MICROELECTRONICS PROCESS ENGINEERING

MODULE 1

- **Introduction**
- **Introduction to semiconductor industry; history and future trends**
- **Basic electronic components and semiconductor devices**

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MICROELECTRONICS PROCESS ENGINEERING

COURSE INSTRUCTOR

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MICROELECTRONICS PROCESS ENGINEERING

COURSE DESCRIPTION

- •Emergence of microelectronic process engineering as a new discipline.
- •Introduces the students already involved in the microelectronics industry with no prior experience to the fabrication of solid-state devices and integrated circuits.
- •Introduction to the basics of semiconductor materials, layouts, and unit processes common to all IC technologies such as substrate preparation, oxidation, diffusion, ion implantation and metallization.
- •Focus on basic silicon processing and applications of these processes in modern IC technologies.
- •The students will be introduced to process modeling using simulation software tools and basic lab experiments.

MICROELECTRONICS PROCESS ENGINEERING

COURSE OBJECTIVES

The goal of this course is to provide the basic information necessary to prepare people already involved in the microelectronics industry with no prior experience for advanced microelectronic processing and manufacturing. The students will be made familiar with the interaction between material properties, standard processing for the microelectronics industry, process design and device layout

MICROELECTRONICS PROCESS ENGINEERING

COURSE TEXT

Introduction to Microelectronic Fabrication, II Edition.
Vol. V of Modular Series on Solid State Devices, by
Richard C. Jaeger, Prentice Hall, 2002.
(ISBN 0-201-44494-1)

MICROELECTRONICS PROCESS ENGINEERING

REFERENCES

•Microchip Manufacturing, Stanley Wolf, Lattice Press, 2004.
•Silicon VLSI Technology, Fundamentals, Practice and Modeling by J D Plummer, Deal M D, and P B Griffin, Prentice Hall, 2000.
•Silicon Processing for the VLSI Era, Vol. I, Process Technology, II Ed. by S. Wolf and R.N. Tauber, Lattice Press, 2000.
•The Science and Engineering of Microelectronic Fabrication, II Ed., by Stephan Campbell, Oxford University Press, 2001.
•Semiconductor Manufacturing Technology, by Michael Quirk and Julian Serda, Prentice Hall, 2001.

COURSE OUTLINE

- Module 1: Introduction and Overview.
- Module 2: Semiconductor Substrate.
- Module 3: Wafer Preparation.
- Module 4: Thermal Oxidation of Silicon.
- Module 5: Oxidation, Contd.
- Module 6: Diffusion.
- Module 7: Diffusion, Contd.
- Module 8: Ion Implantation
- Module 9: Introduction to Metallization
- Module 10: Device Layout, Mask Fabrication and Pattern Transfer

COURSE EVALUATION

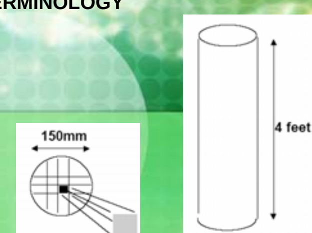
Assignments:	25 %
Final Project	15 %
Mid-Term Exam	30 %
Final Exam	30 %

OUTLINE

- Terminology
- History of the Semiconductor Industry
- Worldwide Semiconductor Industry
- New Technology
- Semiconductor Manufacturing
- What New in Microchips

TERMINOLOGY

- SILICON
- GERMANIUM
- GALLIUM ARSENIDE
- SINGLE CRYSTAL
- SEMICONDUCTORS
- WAFER
- N-TYPE
- P-TYPE
- TRANSISTOR
- INTEGRATED CIRCUIT



TERMINOLOGY

Pure silicon has only 1 / 1,000,000,000 atoms of impurity (25 crabapple trees in a forest covering entire U.S. with trees every 50 ft.

n-type or p-type silicon has impurities intentionally introduced at the level of 1 / 1,000,000 atoms (thus 99.9999% pure!!)

TERMINOLOGY

- **mil = 1 / 1000 inch = 25.4 µm**
- **micrometer = 1 / 1,000,000 meter**
- **nanometer = 1 / 1,000,000,000 meter**
- **Angstrom (Å) = 1 / 10,000,000,000 meter**
- **A hair is 100 micrometers**
- **A 1 micron wide line on a 4 inch diameter silicon wafer is the same scale as a 100 foot wide road**

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HISTORY OF THE SEMICONDUCTOR INDUSTRY

- •1942 Very Pure Silicon and Germanium
- •1947 pn Junction Diodes Invented
- •1947 The Junction Transistor is Invented at Bell Labs by Bardeen, Brattain andSchockley
- •1950 Single Crystal by Teal and Little at Bell Labs
- •1954 Texas Instruments Introduces Commercial Production of the Transistor
- •1958IntegratedCircuits Invented by Kilby at TI
- •1960 First Planer Integrated Circuits Invented byNoyce at Farichild Co.
- •1962 First Commercial Integrated Circuits

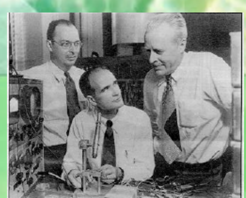
MICROELECTRONICS PROCESS ENGINEERING

HISTORY OF THE SEMICONDUCTOR INDUSTRY

- •1962 - Transistor-Transistor Logic invented
- •1962 - Semiconductor Ind. surpasses $1-billion in sales
- •1963 - First MOS IC
- •1963 - CMOS invented
- •1971 - Microprocessor invented
- •1978 - Semiconductor Industry passes $10-billion.
- •1985 - Intel 80386DX
- •1985 - 200mm silicon wafers introduced
- •1986 - 1Mbit DRAM
- •1988 - 4Mbit DRAM
- •1989 - Intel 80486DXTM
- •1990's-2000's Intel Pentium Series

MICROELECTRONICS PROCESS ENGINEERING

The world's first transistor, built at Bell Labs in December, 1947.



Transistor inventors (from left), Dr. Walter Brattain, Dr. William Shockley, and Dr. John Bardeen.

MICROELECTRONICS PROCESS ENGINEERING

2006	2005	Company	Country	Market	
1	2	Exxon Mobil	US	371,631.30	Oil & gas producers
2	1	General Electric	US	362,526.60	General industrials
3	3	Microsoft	US	281,170.80	Software &computer services
4	4	Citigroup	US	238,935.30	Banks
5	5	BP	UK	233,259.80	Oil & gas producers
6	10	Bank of America	US	211,706.30	Banks
7	7	Royal Dutch Shell	UK	211,279.70	Oil & gas producers
8	6	Wal-Mart Stores	US	196,859.90	General retailers
9	18	Toyota Motor	Japan	196,730.80	Automobiles & parts
10	58	Gazprom	Russia	196,338.50	Oil & gas producers
11	11	HSBC	UK	190,316.10	Banks
12	21	Procter & Gamble	US	189,551.20	Household goods

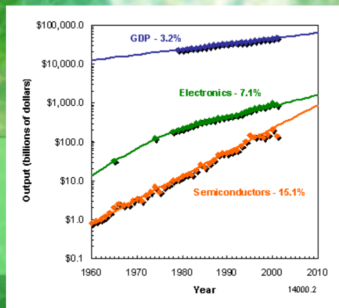
MICROELECTRONICS PROCESS ENGINEERING

2006	2005	Company	Country	Market	
13	9	Pfizer	US	183,359.80	Pharmaceuticals & biotechnology
14	8	Johnson & Johnson	US	176,242.60	Pharmaceuticals & biotechnology
15	22	Saudi Basic Industries	S.Arabia	175,665.90	General industrials
16	16	American IntGro	US	171,634.80	Nonlife insurance
17	14	Total	France	162,792.00	Oil & gas producers
18	82	Mitsubishi UFJ Fin.	Japan	156,336.10	Banks
19	19	GlaxoSmithKline	UK	151,854.90	Pharmaceuticals & biotechnology
20	17	Altria	US	147,881.30	Tobacco
21	23	Novartis	Switzerland	146,023.90	Pharmaceuticals & biotechnology
22	25	JP Morgan Chase	US	145,138.40	Banks
23	20	Berkshire Hathaway	US	139,247.10	Nonlife insurance
24	27	Cisco Systems	US	133,282.60	Technology hardware & equipment
25	34	Roche	Switzerland	130,551.20	Pharmaceuticals & biotechnology
26	13	IBM	US	129,256.20	Software & computer services

MICROELECTRONICS PROCESS ENGINEERING

R	Company
1	Intel
2	Texas Instruments
3	Sanmina-SCI
4	Solectron
5	Jabil Circuit
6	Applied Materials
7	Advanced Micro Devices
8	Freescale Semiconductor
9	Micron Technology
10	Broadcom

MICROELECTRONICS PROCESS ENGINEERING



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July 6, 2006
38% of Global Electronics Output Now Produced in Asia Pacific
May 24, 2006
FPGA Market Will Reach $2.75 Billion by Decade's End
May 22, 2006
MEMS in Mobile Handsets Will Top $1 Billion by 2010
May 8, 2006
China Will Be Largest IC-Consuming Country by 2010

MICROELECTRONICS PROCESS ENGINEERING

EXTERNAL FACTORS

TARIFFS, TRADE AGREEMENTS
TAXES, GOVERNMENT INCENTIVES
RESTRICTIONS/CONTROL/GOVERNMENT REPORTING
CAPITAL AVAILABILITY AND COST
ENVIRONMENTAL CONCERNS
WORKFORCE, EDUCATION

MICROELECTRONICS PROCESS ENGINEERING

YEAR	PROCESSOR	SIZE (uM)	# DEVICES	SPEED
1985	INTEL 386	2.0	229K	16MHz
1989	486	1.2	1.2M	25MHz
1993	PENTIUM	0.8	3.3M	60MHz
1996	PENTIUM PRO	0.6	5.5M	200+MHz
2006	?	<0.1	>80 M	>?GHz
1993	DEC ALPHA	0.75	1.68M	200MHz
1996	ALPHA-6	0.35	> 10M	> 450MHz

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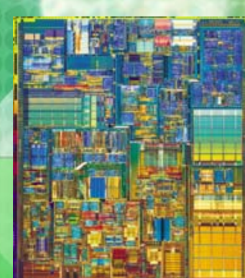
INTEL 386 - 229,000 TRANSISTORS 1985

INTEL 486 - 1.2 MILLION TRANSISTORS 1989

MICROELECTRONICS PROCESS ENGINEERING



INTEL Pentium 4 – 42 Million TRANSISTORS 2001

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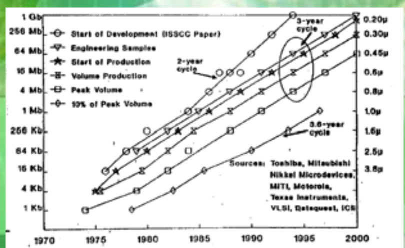
DRAM DEVELOPMENT/PRODUCTION



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ITRS International Technology Roadmap for Semiconductors

MICROELECTRONICS PROCESS ENGINEERING

TECHNOLOGY CHALLENGES

•TRANSISTOR DIMENSIONS ARE GETTING REALLY SMALL
•A 0.15 MICRON TRANSISTOR IS ONLY 1500 ATOMS LONG!!!
•A 20 ANGSTROM THICK GATE OXIDE IS ONLY 4 MOLECULES THICK!!!

MICROELECTRONICS PROCESS ENGINEERING

INTEGRATED CIRCUIT MANUFACTURING

A variety of sequential steps which results in hundreds of thousands of transistors being made at the same time on each chip

Steps are:
•Deposition - cvd, lpcvc,pvd
•Surface altering - diffusion, oxidation, ion implantation
•Photolithography - g-line, i-line, excimer laser, x-ray
•Etching - wet chemical etching, plasma etching, rie
•Cleaning - rca, modified rca

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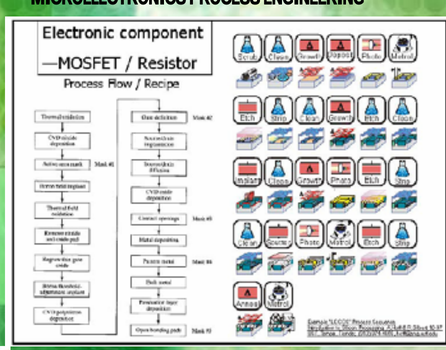

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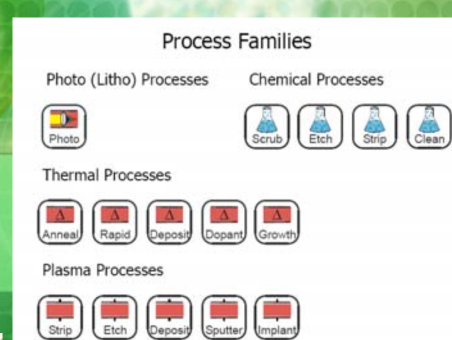
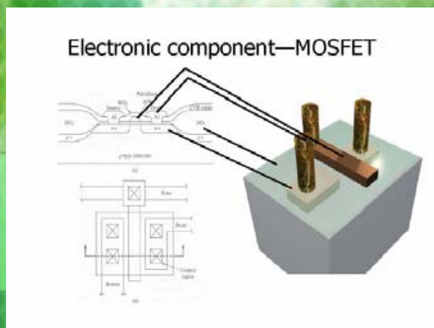
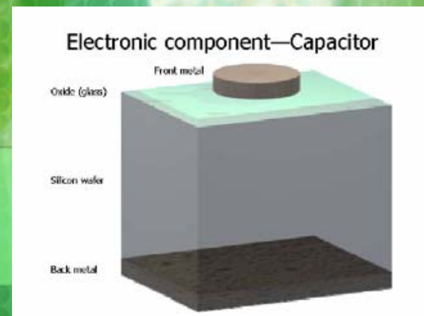
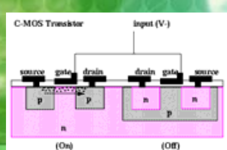
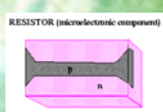
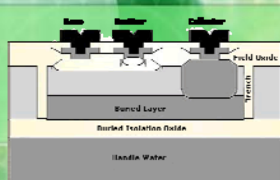










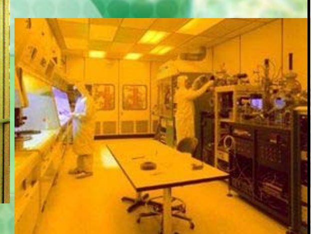


WAFERS 12 AND 16 INCH IN DIAMETER

CLEAN ROOM TECHNOLOGY

- CLASS 100 HAS LESS THAN 100 PARTICLES OF SIZE GREATER THAN 1/2 MICROMETER PER CUBIC FOOT OF AIR
- CLASS 10 CLEANER
- CLASS 1 CLEANEST
- PEOPLE ARE DIRTY:
- PEOPLE GIVE OFF 200,000 PARTICLES PER MIN.
- THE WHITE SUIT REDUCES THIS TO 10,000 PER MIN.

CLEAN ROOM TECHNOLOGY



MICROELECTRONICS PROCESS ENGINEERING

MICRO MACHINES AND SENSORS (MEMS)

NEW MEMS COMBINE TINY MOVING MECHANICAL PARTS AND ELECTRONICS

ON A SINGLE MICROCHIP LIKE THE CHIP IN YOUR CAR THAT FIRES OFF THE AIR BAG

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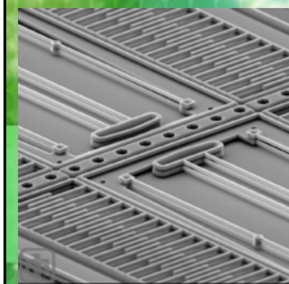

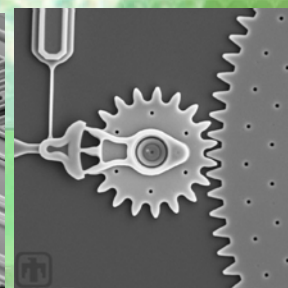

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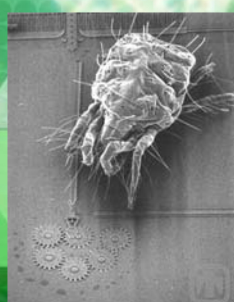

MICROELECTRONICS PROCESS ENGINEERING

SAFETY

- Acids. Corrosives Bases. Organic and inorganic solvents and carcinogenics.
- Toxic gases
- Safety training needed.
- Serious health damage (Burns,eye damage..etc)
- Special protection equipment
- NAWA
- HF, Silane

MICROELECTRONICS PROCESS ENGINEERING

Homework

Chapter 1 Introduction to Microelectronic Fabrication, II Edition.Vol. V of Modular Series on Solid State Devices, by Richard C. Jaeger.
1.1, 1.2, 1.5, 1.7, 1.10, 1.12, 1.15