN

*- 26 OX THICKNESS=5770A, 5370A

*- 27 OX THICKNESS C1=8280A

*- 31 ETCH TIME=10.1 MIN

*- 35 GATE OX THICKNESS C1=543A, C3=563A

Figure 3. DEVICE/LOT HISTORY

PROCESS ID--1106AB

PROCESS DESCRIPTION IS SCRUB & ACID CLEAN AND WAS DEFINED 10/12/76

BY WEAVER

AND ENTERED BY WEAVER

REMARKS

SCRUB, ACID CLEAN WITH 50:1 HF DIP

NOTE: A. USE BENCH #1 OR #2; START AT ACID MODULE #1. ALL RINSE SWITCHES SHOULD BE ON AUTOMATIC.

B. ACID SHOULD BE ASPIRATED OUT OF THE BEAKERS AFTER USE AND THE BEAKERS SHOULD BE RINSED OUT 4 TIMES.

C. ALL TWEEZERS TO BE CLEANED PER SPEC. 1007AA.

D. WAFERS ARE TO BE STORED ONLY IN QUARTZ BOATS.

E. ADD H2O2 TO H2SO4 IMMEDIATELY BEFORE USE.

1. SCRUB WAFERS IN AUTO-SCRUBBER PER THE STANDARD CYCLE. USE CLEAN METAL BOATS FOR THE SCRUB CYCLE, THEN TRANSFER TO A CLEAN A-73 BOAT FOR THE ACID CLEAN.
2. H2SO4(7)-H2O2(3) OR FILL BEAKER ACCORDING TO MARKS ON THE SIDES. A73 BOAT, 10 MIN-SET TIMER AND PUSH RED START BUTTON.
3. WHEN BUZZER SOUNDS, PLACE BOAT/WAFERS INTO THE QUENCH RINSE UNTIL 500K-OHM IS REACHED.

NEXT PAGE?(Y OR N): Y

4. PLACE BOAT/WAFERS INTO CASCADE RINSE #2, SET TIMER FOR 1 MIN. OF N2 AGITATION AND PRESS RED BUTTON. WHEN BUZZER SOUNDS, LEAVE THE WAFERS IN THE RINSE UNTIL 5 MEGOHMS IS REACHED.
5. HF(1)-H20(50); TEFLON TANK, 30 SEC.
6. PLACE BOAT/WAFERS IN THE QUENCH RINSE IN FRONT OF HF TANK UNTIL IT REACHES 500K-OHMS. AGITATE EVERY 30 SEC.
7. PLACE BOAT/WAFERS IN CASCADE RINSE #2, SET TIMER FOR 1 MIN. OF N2 AGITATION AND PRESS THE RED BUTTON. WHEN THE BUZZER SOUNDS, LEAVE THE WAFERS IN THE RINSE UNTIL 5 MEGOHM IS REACHED.
8. PLACE THE BOAT/WAFERS IN THE FRONT RINSE OF THE CASCADE FOR 3 MIN.
9. SPIN DRY WAFERS FOR 2 MIN. AT MAX. RPM.

END

Figure 4. PROCESS RECIPE--WAFER CLEAN

TUBE NO.	AUTO LCL	END TIME HH MM SS	TUBE TEMP	TUBE UTLZ	ACTIVE DEVICE	REMARKS
1	A	: :	1050	0000		P+PREDEP,1050C
2	A	: :	1000	0000		GATE OXIDE
3	A	: :	1000	0000		GATE OXIDE
4	A	11:13: 3	1000	.05		N+ PREDEP,1000C
5	A	: :	900	0000		N+ PREDEP,LOW TEMPS & EXPERIMENTAL
6	A	9:22: 3	800	.02		DRIVE-IN
7	A	: :	850	0000		850C STEAM ONLY!!
8	A	9: 6:44	1100	.01		DRIVE-IN, 1100C
9	A	: :	550	0000		ANNEAL TUBE
10	A	: :	850	0000		ANNEAL TUBE
11	A	: :	1000	0000		900,1000,1000 DRIVE INS
12	A	: :	450	0000		SINTER
13	A	5:45:14	1200	0000		1100C STM,1200C DRIVE-IN
14	A	9:38:49	1200	0000		1200C DRIVE-INS ONLY

(a)

ENTER REPORT DESIRED (NEW,ACTIVE,HOLD): ACTIVE
SDI. DEVICE STATUS FOR 3/28/80

DEVICE	OPTR	TOTAL STEPS	PRESENT STEP	DEVICE STATUS FOR PREVIOUS 6 DAYS					
				-1	-2	-3	-4	-5	-6
S0804A-D	EH	44	13	12	10	9	8		
D0604A-D	EH	54	31	30	21	19	14		
B1069A-P	EH	84	4	1					
A3008A-P	EH	105	75	68	52	49	35		
A0728A-P	EH	79	28	21	14	12			
J0807A-D	EKL	108	75	60	59	58	54		
B1312A-D	EKL	100	87	80	77	72	67		
B0436A-D	EKL	83	10	8	4	1			
B1067A-P	EKL	84	68			63	57		
B1068A-P	EKL	84	66		61	59	55		
B1314A-D	JMG	103	85	81	76	75	73		54
B1109A-D	JMG	130	3		1				
KU403A-D	JMG	11	9	7	3	1			
S0006A D	JMG	50	12			4	1		
K0503A-D	MMW	9	6	3	1				
S1203A-D	MMW	78	18			17	16		
A3204A-P	MMW	72	72	68	61	57	51		
A0729A-P	MMW	72	30	26	22	13	11		
B1110A-D	MRT	129	43	38	34	30			
B1602A-D	MRT	88	60				52		
S1402A-D	MRT	44	28	21	18	17	15		
B0435A-D	MRT	83	46	38	32	29	21		

ENTER CODE (0 to 9,10, or 100): 100
(b)

(This figure continued on next page)

ENTER WAFER TYPE (PREPROCESSED,SPECIAL,STOP,VIRGIN): VIRGIN

NO	PROCESS NUMBER	ORENT	TYPE	RESISTIVITY		NUMBER WAFERS	
				LOW	HIGH		
1		100	N-PH	.80	1.20	5431	12 MIL,MONS.,MONEEX!!
2		100	N-PH	.80	1.20	699	15 MIL,MONS.,3 INCH!!
3		100	N-PH	1.20	1.80	360	12 MIL,MONSANTO
4		100	N-PH	1.60	2.40	509	12 MIL,MONSANTO
5		100	N-PH	3.00	5.00	191	15 MIL,WESTERN
6		100	N-PH	1.50	3.00	1028	12 MIL,CRYSTECO
7		100	N-PH	3.00	6.0	2071	12 MIL,MONSANTO
8		100	N-PH	3.00	6.00	492	12 MIL,CRYSTECO
9		100	N-PH	4.00	5.00	137	12.5 MIL,SPC,SOLAR
10		100	N-PH	4.00	8.00	843	12 MIL,MONSANTO
11		100	N-PH	5.00	9.00	450	12 MIL,MOTOROLA
12		100	N-PH	5.00	10.0	864	12 MIL,MONSANTO
13		100	N-PH	8.00	12.0	255	12 MIL,MONS,MON-X
14		100	N-PH	5.00	15.0	810	12 MIL,MOTOROLA
15		100	N-SB	.01	.02	785	12 MIL, MONSANTO
16		100	N-SB	.01	.02	503	12 MIL,MOTOROLA
17		100	N-PH	.20	.40	- 51	15 MIL,SILTEC
18		100	N-PH	.20	.40	776	12 MIL,MONS.,MONEEX
19		100	N-PH	1.00	2.50	9	10 MIL,MONSANTO
20		100	N-AN	.01	.03	394	15 MIL,SILTEC

PRESS SPACE BAR AND CARRIAGE RETURN TO CONTINUE:
(c)

Figure 5--Typical Auxiliary CRT Displays--(a) Furnace Tube Status,
(b) Device Status, and (c) Wafer Inventory

TABLE
Major Equipment Contained in the SDL

2	Applied Materials AMV-1200 CVD Reactors
1	Applied Materials AMS-1045 silox reactor
4	Applied Materials AMT-5100 RPCVD furnace tubes
1	Applied Materials Plasma I reactor
1	Dionex Series 2000 barrel etching reactor
17	Lindberg Lancer diffusion furnace tubes*
3	Kasper Uniplane System 4000 photoresist coaters tracks with double side IR bake ovens
3	Kasper Uniplane System 4000 photoresist developers tracks with double side IR bake ovens
3	Kasper Uniplane System 4000 scrubber tracks
5	Kasper 2001 contact aligners
1	Nanometric Nanoline system
1	Nanometric Nanospec system
1	Vickers electronic image shearing inspection system
1	Perkin-Elmer Model 554 spectrophotometer
1	Gaertner automatic ellipsometer
1	Tencor Profilometer
1	ADE bow/taper/wafer thickness gauge
1	Fluorowave 2120S automatic wafer cleaning unit
80	Lineal feet of Modular wet cleaning bench
6	Zeiss KK-08 phase contrast inspection microscopes
1	Extrion ion implanter Model 200-20A with wave flow end station
1	Silicon Valley Group automatic wafer edge grinder
1	UTI gas analyzer Model Q30
1	Varian 3135 vacuum evaporator system with 26-inch bell jar; Applied Materials In-Source 1500 and Inficon IC-6000 deposition controller
2	Varian VI-460 vacuum deposition systems. One with an Airco CV-8 e-beam evaporation source, and one with an Applied Materials In-Source 1500 and Inficon IC-6000 deposition controller
1	Materials Research Corp. MAG Sputter System.

* Being replaced with 24 tubes of Bruce Industrial Controls DDC furnaces in an 8 Pac configuration.

Distribution:

2100 D. M. Olson
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[illegible]

* Recipient must initial on classified documents.