EPFL

PHYS-627

Magnetic and semiconducting nanostructures

Butté Raphaël, Rusponi Stefano

Cursus	Sem.	Type
Photonics		Obl.
Physics		Obl.

Language of teaching	English
Credits	3
Session	
Exam	Oral
Workload	90h
Hours	**42**
Courses	28
Exercises	14
Number of positions	

Frequency

Every 2 years

Remark

Every 2 years / Next time: Spring 2020

Summary

Introduce students to the magnetic and electronic properties of nanostructures

Content

1) Epitaxial growth of metallic 2D nanostructures (2h):
   1. Cluster nucleation and aggregation: the importance of kinetics
   2. Controlling shape and composition of 2D clusters grown by self assembly methods

2) Magnetism at the nanoscale (4h):
   1. Orbital and spin magnetic moment: from single atoms to 3D clusters
   2. Surface supported nanostructures: the effect of the supporting substrate on the cluster magnetic properties
   3. Superparamagnetic limit in magnetic data storage

3) Electronics *vs.* spintronics (8h):
   1. 2D electron gas at heterogeneous semiconductor interfaces
   2. Single electron transistor
   3. A new 2D material: the electronic properties of graphene
   4. Spin transport: spin valve, GMR and TMR
   5. Observing the magnetism of a single atom with Scanning tunnelling microscope

4) III-V quantum heterostructures and their optical properties (6h)
   1. Introduction; quantization phenomena in two-dimensional (2D) heterostructures: quantum well (QW) energy levels, excitons in QWs
   2. Tunneling structures (superlattices), optical matrix elements, notion of oscillator strength, optical selection rules, pseudo-smooth quantum wells, excitonic and biexcitonic features in GaAs/AlGaAs QWs
   3. Transverse and longitudinal Stark effect, physics of wurtzite QWs (spontaneous and piezoelectric polarizations), giant built-in field and quantum confined Stark effect, excitonic and biexcitonic features in GaN/AlGaN QWs

5) Electronic Properties of quantum dots (2h)
   1. Introduction to epitaxial semiconductor quantum dots (QDs), analogy with the atomic case, dipole moment (Stark effect), case of multiexcitonic complexes, single QDs as efficient single photon emitters, dephasing time in QDs, temperature-dependent excitonic linewidth (from 3D to 0D)

6) Light-matter interaction in III-V photonic structures (2h)
   1. Bragg mirrors, microcavity effect, photonic crystal slabs, enhanced spontaneous emission in the weak coupling regime: Purcell effect, strong coupling regime with single QDs

7) Physics of semiconductor laser diodes (4h)
   1. Electrical injection in laser diodes (LDs), stimulated emission, material gain, optical feedback, laser oscillations, edge emitting laser diodes, output power
   2. Beam spatial distribution, DFB laser diodes, temporal behavior of QW-LDs, high-beta nanolasers

Learning Prerequisites

Recommended courses

Basic condensed matter physics and quantum physics