**Name of the module: “Interfaces and Interface Related Properties of Nanostructured Materials”**

**Number of module: 365-2-6952**

BGU Credits: 3

ECTS credits: 4

Academic year: 2012-2013

Semester: Spring semester

Hours of instruction:3 hours per week

Location of instruction: will be defined

Language of instruction: English

All the students will receive the detailed synopsis of ALL THE LECTURES in English

Cycle: Second cycle

Position: An advanced course for graduate students in Materials Engineering Department

Field of Education: Materials Engineering , Nanotechnology.

Responsible department: Materials Engineering

General prerequisites: Introduction to MSE course , or equivalent

Grading scale:the grading scale would be determined on a scale of 0 – 100 (0 would indicate failure and 100 complete success 0 to 100), passing grade is 65.

Lecturer: Prof. Evgeny E. Glickman

Contact details: room 010, building 59

Office phone: 08-6461460

Email: evgeny.glickman@bgu.ac.il

Office hours: Sunday , from 12-00 to 14 -00AM

Module evaluation: at the end of the semester the students will evaluate the module, in order to draw conclusions, and for the university's internal needs.

**Course Description:**

Nanostructured materials (NsMs) are at the heart of nanotechnology. They have very large interface area per unit volume and can be considered as the ‘composites’ with two major phases: the grain core and interfaces. Many NsMs feature intriguing discontinuous changes in their properties (“size effect “) below a certain threshold d\* ≤ (5...50) nm, or so, in the interface separation distance d. Understanding interface-related properties is essentially needed to control the properties of NsMs and explore their great potential in a wide range of application. The course focuses on mechanical and electrical properties of inorganic NsMs, but considers also, diffusion, corrosion, radiation damage and adsorption /catalytic properties.

**Aims and Objectives the module:**

To teach the students how atomic structure and local chemical composition of the interfaces determine unusual macroscopic properties on NsMs , how NsMs can be obtained , tested and used for critical application related to their strength , electrical conductivity , radiation and corrosion resistance .

**Learning outcomes of the module**:

On successful completion of the course the students should be able to:

•understand structural and kinetic models used in description of the interfaces (free surface , grain boundaries , twin boundaries and stalking – faults) in NSMs

•recognize the physical origin of ‘size effects’ in the properties of NsMs

•select the appropriate fabrication routes and test methods for inorganic NsMs

•appreciate future materials engineering issues associated with the use of NsMs

**Attendance regulation:**

attendance and participation in class is mandatory (at least 80%).

**Teaching arrangement and method of instruction**: lectures, which include the examples for solving problems.

**Assessment:** Exam: 75% .Home works :25%

**Assignments**: three home works of about 15 problems taken together .

**Exam** : consist of 5-6 numerical problems and conceptual questions

**Time required for individual work**: in addition to attendance in class, the students are expected to do their assignment and individual work: at least 2 hours per week.

**Module Content and 3 hour Lecture Outlines** :

1. **1**. **Introduction:** nanomaterials in nanotechnology;graphene; atomic probe tools. **2**. **Processing of** NsMs**:** bulk objects, coatings, thin films. **.**
2. **3**. **Basics of Interfaces (I):** thermodynamics, structure, kinetics, dangling bonds and surface/interface energy and stress; surface relaxation and reconstruction. **4**.**Basics of Interfaces** (II): structural models and interface defects, adsorption, equilibrium and non-equilibrium segregation; interface diffusion, sliding .
3. **5. Internal** **Interfaces in NsMs**: grain boundaries (GB), twins, heterogeneous interfaces. Thermal stability /instability of internal interfacess in NsMs **.**
4. **6**. **Diffusion in NsMs .**
5. **7. Mechanical Properties of NsMs:**
6. 7-1. Size effect in elastic modulus . 7-2. Yield stress and inverse Petch relation.7-3. Anomalous strain hardening: critical role of nano-twins in ductility. 7-4.Coupling dislocation mediated plastic flow and GB sliding / rotation. 7-5. Surface energy induced high temperature deformation and “zero-creep” technique. 7-6. Grain boundary diffusional creep. 7-7. Low temperature, high-speed super-plasticity NS metals and ceramics. 7-8. Fracture resistance. 7- 9.NsMs vs. Glasses.
7. **8. Size Effect in Electrical Resistivity (SER) of NsMs** .
8. 8-1. SER in microelectronics. 8-2. Contribution of surface and GB electron scattering to SER; challenging models (Fuks, Myadas –Shatzkes, Namba, Glickman et al.)
9. **9. NsMs with high resistance to radiation damages**
10. **10. Corrosion and Catalytic Properties of NsMs**: quantum confinement and unusual chemistry of nano-clusters
11. **11**. **Current Trends** **and** **Open Questions** in understanding and applications of NsMs.
12. **Literature to the course:**
13. *[1] K. T. Ramesh, Nanomaterials: Mechanics and Mechanisms, Spinger, 2009*
14. *[2] C. Koch, I. Ovid’ko, S. Seal, S.Veprek , Structural Nanocrystalline Materials: Fundamentals and Applications, Cambridge University Press, 2007, pp. 364, ISBN: 978-0-521-85565-5*
15. *[3] A. Sutton and R. Balluffi, Interfaces in Crystalline Materials, Oxford University press, 2007*
16. *[4] J. Howe, Interfaces in Materials, Willey, Interscience Publishing, 1997;*
17. *[5] E. D . Honduras , P. Seah , Interfacial and Surface Microchemistry , in the book by R. W. Cahn and P. Haasen (eds.) Physical Metallurgy , 3rd edition , chapter 13 , Elsevier , 1984 , pp. 856-931*

Confirmation: the syllabus was confirmed by the faculty academic advisory committee to be valid on 2012-2013.

Last update: 04.09.2012