Microelectronics:

This course covers all major microfabrication processes: General overview of the microfabrication technology. The structures of crystals and the silicon crystal, defects in crystals, fabrication processes of silicon crystals (CZ, FZ). Ion implantation. Diffusion. Thin layers: Evaporation, sputtering, CVD, PECVD, oxidation. Etching processes: Wet etching, dry etching (physical, chemical, RIE, DRIE). Photolithography. Conducting coatings. Electrical contacts and packaging: Wire bonding, flip-chip, wafer scale packaging. Overview of the Bipolar and CMOS technology in light of the subjects studied. Overview of MEMS in light of the subjects studies. Yield and reliability of the VLSI technology. Basic CAD for VLSI.

The course content topics/keywords:

1. Lithography
2. Ion implantation
3. Diffusion
4. Oxidation
5. Chemical vapor deposition
6. Atomic layer deposition
7. Wet and dry oxidation
8. Metallization

Each lecture will start with basic principles, modeling, and continues with manufacturing, tools and methods and finally with metrology need and challenges, metrology tools and methods.

Advanced Electronic:

Introduction: review of basic modeling principles, ambipolar continuity equation, Poisson's equation, the concept of minority carrier life time, effect of doping and contamination, recombination near surfaces, surface recombination velocity, effective life time. Diodes. Diodes: - modeling – Large signal, small signal, noise model, applications to SPICE. Leakage currents, Shockley Read Hall Model, generation recombination current in space charge layers. Test cases – a) examples of planar junctions, b) the relation between process parameters to actual device parameters.
Bipolar device structures: Review PNP and NPN processes, parasitic transistors, steady state solution, Ebbers Moll model, modeling of leakage currents under short, open and loaded conditions. Second order effects and Gummel-Poon model, high injection and current crowding effect, substrate series resistance effects. Leakage currants in BJT- definitions, BJTs as diodes. Applications for analog circuits – i.e. logarithmic amplifiers, switches. Bipolar devices: Small signal models and applications to SPICE- equivalent circuits, small signal

models, physical models and parametric models, S parameters, critical figure of Merits like ft, gain, GBW product, miller effect. Noise models. Bipolar device high speed switching, examples of special bipolar VLSI circuits – i.e. I2L. Test cases – a. parasitic CMOS bipolar transistors models. B. Low noise BJT structure; The field effect: basic analytical solution (Bare Si and Si with oxide), surface states effect, MOS capacitor - static model, dynamic model (deep depletion). Example – CCD and CID devices.
The field effect – trapping and contamination effects, applications of the Schocley Read Hall model on capacitor transient analysis, the concept of surface recombination velocity, the effect of the surface potential.. MOS capacitor – non-uniform doping effect, effect of ion-implantation on threshold voltage, surface and periphery effects, multi-layer gate insulator (ONO). Gate controlled diode - surface effects, long-channel MOS transistor model, threshold voltage, the transition from the linear regime to saturation, modeling at saturation, sub-threshold modeling. Surface effects on the leakage current of diodes. Short channel MOS models- DIBL, punch-through, Advanced MOS structures- LDD, HALO, CMOS; MOS transistor – Small signal models, noise models, applications to SPICE. Test cases – a 90 nm CMOS inverter nodeling. ULSI MOS structures - CMOS, new structures - strained Si MOS, SiGe HBTs; ULSI MOS structures - case studies

The course content will be as follows:

1. Introduction electronic devices - provides the basic concepts and terminology for understanding semiconductors;
2. pn junction - PN junction junction are analyzed in the forward bias and reverse-bias conditions. Of particular importance are the concepts of the depletion region and minority carrier injection;
3. Carrier generation and recombination in the depletion region - Shockley Read Hall model;
4. MOS capacitor and Nonideal MOS capacitor - The key topics are the concepts of surface depletion, threshold, and inversion; MOS capacitor C–V; gate depletion; inversion-layer thickness;
5. MOS transistor - It covers the topics of surface mobility, body effect, a simple IV theory, and a more complete theory applicable to both long- and short-channel MOSFETs.
6. Modern FET structure – Small dimension effects and SOI structure; Special emphasis is placed on the understanding of the opportunities for future MOSFET scaling including mobility enhancement, SOI, multigate MOSFET, metal source/drain, etc

1. Hot electrons