28 & 29 JUNE, 2015 • MUNICH-GERMANY

NANOSIZED- & NANO-STRUCTURED MATERIALS MADE by NATURE and MAN: FUNDAMENTALS AND APPLICATIONS

INSTRUCTOR:
PROF. DR. PROF. H.C. DR. H.C. STAN VEPREK
TECHNICAL UNIVERSITY MUNICH,
GERMANY

COURSE CONTENTS:

1. Introduction and short overview
- Charging by one electron
- How old is nanotechnology? (color of old glasses)
- Nanotechnology made by nature
- Often we are using nanotechnology without knowing it
- Nanoscience & Nanotechnology: Why and when (scientific facts vs. fiction)

2. Properties of nano-sized and nano-structured materials when approaching the molecular size
- Localization phenomena (crystallite size and separation):
  - Electronic states
  - Surface plasmons
  - Phonons
- Nano-materials in
  - Microelectronics
  - Optoelectronics
- Nanomagnets approaching the domain size (efficient transformers, hard memory discs, medical applications):
- Organization at nanoscale: Self-organization (bottom-up) vs. lithography & etching (top-down)
- Thermodynamics properties of nano-sized materials
- Surface properties of nano-sized materials (fundamentals, nanosilver & nanogold in the catalysis and in everyday life)
- Mechanical properties at nanoscale
- Learning from nature:
  - super-hydrophobic, self-cleaning surfaces (“lotus effect” made by nature and by man)
  - "lotus effect" upside down (super-adhesive surfaces made by nature and by man)
  - hierarchic design of high-specific strength & toughness
  - design of structural colors (origin of the colors of peacock, butterflies, …)

3. Structural bulk nanocomposites:

COURSE CONTENTS

- Graphite fibres carbon composites with high specific strength
- Polymer-based nanocomposites reinforced by inorganic fillers
- Future trends: carbon and c-BN nanotube reinforced nanocomposites

4. Wear protection and functional nano-structured coatings for machine parts and tools

- The role of the ratio of elastic modulus to hardness for wear of machine parts
- Self-lubricant hard nanocomposites for harsh and variable environment (humid-dry, low- & high-temperature etc.; e.g. coatings in the machine of your car)
- Why coatings on tools? (Transition Metal Nitrides, Carbides, Borides, Oxides)
- Nanocrystalline diamond and diamond-like carbon

5. The Recent Search for New Superhard Materials: Go Nano!

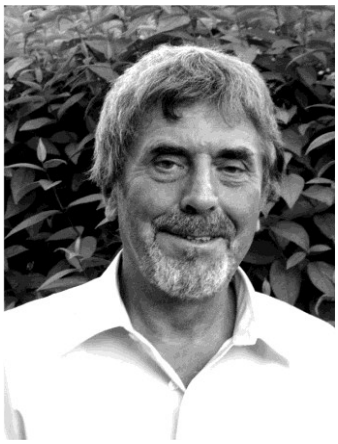
5.1. Different approaches to superhard coatings, their advantages and drawbacks:
  - Why the intrinsically superhard materials will hardly reach the hardness of diamond
  - Hardening by energetic ion bombardment
  - Superhard heterostructures
  - Superhard nanocomposites reaching the hardness of diamond: Design concept, their preparation, properties and recent progress in their understanding.

5.2. Industrial applications of hard and superhard nanocomposites in comparison to other advanced coatings including polycrystalline diamond.

6. Summary and Conclusions

ABOUT THE COURSE INSTRUCTOR:

PROFESSOR STAN VEPREK

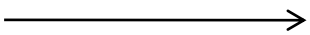


Prof. Dr. Prof. h.c. Dr. h.c. Stan Veprek:

Short Summary

Stan Veprek received his diploma in physics from the Charles University in Prague in 1963, and immediately began his work on the deposition of thin films by means of plasma CVD at the Institute of Physics of the Czech Academy of Science. His first major result was the deposition of nanocrystalline Si and Ge by means of chemical transport in hydrogen plasma (published in 1968). Nowadays, nc-Si is an important material for large-scale microelectronics, flat panel displays and thin films solar cells. Between 1968 and 1971 he was visiting scientist at the University Münster (Germany), where he continued his work in plasma chemistry. He received his Dr Phil. in chemistry (1972) and habilitation (1977) from the University of Zurich, where he became involved also in the research of the plasma-wall interactions in the TOKAMAK devices for controlled nuclear fusion. In 1976 he proposed and later developed the in-situ plasma CVD of boron carbide protective coatings ("boronization"), which found successful application in many large TOKAMAK devices around the world.

His continuing interest in nc-Si resulted, among others, in the classical papers on Raman scattering and phonon confinement, later extended to in-depth studies of the photoluminescence from nc-Si/SiO_2 nanocomposites. Together with the Swiss national museum he developed a new plasma-chemical method for the restoration and conservation of archeological metallic artifacts.



ABOUT THE INSTRUCTOR

In 1988 he was appointed full Professor and head of the Institute for Chemistry of Inorganic Materials at the Technical University of Munich, where he continued his research on a- and nc-Si and Ge, organometallic CVD, heteroepitaxy of 3C-SiC and others. Here, also the design principle for the novel superhard nabocomposite materials was born in 1995, and has been further developed in collaboration with many colleagues and students during the subsequent years. In 1996 he begun collaboration with a Czech company SHM, which pioneered the industrialization of superhard nanocomposites coatings based on that design concept. His latest work focuses on the understanding of the formation of the superhard nanocomposites by spinodal phase segregation and of their mechanical properties by means of combined *ab intio* DFT and thermodynamics studies, and by non-linear FEM in collaboration with Ruifeng Zhang (presently at Los Alamos Nat. Lab.), Volodymyr Ivashchenko (Kiev), Prof. A.S. Argon (MIT – Cambridge, USA) his wife Maritza, and with other colleagues from different countries. He has been visiting scientist and professor in many countries.
Stan Veprek published over 390 papers in international journals, and only since January 2005 (i.e. after his formal retirement from the Tech. Univ. Munich) he gave more than 70 invited, Keynote and plenary lectures at international conferences. He is also teaching courses on the Nano-Science and – Technology in various countries.

STAN RECEIVED VARIOUS AWARDS: Silver Medal of the Societe d'Encouragement Pour la Recherche et l'Invention, Paris (1979), Silver Medal (1991) and Honorary Doctorate (Dr. h.c.) from the Masaryk University Brno, Czech Republic (1999), the Blaise Pascal Medal of the European Academy of Sciences (2004), the AVS John Thornton Memorial Award of the American Vacuum Society (2005), Honorary Professor of the Qingdao University of Science and Technology (2009), the Award for Career Achievements by the organizers of the Int. Conf. for Diffusion in Solids and Liquids (July 2010), and the R.F. Bunshah Award and ICMCTF 2011 Lecture of the American Vacuum Society – Advanced Surface Engineering Division (May 2011).