ME 730: Ultra-Precision Machining

Course Structure

Prof. Suhas S. Joshi
Prof. Deepak Marla

Department of Mechanical Engineering, Indian Institute of Technology, Bombay, Powai, MUMBAI – 400 076 (India) Phone: 91 22 2576 7527 (O) / 2576 8527 ®; ssjoshi@iitb.ac.in

Course Structure

- **Introduction:** Definition of ultra-precision machining; Taniguchi curves of evolution of accuracy in the twentieth century; definition of **Nanotechnology**; Positional accuracy of today's manufacturing processes and equipment; Deviational and scattering errors in achieving nanometric resolution.

- **Atomic-bit and atomic cluster processing methods:** Nano-mechanical, nano-physical and nano-chemical and –electrochemical processes, their capabilities and advantages.

- **Mechanism of nano-mechanical processing of atomic clusters:** Processing stress, breaking stress and processing energy density; Concept of size effect in mechanical processing; thresholds of specific energy; Nano-machining, abrasive and adhesive processing, theories of nanometric processing of ductile and brittle materials, and polymers; Failure and fracture under uniform and localized loading; Atomic-bit processing and lattice defect density, theories of nano-indentation and scratching.

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- **Mechanism of nano-physical and -chemical processing of atomic-bits:** Scanning tunneling effect, directional photon, electron and ion beam processing, plasma surface processing, molecular beam processing; Principles of chemical and electro-chemical processing, equilibrium of chemical and electro-chemical reactions.

- **Nano-processing systems (Nano-mechanical processing) - Diamond turning:** Soft metal single-point diamond turning technology, the ultra-precision CNC machine, plane and spherical mirrors machining; **Nano-grinding**: technology and requirements, concept of critical depth of cut, size-effect in form and fine grinding, Elid grinding, Elastic emission grinding; mechano-chemical polishing of Si wafers, principles and models; **Ultra-precision polishing:** Principles of ultra-precision polishing of block gauges, balls and aspherical lenses.

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- **Nano-processing systems (Nano-physical and –electrochemical processing): Photo beam processing:** Thermal and chemical processes in photon beam ablation; **Electron and ion beam processing:** removal mechanism in electron and ion beam processing, abilities and limitations; scanning tunneling microscope (STM) processing; Chemically reactive milling and etching processes, Chemically reactive deposition and consolidation, electrochemical machining and deposition processes.

- **Nano-measuring systems:** In-situ processes, mechanical and optical measuring systems, Scanning probe and image processing systems.

- **References**
- N. Taniguchi, **Nanotechnology: Integrated Processing Systems for Ultra-precision and Ultra-fine Products**, Oxford University Press Inc., NY, 1996.
- J. McGeough, **Micromachining of Engineering Materials**, Marcel Dekker, Inc., NY, 2002.
- M. C. Shaw, **Principles of Abrasive Processing**, Oxford: Clarendon Press, 1996.

Scheme of Assessment

Project (one / two students)	- 20%
Quizzes	- 30%
End semester Examination	– 50%
Total	– 100%