NSF - Summer Institute on Nano Mechanics and Materials

Surface Engineering and Coatings

Ali Erdemir
Argonne National Laboratory
Energy Technology Division
Tribology Section
Argonne, IL 60439

Ivan Petrov
Center for Microanalysis of Materials
Frederick Seitz Materials Research Laboratory
University of Illinois
104 S. Goodwin Avenue
Urbana, IL 61801
Course Objectives

• Provide a comprehensive overview of the latest developments in surface engineering and coating technologies with special emphasis on:
  – Multi-functional, nano-structured and -composite coatings
  – Details and the basic mechanisms involved in the nucleation and growth of functional coatings

• The course will also provide a general overview of advanced tools and techniques used in the characterization and testing of these coatings
Course Outline

• Session Layout:
  – 5x3 morning sessions (Lectures)
    • Each session is 50 min, 10 min break between sessions
  – 4x3 afternoon sessions (Lectures + Practicum)

• Lab Tours (All at Northwestern University)
  – Materials Science and Engineering
    • Prof. Y. W. Chung’s Lab
    • Prof. M. Graham’s Lab
    • Prof. Dravid’s Lab
  – Mechanical Engineering
    • Prof. Ruoff’s Lab
    • Prof. Wang’s Lab
  – Hands-on Nano-indentation (Micro Material, Ltd)
Course Outline Cont’d

• Mon 8:30-12:00
  – L1: Introduction to Surface Engineering and Coating Processes
  – L2: Fundamentals of Vacuum Science and Technology
  – L3: Fundamentals of Sputter Deposition

• Mon 1:00-4:30 pm
  – L4: Fundamentals of Nucleation and Growth
  – L5: Computational Methods: Atomistic and Molecular Dynamics Simulation of Film Growth
  – P1: Lab tour: Thin film deposition and surface engineering facilities (MSE)

• Tue 8:30-12:00
  – L6: Recent Advances in Surface Cleaning and Preparation Techniques
  – L7: Recent Advances in Surface Engineering and Coating Technologies
  – L8: Hybrid Coatings and Deposition Processes

• Tue 1:00-4:30 pm
  – L9: Novel Coating Architectures
  – L10: Scale-up and Design; Industrial Systems and Practices
  – P2: Hands-on with Plasma Deposition Processes (MSE)
Course Outline Cont’d

• Wed 8:30-12:00
  – L11: Introduction to Thin Film Characterization: Structural and Morphological Characterization
  – L12: Mechanical Characterization
  – L13: Introduction to Thin Film Characterization: Surface Analysis
• Wed 1:00-4:30 pm
  – L14: Introduction to Thin Film Characterization: Structural and Chemical Characterization
  – P3: Lab Tour: NUANCE Microscopy Facilities (MSE)
  – P4: Nanoscale Science and Engineering Laboratory (ME)
• Thu 8:30-12:00
  – L15: Tribological Characterization
  – L16: An Overview of Emerging Technologies
  – L17: Superhardness and Superlubricity: Theory and Experiments
• Thu 1:00-4:30 pm
  – L18: Classification and Industrial Applications of Coatings
  – P4: Hands-on Nano-indentation (Micro Materials)
  – P5: Lab tour: Tribology Test Facilities (ME)
Guest Speakers

- Fri 8:30-12:00
  - L18: Guest Speaker 1: Dr. Kathryn J. Wahl, NRL, “Nanomechanics and Tribology of Coatings”
  - L19: Guest Speaker 2: Prof. Yip-Wah Chung, NSF, “Applications of Tribological Coatings in Extremely High-Density Computer Disk Drive Applications”
  - L20: Guest Speaker 3: Dr. Jeffrey H. Sanders, AFRL/MLBT, “Surface Engineering for Aerospace Applications”
Acknowledgment

• Authors would like to thank:
  – Argonne National Laboratory (DOE, The University of Chicago)
  – University of Illinois at Urbana-Champaign
  – Research colleagues and collaborators for helpful discussions and contributions

• Special thanks are due to our guest speakers:
  – Prof. Yip-Wah Chung (NSF)
  – Dr. Kathryn J. Wahl (NRL)
  – Dr. Jeffery H. Sanders (AFRL/MLBT)

• Additional thanks are due to:
  – Drs. O. L. Eryilmaz and K. Kazmanli (Argonne), Mr. N. Mehta (Auburn University), Dr. Rick Haasch, Dr. Mauro Sardela, Dr. Ray Twesten, Nancy Finnegan, Judy Baker, Dr. Jim Mabon, Dr. Kenji Ohmori, Hwan-Seok Seo, Dr. Todor Donchev (all from UIUC) for insightful discussions and their help in the preparation of some of the course materials.
  – And many contributors from industry and research laboratories (in particular; D. Teer (Teer Coatings); G. Lake (CemeCon), M. Pellman and R. Hill (von Ardenne), K. Holmberg (VTT), W. Sproul (Advanced Energy), R. Dielis (Hauzer Techno Coatings), A. K. Both (PVT Vacuum), G. Plint (Phoenix Tribology) and many more).
DISCLAIMER

Opinions expressed in this course are the author’s only, not necessarily those of the Argonne National Laboratory or the University of Illinois at Urbana-Champaign. Any commercial products or processes identified or used in presentations are for illustration purposes only and they do not imply any endorsement by these authors or their institutions.