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**Nano- and Micro-Mechanical Behavior Laboratory**  
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Thin Film Deposition

- Sputter deposition (AJA International)
  - 3 targets, co-sputtering arrangement, RF and DC magnetron
  - typical targets: Cu, Al, Ti, Au, Pt, Ni, W, V, Ni-V, Pt-Ru
  - base pressure typically  $3 \times 10^{-7}$  torr
  - substrate bias, reactive sputtering and substrate heating capability
  - in-situ substrate curvature (film stress) measurement is possible
- Evaporation
  - Resistance heated, 3 boats
  - typical materials: Cu, Al, Ni, Au
  - base pressure typically  $8 \times 10^{-7}$  torr

Small-scale Mechanical Testing

- Nanoindentation (Hysitron Triboscope on DI small sample AFM)
  - Surface imaging with indentation tool
  - Vertical loading: 1nN – 10 mN, Lateral loading:  $3 \mu\text{N}$  – 10 mN
  - Scratch testing, micro/nano-wear testing
  - Heating to 150 °C
  - Typical specimens: thin films, coatings, treated surfaces, small structures
- Micro-tensile load frames (2)
  - Load resolution: <1 mN
  - Displacement: 5 nm – 50  $\mu\text{m}$
  - Heating to 400°C (in development)
  - Typical specimens: thin films, fine wires
- Mini-tensile load frame
  - Environmental Scanning Electron Microscope in-situ testing compatibility
  - Load cells: 250 g,-f, 100 lbs., 1000 lbs. tension/compression
  - Displacement:  $\mu\text{m}$  – mm range
  - Tension, compression, 3 or 4 point bending
  - Typical specimens: wires, foils, small structures (metal, ceramic, polymer)
- Thin film stress tool, substrate curvature
  - $\text{N}_2$  up to 500 °C
  - Vacuum up to 800 °C
  - Typical specimens: thin films on Si wafer substrates
- Thin film adhesion test fixtures, 4-point bend
- Thin film stress measurement, in-situ wafer curvature (k-Space)
- Thin Film Creep measurement by membrane resonance
  - Vacuum up to 500 °C
  - Typical specimens: electrically conductive thin films on Si wafer substrates
  - Capable of stress measurement in films of nano-scale thickness
- Thin Film Bulge test (vacuum, elevated temperature, under development)

Surface Roughness Measurement

- Atomic Force Microscope (Digital Instruments 3000, also small sample heads)
  - Vertical range: 5 nm – 5  $\mu\text{m}$
  - Horizontal range: 1  $\mu\text{m}$  – 100  $\mu\text{m}$  square
  - Chemical cells
  - Contact, Tapping Mode, SPM

### Sample Preparation

- Bulk micromachining by TMAH or KOH
- RIE of metals and nitrides

### Medium/Large scale Mechanical Testing

- Charpy and Izod testers
- Instron 5567 load frame
  - Load cells: 100 lbs., 6000 lbs. tension/compression
  - Displacement:  $\mu\text{m}$  –m range
  - Strain gage channel
  - Merlin software suite

Related facilities at Lehigh University include:

### The Electron Microscopy Center (<http://www.lehigh.edu/~inmicro/>)

- FEI Strata DB 235 Dual-Beam FIB
- FEI XL30 Environmental SEM
- JEOL 6300F field-emission high-resolution SEM
- JEOL 733 electron microprobe
- JEOL 2010F 200kV field-emission TEM
- JEOL 2000 FX 200 kV TEM
- Vacuum Generators HB 603 STEM (300 kV)
- Vacuum Generators HB 501 STEM (100 kV)

### The Sherman Fairchild Center for Solid State Studies

- Microelectronics Laboratory (<http://www.lehigh.edu/~insfl/micro/micro.htm>)
- Flat Panel Display Laboratory (<http://www.lehigh.edu/~indrl/>)