UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Surfaces and Interfaces

1819-1-F5302Q012

Aims

The course has two targets: on the one hand, to complete the knowledge acquired during the courses of Solid State Physics, answering the fundamental question: what happens to the properties of a perfect and infinite solid when the lattice periodicity ends at a surface? On the other hand, it is intended to provide the basis for all applications of Semiconductor Physics, Physics of Electronic Devices and Nanotechnologies, inevitably involving surfaces, interfaces and epitaxial depositions. The approach is both theoretical and experimental.

Contents

Free Surfaces (3 CFU): Vacuum technology; Chemical, structural, and morphological characterization of surfaces; Electronic states and reconstructions at metal and semiconductor surfaces; Pinning of the Fermi level by surface/interface states; Vibrational states at surfaces;

Interfaces (1 CFU): Structural issues at interfaces and extended defects; The metal-semiconductor junction; The semiconductor-semiconductor heterojunction; The Silicon-Silicon Oxide interface;

Absorption, Diffusion and Desorption (1 CFU): Physisorption; Chemisorption; Surface diffusion; Desorption; Kinetic issues occurring at deposition/etching; Thermodynamics of surfaces and Wulff construction;

Epitaxial Growth (1 CFU): Capillarity model of epitaxial growth; Technologies for the epitaxial growth and selected area deposition; Growth of thin films and misfit defects; Nucleation and growth of epitaxial quantum dots; Growth of axial and radial nanowires.

Detailed program

Introduction to FdS, UHV and surface preparation

Methods of chemical and physical analysis of surface contamination

Direct and reciprocal 2D lattices, surface reconstructions

Diffraction of electrons from surfaces, LEED, analysis of the patterns

Structural analyzes for ion scattering

Structural analysis for scanning probes: STM, (SEM outline)

Electrons to metal surfaces and alterations with alternating signs

Electronic states of surfaces in the Nearly Free Electron 1D model and Schokley state s

Recalls of the Tight Binding sp3 method to first neighbors

Linear chain TB and Tamm surface states

The development in moments of the Local Density of States at the sup.

Surface and bulk surface projection

Photoemission resolved in angle and dispersion bands: ARUPS

Measurement of surface electronic states in metals

Surface electronic states and silicon reconstructions

Pinning of the Fermi level from surface states

Surface electronic states in III-V and polar

Amplitude of vibration at the surface and surface melting

Rayleigh waves at the surface in the continuous elastic pattern

Surface phonons in the 1D model of the linear chain

Extension to 3D and projection on the surface plane; slab calculation technique

Experimental determination of the phononic dispersion

Examples of realistic phononic dispersions in alkaline halides, metals and semiconduc tors

Structure of the interfaces and theory of misfit dislocations, with references to the theory of continuous elasticity

Calculation and measurement of the critical thickness of a film for plastic relaxatio n from dislocations

Recalls of space-charge layers to semiconductor surfaces

Introduction to the alignment of the bands to the interfaces: MIGS

Alignment of bands and their measurement in semiconductors: VIGS

Thermodynamics: surface energy and surface tension

Thermodynamics: Wulff diagram and anisotropies in ?

Physisorption theory with some examples

Chemisorption theory with some examples

Kinetics of adsorption processes

Kinetics of the diffusion of atoms and molecules at the surface

Desorption kinetics, Langimur isotherm; 2-phase phase transitions

Surface thermodynamics and Wulff construction

Introduction to the kinetics of epitaxy

Introduction to the Molecular beam Epitaxy growth technique

The 3 forms of epitaxial growth and the model of capillarity

Epitaxial growth of quantum dots Ge / Si: introduction

Epitaxial growth of quantum dots Ge / Si: nucleation and growth models

Epitaxial growth of nanowires: introduction

Epitaxial growth of nanowires: axial structures and radial structures

Prerequisites

Advanced Course in Solid State Physics

Teaching form

Lessons

Textbook and teaching resource

MAIN TEXT
H. Luth, Solid Surfaces.., Sixth Edition, Springer 2015;

ADDITIONAL TEXTS

Zangwill, Physics at Surfaces, Cambridge 1990;

J.E. Ayres, Heteroepitaxy of Sem., CRC Press, 2007;

Prutton, Introd. to Surface P., Oxford UP 1994;

J.A. Venables, Introd. to Surface.., Cambridge 2000;

J.B. Hudson Surface Science, Wiley IP 1998.

Semester

Second semester

Assessment method

Oral examination, consisting in two, or three questions on different parts of the course, where the illustration of the topic is requested to be accompanied by sketches, equations or numerical data, depending on the case. The final mark is given di a numerical scale, from 18 to 30 cum laude.

Office hours

by appointment after e-mail request at leo.miglio@unimib.it. Usually on Monday, Wednesday and Friday.