UNIVERSITY OF CHEMICAL TECHNOLOGY AND METALLURGY

CENTRE OF MATERIALS SCIENCE

MATERIALS SCIENCE ENGINEERS

Master degree course

Educational programme

Discipline (Optional Group B):

NANOMATERIALS AND NANOSTRUCTURES

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I. Discipline (Optional Group B):

NANOMATERIALS AND NANOSTRUCTURES

	SEMESTER	Hours
1. Lectures	**III**	**20**
2. Laboratory	**III**	**10**
3. Grading Policy	**Current control**	
4. Credits	**2**	

II. Introduction

The term nanosructured materials (Nanomaterials) refers to materials heaving a characteristic length scale in the lower nanometer range (at least one dimension in the nanometer) that influences their physical and chemical properties. They can be metals, ceramics, semiconductor or polymers containing single or multiple crystalline or amorphous phases. Nanotechnology is the ability to understand, control and manipulate matter at the level of individual atoms and molecules as well as at the supra molecular level involving clusters. The goal is to create materials devices and systems with essentially new properties and functions. The teaching goals of this course is to familiarize students with basic principles governing the nano-systems, their synthesis properties, structures and applications. It is very important to control the size and the composition of nano-clusters and to modified the interfaces and distributions of nano-components within the fully formed materials. The lectures consider the problems associated with different methods for synthesis of nano-structures and how to stabilize the physical parameters of the particles Low temperature synthetic methods are thought to be especially promising because they permit easy formation of various nano-particles with reproducible properties. An information is presented for some important realized applications in nanoelectromcs, information technologies, nanooptoelectronics, energy and hydrogen storage, chemicals, catalysts, biological, medical, ceramics, immobilizations. New directions and opportunity for engineering design and manufacturing of passive or active, nanostructures and heterogeneous nanosystems are discussed. The practicum is connected with the preparation of the nanomaterials with special optical magnetical and electrical properties using precipitation method, sol-gel technology and nanocrustallization in bulk materials.

II. Lecture subjects and schedules

1. Introduction to Nanoscience and nanotechnology. The characterization of nanoparticles and nanosrctures. Classifications. Geometric (crystallographic) and electronic structure. Investigative tools: experimental methods and modeling. 1 h

2. Strategies for synthesis of nanostructured materials. Variety of methods. The bottom up approach - creation of nanostructured building blocs. Top-down approach - from bulk to nanoparticles. 1 h

3. Formation of nanoparticles from supersaturated vapors. Evaporation condensations methods: PVD (physical vapor Deposition), CVD (Chemical vapor Deposition). Spray pyrolisys of metal salt solutions. Arc discharge heating, laser and electron beam heating, spark and microwave plasma processing. 2 **h**

4. Nanostructured materials prepared by solid state processing. High energy ball milling, mechanical attrition. 1 h

5. Nanomaterials prepared by supercritical fluids. Physical and chemical processes. Supercritical freeze drying. Water in oil micro emulsions. Inverse micelle structures. 1 h

6. Coprecipitation. Nitrate salt solutions, hydroxides oxalates, hydroxide-carbonates. Colloidal synthesis of nanoclusters. Reduction of metal salts solution with borohydride agent. Sonochemical treatment. 2 **h**

7. Sol-gel processing. Selection of the precursors, hybrid structures nanocomposites. Features of biogenic fabrications. Self-assembly and self-organization of 2D and 3D- structures. Encapsulation of organic and biomoleculs (enzymes, proteins). 2 **h**

8. Nanocrystalline powder consolidation methods. Nanoparticles aggregates (chains, wires), nanometer fibers and tubes. Coatings - manufacturing of small

functional systems. Nanoporous and high surface area materials. Full densification of nanopowdwrs, sintering mechanisms, gram growths. 2 h

9. Size effects, surface and interface effects. The evolution, optical magnetic and electrical properties with increasing size of the particles, Colomb blockage, single domain, superparamagnetism, surface plasmons. Properties of bulk nanostructured materials: mechanical (hardness, strength, ductility, toughens) and ferromagnetic (permeability, magnetic flux density). 4 h

10. Applications, functional nanoscale devises. Nanoelectronics, information technologies, nanooptoelectronics, energy and hydrogen storage, chemicals, catalysts, biological, medical, ceramics, immobilizations. **4 h**

III. Laboratory Practice and Seminars

1. Synthesis of colloidal Au-nanoparticles in silica matrix. Determination of the size effects on the optical properties. 4 h

2 Precipitation of mono domain ferrite nanoparticles from solutions and magnetic properties of nanostructured bulk materials. 4 h

3. Nanocrystalization by heat treatment of amorphous oxides and metal materials Microscopic investigation of the particles size distribution. 2 h.

V. Topics for personal projects.

1 Perspectives and directions of research and development of nanostructured advance materials;

2. Atomic and molecular clusters;
3. Frontiers and nanotechnology. Research and directions;
4. Measuring on the physical properties of nanometer scale particles, coatings and bulk materials;
5. Applications of nanomaterials in biology and medicine;

6,, Applications of nanomaterials in information technology;

7. Applications of Nanomaterials in nanooptoelectronics.

VI. Recommended Literature for Further Reading

1. C.C Koch, Nanostructured materials, W. Andrew Rube, New York, 2002
2. C.P. Poole, J.R. Frank, F.J. Owens, Introduction to nanotechnology, WILEY-INT, 2003.
3. P,M, Ajayan, J.S. Schadler, P.V. Braun, Nanocomposites Science and Technology, WILEY-INT, 2003.
4. M.C. Roco, Nanotechnology Research Direction, Kluwer Ac. PubL, 2002
5. K.J. Klabunde, Ed, Nanoscale Materials in Chemistry, Wiley, New York, 2001.
6. G. Schmid (Ed.), Nanoparticles - from to applications, VCH, Weiheim, 2004.
7. M.C. Roco, R.S. Willians and P. Alivisatos, eds. Nanotechnology Research directions, Kluwer Academic Publishers, Boston, 1999.
8 R.W. Sigel, E. Hu, M.C. Roco (Eds.) Nanostructure Science and Technology, Kluwer Academic Publishers, Boston, 1999.