Scuola di Dottorato in Fisica Applicata "Galileo Galilei" - Pisa
Corso di Tecniche Sperimentali - a.a. 2004/5
Topics in Nanotechnology – F. Fuso

Foreword. Aim of the lectures is to provide an overview of some recent trends in nanotechnology. Selected topics will be addressed from the point of applied physics. Starting from discussion of state-of-the art fabrication techniques and device architecture, physical limitations in miniaturization and alternative approaches will be pointed out. New functionalities related to quantum confinement and single-electron operations will be addressed. Tools for material and nanostructure investigations at the atom level will be discussed.
Lectures are organized in a series of two-hour seminars, including discussion, with the following schedule.

1. **Filling the gap between micro- and nanotechnology.** Wed April 6, 16-18, room S1.
Introduction: definitions and components of nanotechnology. The wide world of nanotechnology and its major driving forces: trends and problems. A short overview of microelectronics: a few words on field effect devices (mosfet, dram) and charge transport in bulk and thin film heterostructures.

2. **Deposition of thin films and heteroepitaxy.** Mon April 11, 16-18, room T1.
Planar technology: overview of physical methods for thin film deposition. Molecular Beam Epitaxy: surface and interface phenomena, diffusion, coalescence, growth. Self-assembly in the inorganic and organic world. Novel materials for sub-100 nm devices.

3. **The top-down approach.** Mon April 18, 16-18, room T1.
Patterning and lateral definition of structures. Optical and x-ray lithography: resists and masks. Diffraction limits: sources and strategies to improve the space resolution, phase-shifting masks. A concise overview of alternative lithographies: electron lithography, FIB and SCALPEL, atom lithography, nanoimprint.

4. **Quantum confinement and electron transport.** Mon May 2, 16-18, room T1.
Density of states in low-dimensional systems, basics of quantum confinement. Landau levels and Quantum Hall Effect: quantum of resistance. 1D quantum gases: Landauer levels. Diffusive vs ballistic transport: electron waveguides. A concise overview of practical realizations, including quantum wires, nanotubes and organics.

5. **Coulomb blockade and single electron nanodevices.** Mon May 9, 16-18, room T1.
Nanosized capacitors: discrete charge vs continuous potential. Physical conditions for the occurrence of Coulomb oscillations and staircase. Charge tunneling between nano-objects: resonant tunneling. Three-wire devices: single electron transistors and memory cells.

6. **Tools for nanometer scale investigations.** Wed May 11, 16-18, room S1.
Basics of scanning probe microscopy: concepts and experimental setups. Scanning Tunneling Microscopy: operating modes, spectroscopy. Artifacts and derivation of genuine data. Overview of SPM techniques (featuring AFM, LFM, SNOM). Bottoms-up techniques of single atom manipulation by scanning methods.

Further information will be posted at http://www.df.unipi.it/~fuso/dida