Thin Films

Manufacturing Technologies

The Thin Film laboratory provides a variety of vapor deposition processes and facilities for cooperative research and development. Available capabilities include electron beam evaporation, sputter deposition, reactive deposition processes, atomic layer deposition (ALD) and specialized techniques such as focused ion beam induced chemical vapor deposition. Equipment can be reconfigured for prototyping, or it can be dedicated to long-term research, development and manufacturing. Most sputter and evaporative deposition systems are capable of depositing multiple materials.

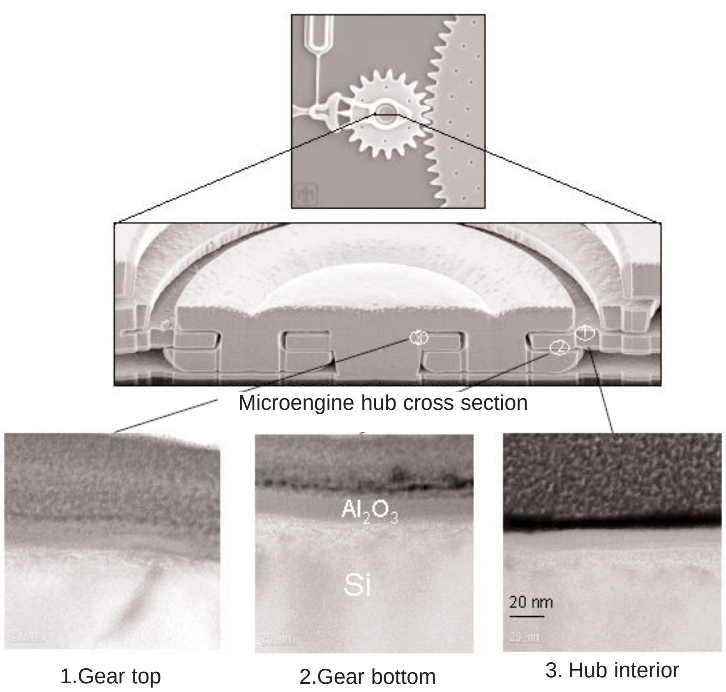
Deposition capabilities and expertise

- Deposition of a large variety of thin film materials
- Multiple sputter deposition systems
  — Capable of depositing four materials in a single run
  — Substrate heating during deposition to temperatures as high as 600°C
  — Provides uniform (up to 99.5%) film coatings to diameters of 8”
  — Automated control of layer thickness and multilayer design
  — Capable of depositing films uniformly onto complex-shaped substrates such as tubes, fiber, etc.
- Multiple electron beam evaporation systems.
  — Capable of depositing 1-4 materials in a single run
  — Substrate heating during deposition to temperatures as high as 550°C
  — Provides uniform coatings to diameters of 12”
  — Capable of depositing films uniformly onto complex-shaped substrates such as tubes, fiber, etc.
  — Deposition of compounds by evaporation in the presence of reactive gas possible

Multi-layer Thin Films

Planetary Sputtering Systemå

- RF/DC sputter deposition with in-situ sputter etching, RF sputter bias and reactive sputtering capabilities
  - — Pulsed DC sputtering also available on two systems
  - — Current reactive sputter systems offer O_2, N_2, H_2 or D_2 as process gas
- Ion beam sputter deposition using Kaufman ion sources
- Dedicated thin film deposition systems for growing ‘exotic’ materials (Pb, In, Teflon) including ones with high vapor pressures such as ZnS
- Sputter deposition of magnetic materials including Ni, Fe and Co
- Atomic layer deposition
  - — Thin conformal coatings on 3-dimensional structures (See Figure 1 for an example)
  - — Currently depositing metal oxides, sulfides, nitrides
- Focused ion beam induced chemical vapor deposition
  - — Material can be grown locally onto conductive substrates or layers.
- Physical vapor deposition of precious metals including Pt, Au, Ag
- Sputter deposition onto transported powder substrates



Microengine hub coated with 10 nm of Al2O3 by Atomic Layer Deposition. Transmission electron microscope cross sections show uniform film coating on both exposed and shadowed surfaces.

Analysis capabilities

- Analysis of thin film stress ex-situ using Flexus Tencor laser curvature measuring device
- In-situ analysis of thin film stress using MOSS™
- Spectroscopic ellipsometry for determining film thickness, refractive index or multilayer film structure; measurements can be made into the IR (λ of 750 nm to 1.5 µm)
- Focused ion beam sectioning and SEM
- Temperature programmed desorption and depth-profiling Auger electron spectroscopy analysis system
- Stylus profilometry and interferometric microscopy instruments for determining roughness, film thickness; equipment includes Dektak and ADE Phase Shift MicroXAM instruments
- Sheet resistance measurements
- Adhesion pull tests

Resources

- 15+ high vacuum deposition systems
- Over 3500 ft^2 of class 10000 (or better) clean room space
- Over 650 ft^2 of clean room for classified projects
- Vapor degreasers with ultrasonic cleaning
- UV ozone substrate cleaning unit
- Access to plasma ashers for cleaning
- Wet chemistry lab for substrate cleaning
- 2 portable leak detection units
- 2 custom-built focused ion beam systems for cross-sectioning samples

Accomplishments

- Developed energetic multilayer thin film deposition processes. Films to be used for pyrotechnic devices. Examples include Mg/Teflon multilayers deposited by sputtering.
- Developed a novel coating process called atomic layer deposition, which uniformly coats shadowed surfaces such as gear hubs and teeth with wear-resistant or lubricating films; demonstrated process that uniformly coats high aspect ratio (1000:1) features integral to MEMs devices.
- Demonstrated control of stress in metal hydride thin films grown by evaporation. Stress was monitored in-situ using MOSS. Characterized evolution of stress for production process.
- Successfully deposited compositionally pure rare earth metal hydride films by reactive sputtering
- Discovered new phase of erbium hydride – cubic erbium trihydride interpreted as a strain-energy stabilized crystal structure.
- Development of low stress (< 1 MPa) multilayer thin films for MEMs mirrors; highly reflective, gold coatings (with different underlayers) were coated onto 750-micron diameter Si MEMs mirrors that maintained $\lambda/40$ flatness.
- Developed patterned nichrome thin film heater for localized heating/bonding of electronics submodule.

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