Advanced optoelectronic instrumentation & materials

This course aims to provide an insight on recent advances in optoelectronic instrumentation and semiconducting materials applied to optoelectronics. The course covers the key aspects of developing micro/nano optoelectronic devices, including design, fabrication, characterization and popular applications. The content will follow the ultimate research trends and industrial developments worldwide, with emphasizes on organic photodetectors, graphene-based devices and high-performance optoelectronic architectures employing perovskite or other advanced oxides.

Main topics:

1) Overview of micro/nanooptical detection
2) Organic semiconductors (small organic molecules, large conjugated polymers, fullerene molecules, blend interpenetrating networks)
3) Optoelectronic device architectures (photodiodes, phototransistors, optical sensor arrays, waveguides, light-emitting devices, advanced electrodes, lens, mirrors, etc.)
4) Emerging 2D materials and advanced oxides (graphene, molybdenum disulfide, perovskite, etc.)
5) Nanofabrication technologies (spin-coating, spray coating, inkjet printing, chemical vapour deposition, thermal evaporation), optoelectronic characterization (principles of photo-responsivity, specific detectivity, photo-conduction gain, etc.) and main applications (examples in the fields of communications, solar-energy harvesting, biosensors, etc.)

Top-Down ASIC Design Flow

The aim of the course is to give a general and complete overview on the standardized design process involving ASIC design. The course should follow the Gajski-Kuhn chart (or Y diagram), designing a simple and complete system in all the aspects, for example a synchronous counter, from the system specifications (functional and non-functional requirements) to the floorplan. The course should give code examples (System C, Verilog, TCL, Spice…), design validation examples (RTL simulations, dc-shell pt-shell outputs, Spice waveform), and visual implementation of the design in all the layers.

Topics

1) Gajski-Kuhn chart
2) ASIC system specifications
3) C to HDL conversion (behavioural vs structural description; pipeline, parallel architectures…)
4) HDL to netlist (multiple Vth or multiple cell sizes; area/power/time trade-off…)
5) Floorplan (place and route, electromigration, heating, skin effect, cross-talk…)

Transportation in Micro and Nano Systems

This course covers the details of transport mechanisms in micro and nano scale, with consideration of photons, electrons, phonons, and molecules as energy carriers. This course addresses both the fundamentals of micro/nano scale transports of heat, mass, momentum and species as well as the applications of these to specific areas like electronic cooling, thermal management of electronic system, micromanipulation of droplet/bubble in MEMS and NEMS, microfluidic devices for assay and clinics, etc.

Main topics:

1. Introduction to transport phenomena in micro and nanoscale
2. Fundamentals of kinematics and scaling laws
3. Wave/Particle description of transport processes
4. Species and charge transport
5. Particle and droplet actuation
6. Multiscale modelling of liquid flow and particle-based methods, such as Lattice Boltzmann Method (LBM) and Molecular Dynamics (MD) method