Introduction to Microelectronic Fabrication Processes - Web course

NPTEL

http://nptel.iitm.ac.in

Chemical Engineering

COURSE OUTLINE

This is intended to be an introductory course for semiconductor chip fabrication processes.

The target audience is undergraduate chemical engineering and electronics and communication engineering students.

The focus will be on the various modules (equivalent to unit operations in traditional chemical engineering) relevant for chip manufacturing.

The course will start with an overview of the manufacturing process.

Bulk of the course will deal with understanding the individual processes and the tools used.

An overview of the MOS transistor structure and operation will be given so that the sequence of processes needed to create the transistor can be viewed from that perspective.

The issues relevant for the industry such as process integration, testing and yield will be covered at the later stages of the course.

The analytical tools used in the semiconductor industry are different compared to the typical tools used in chemical industry.

Hence a brief overview of the relevant analytical tools and techniques will also be given.

Course contents:

Overview, Lithography, Deposition techniques (physical vapor deposition, chemical vapor deposition, electrochemical deposition and spin on coating).

Removal methods (wet etching, dry etching, chemical mechanical planarization), front end of line (FEOL) basics, transistor structure and operation.

Material modification methods (diffusion, ion implantation, oxidation), process integration, testing and yield, relevant tools and techniques.

Additional Reading:

1. ULSI Technology, by C.Y. Chang and S.M. Sze, McGraw Hill, 1996.

Hyperlinks:

www.semiconductor.net

Coordinators:

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COURSE DETAIL

S.No	Topics	No. of Hours
1	**Introduction:** overview of Chip Manufacturing Process, FEOL and BEOL concepts.	1
2	**PhotoLithography:** 1. Lithography basics, layout, hierarchy vs flat file, levels and layers in layout file. 2. Mask making with e-beam, alignment and test structures in masks.	2

3	**Lithography details:** 1. Projection printing, dark field mask, positive resist and its advantages. 2. Process details including resist coating, pre-exposure bake, exposure, soft bake, developing and hard bake. 3. Stepper vs scanner.	2
4	Advanced Lithography; Resolution, numerical aperture, optical proximity correction (OPC), anti reflective coating (ARC), phase shift mask (PSM).	2
5	**Production issues:** Depth of focus, focus exposure matrix, misalignment, partial field vs full field, next generation litho (Extreme UV, XRay).	2
6	Physical Vapor Deposition (PVD) basics, equipment description and operation details, RF/magnetron sputtering, long throw, ionized metal plasma (IMP) sputtering, collimated beam, sputtering yield.	2
7	Chemical vapor deposition (CVD) basics, Atmospheric pressure (APCVD), low pressure (LPCVD), plasma enhanced (PECVD), mass transfer control and reaction kinetics control. Reactor description and operation, deposition of silicon, poly silicon, oxide, nitride and tungsten, brief introduction to atomic layer deposition (ALD) and molecular beam epitaxy (MBE).	2
8	Electrochemical deposition, Electro-migration vs grain size, conformal, anti conformal and super fill. Suppressor, accelerator, levelers, effect of seed layer, spin on coating.	2
9	**Wet etching:** 1. Isotropic etch, selectivity, anisotropic Si etch in KOH, cleaning, micro loading and process proximity correction (ppc). 2. Chemicals for oxide and nitride removal, effect of dopants, photoresist development.	2
10	**Dry etching :** 1. Plasma, anisotropic etch, equipment details and operation. 2. Reactive ion etching (RIE), veil formation and de-veil, electrostatic discharge (ESD), aluminum etch.	2
11	Chemical Mechanical planarization (CMP) basics, Dishing, Erosion, Issues in Shallow Trench Isolation. Oxide Polish and Copper Polish, Dummy fill, slotting.	2

12	**FEOL:** Semiconductor electron band structure, band gap MOS capacitor, MOS transistor structure for enhancement mode devices.	2
13	**MOS transistor operation:** I-V curve, pinch off, hot carrier effect, lightly doped drain (LDD), scaling.	2
14	**Diffusion :** Junction depth, Concentration profile, interstitial and substitutional diffusion. Constant source and limited source diffusion, dopant redistribution, Lateral diffusion, Rapid thermal annealing, Gettering.	2
15	**Ion implantation :** Detailed Equipment description, ion source, analyzer, accelerator, scanning, target chamber, elastic and inelastic collisions, transverse straggle, channeling and methods to prevent channeling.	2
16	**Oxidation:** 1. Native oxide, Wet and dry oxidation, Electro-chemical oxidation, solubility and diffusion of various species in oxide. 2. Deal-Grove model, exponential growth regime, Effect of doping.	2
17	**Process Integration:** BEOL Issues, Cu vs Al metallization, oxide vs low-k integration.	3
18	**Testing:** Scribe line Test (for process evaluation), Functional Test (for product evaluation), Optical testing (KLA).	2
19	Yield Models, process and design modifications for yield optimization.	2
20	**Tools and Techniques:** SEM, FIB, AFM, Ellipsometry.	2
	Total	40

References:

1. The Science and Engineering of Microelectronic Fabrication (2nd Edition) by S.A. Campbell, Oxford University Press, 2001.

2. Introduction to Microelectronic Fabrication, Vol. 5 of Modular Series on

Solid State Devices (2nd Edition) by Richard C. Jaeger, Prentice Hall, 2001.

3. Microchip Fabrication: (5th Edition) by Peter Van Zant, McGraw Hill, 2004.