Tribology Section Facilities

Buchyrus Visit

R. Erck

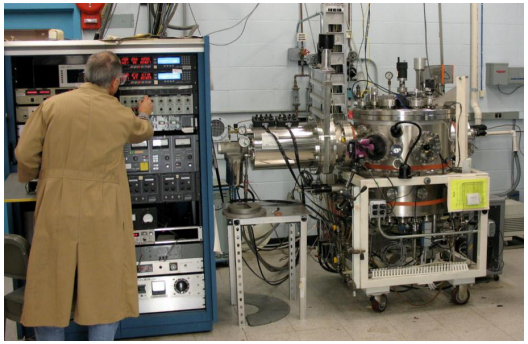
4-29-11

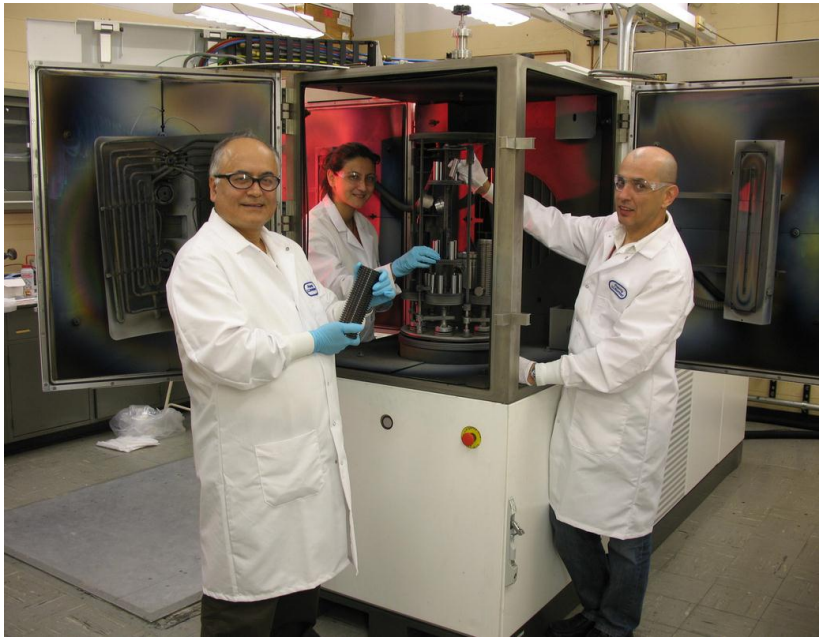
Outline

- Thin film deposition
- Tribological testing
- Characterization
- Sample preparation
- Other facilities

Facilities

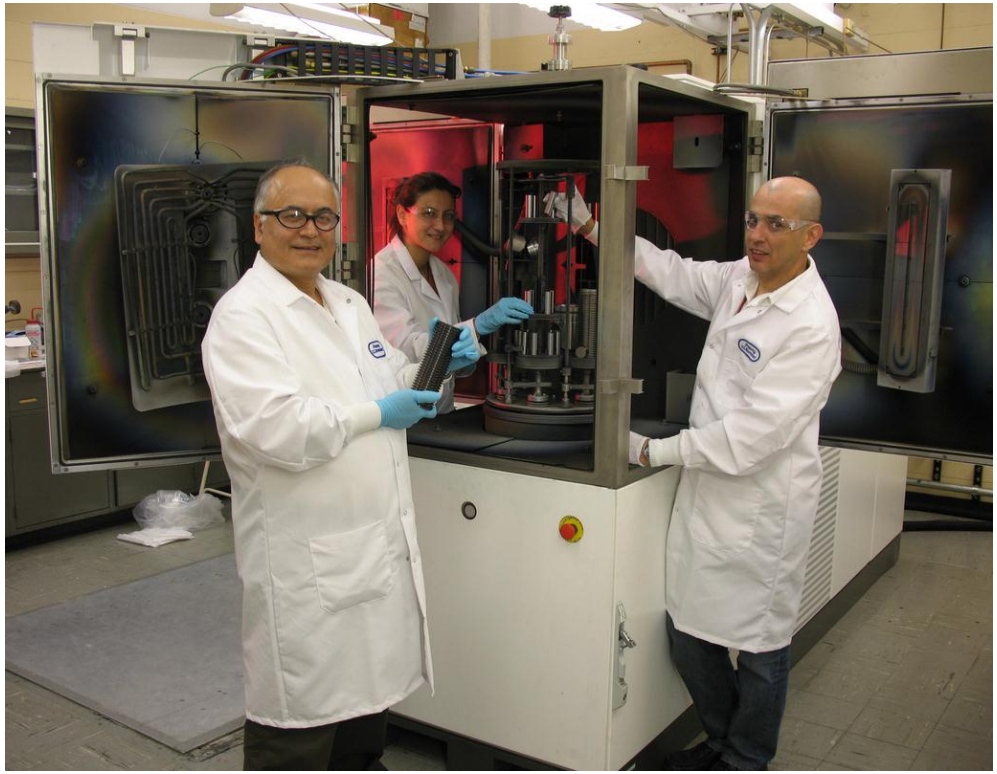
Thin Film Deposition

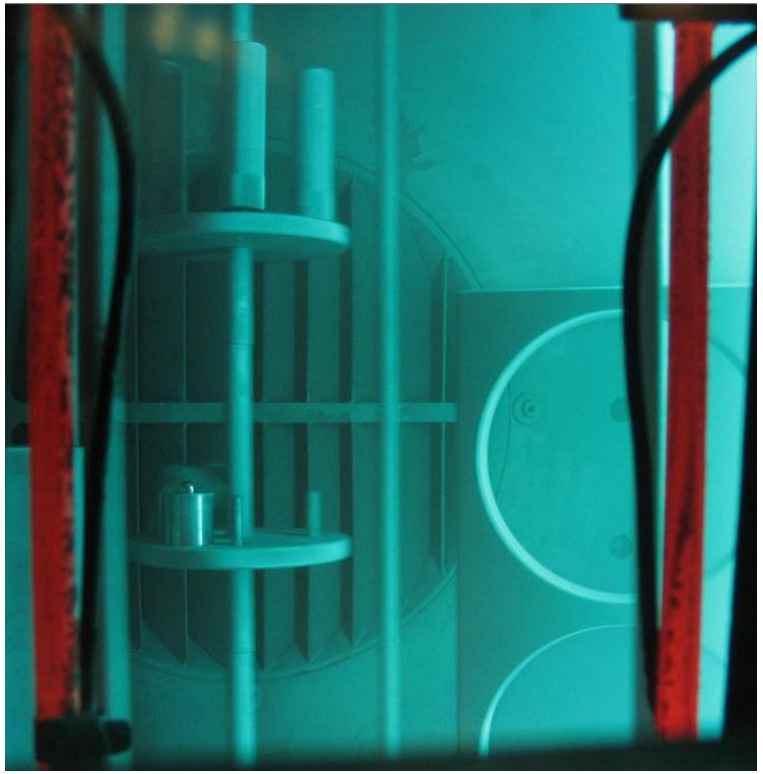




Magnetron sputtering / PACVD

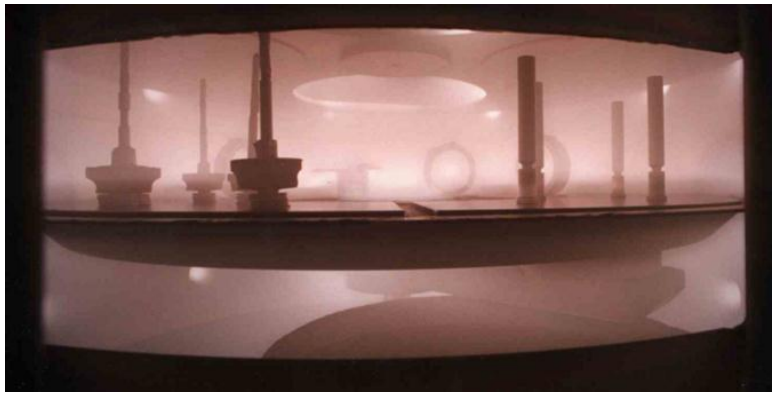
- Cemecon CC900 dual magnetron sputtering and PACVD upgraded to HiPMMS
- Many sputtered thin films using Ar, hydrocarbon gases, H_2





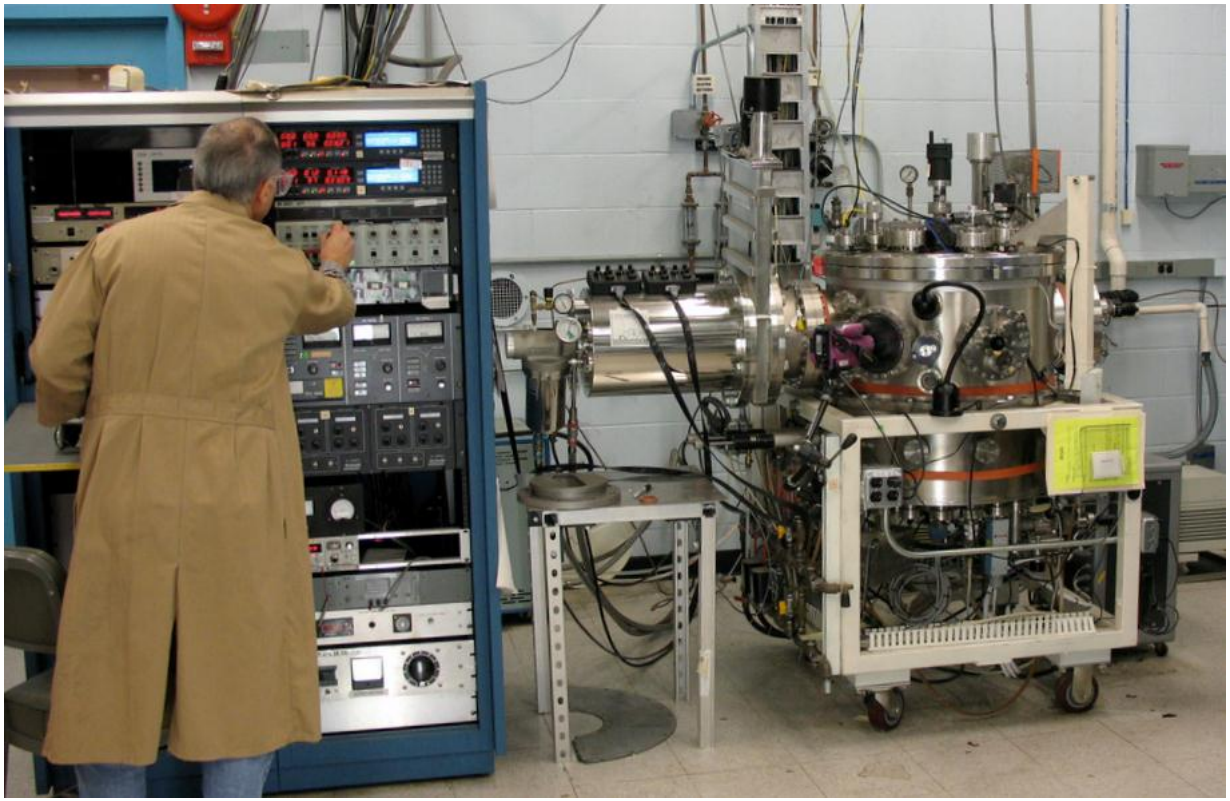
Sputtering / PACVD

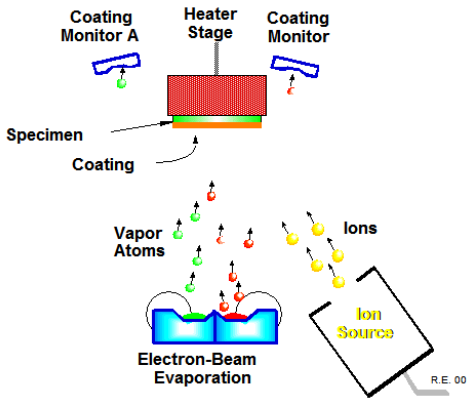
- Perkin Elmer Deposition System – three targets, sputtering and PACVD, silane capable



Electron beam evaporator

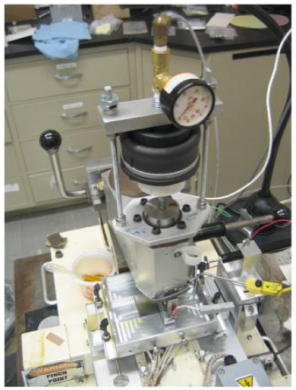
- Dual electron beam evaporator and Kaufman ion source
- Metals and oxides, substrate to 800°C, 200-1000 eV ions, O_2, N_2, Ar





Tribological Testing

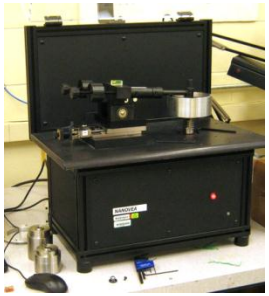
Micropitting



Ring-on-liner

Block on ring

4-Ball

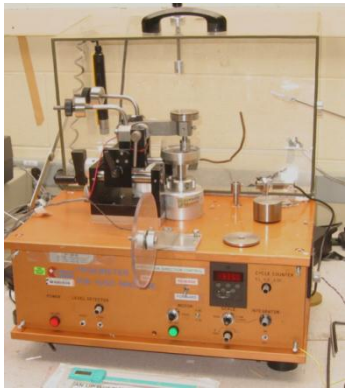


Pin on disk

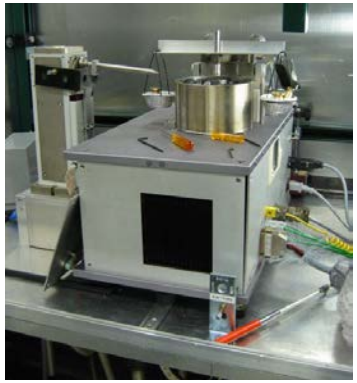
High-temp H2/N2/air

Ball on three-disk

RT N2/CH4/H2/air



Ball on disk

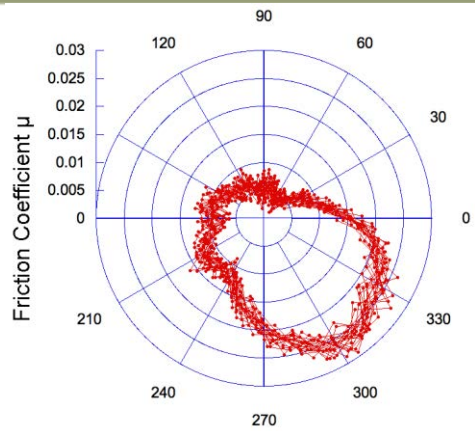


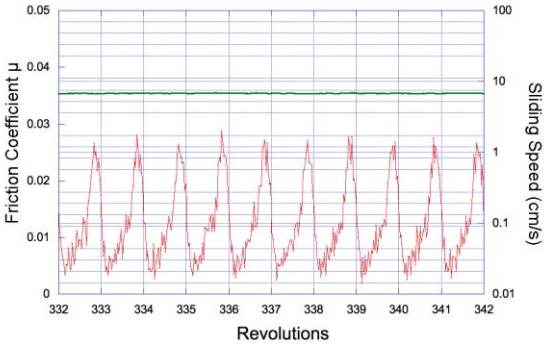
Hi-Temp ball-on-disk

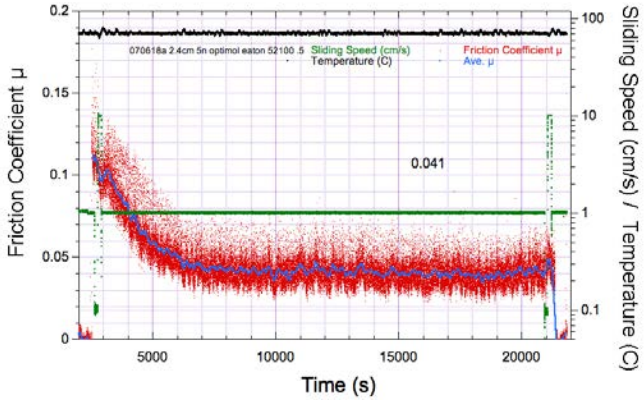
High-temp reciprocating

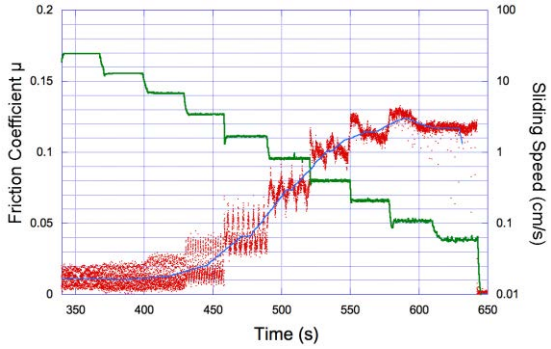
CSEM Ball on Disk

- Controlled environment, N_2, air
- 0.2 - 500 rpm
- 100 g - 20 N load
- Radiant heating to 125°C
- 30 Hz data acquisition
  - Friction Force
  - Temperature
  - RPM
  - Angular position



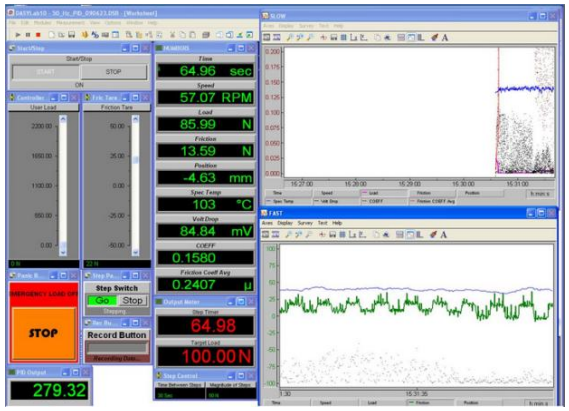






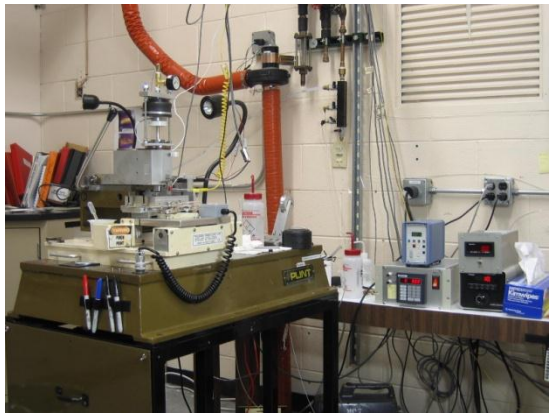
Reciprocating #1

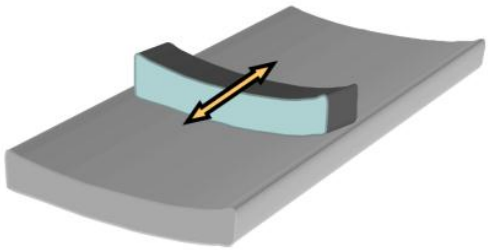
- Controlled environment
- 15-500 rpm
- 25-2000 N pneumatic load controlled by computer
- Stroke to 2”
- Load cell friction force
- Heating to 200°C
- 1000 Hz data acquisition
  - Friction Force
  - Position
  - Load
  - Temperature
  - Contact resistance
  - RPM
- Ring/liner, ball/flat, cylinder/flat



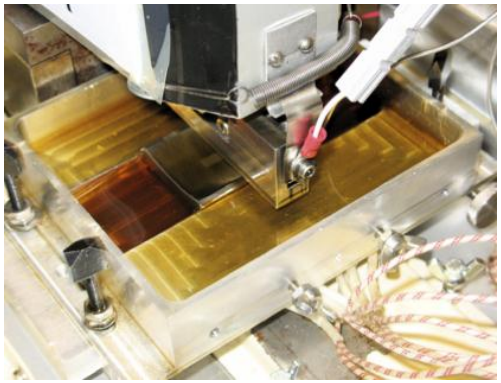
Reciprocating #2

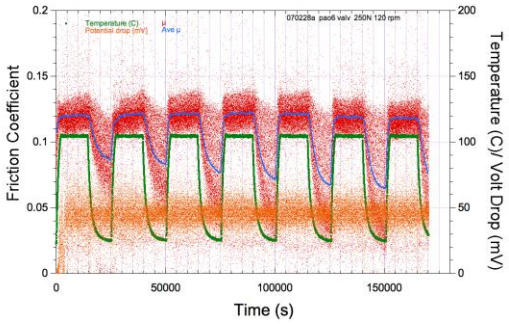
- 15-500 rpm
- 5-2000 N pneumatic load
- Stroke to 2”
- Piezo friction force
- Cyclic heating to 200°C
- 1000 Hz data acquisition
  - Friction Force
  - Position
  - Load
  - Temperature
  - Contact resistance
  - RPM
- Ring/liner, ball/flat, cylinder/flat

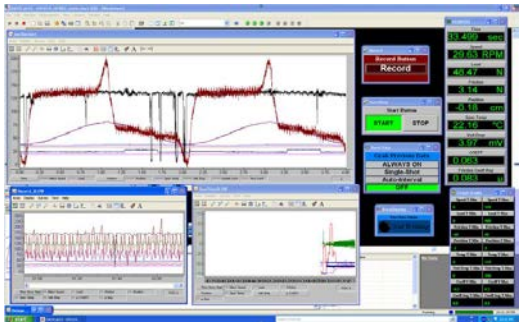


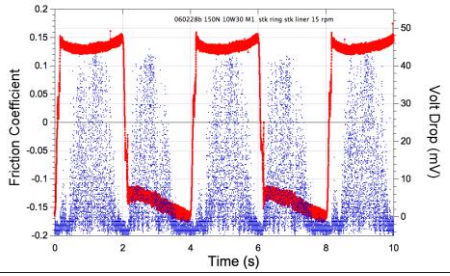


Ring on Liner



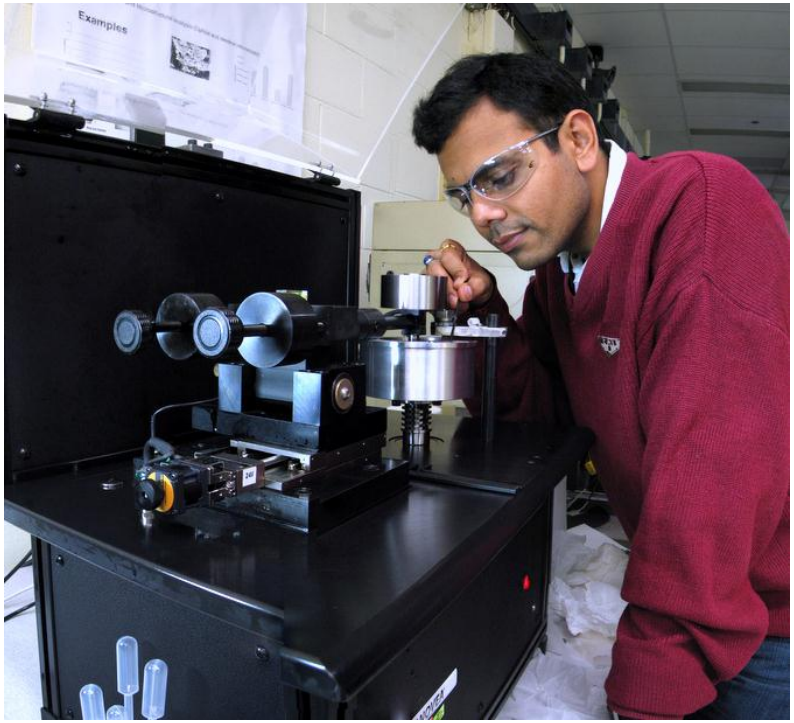


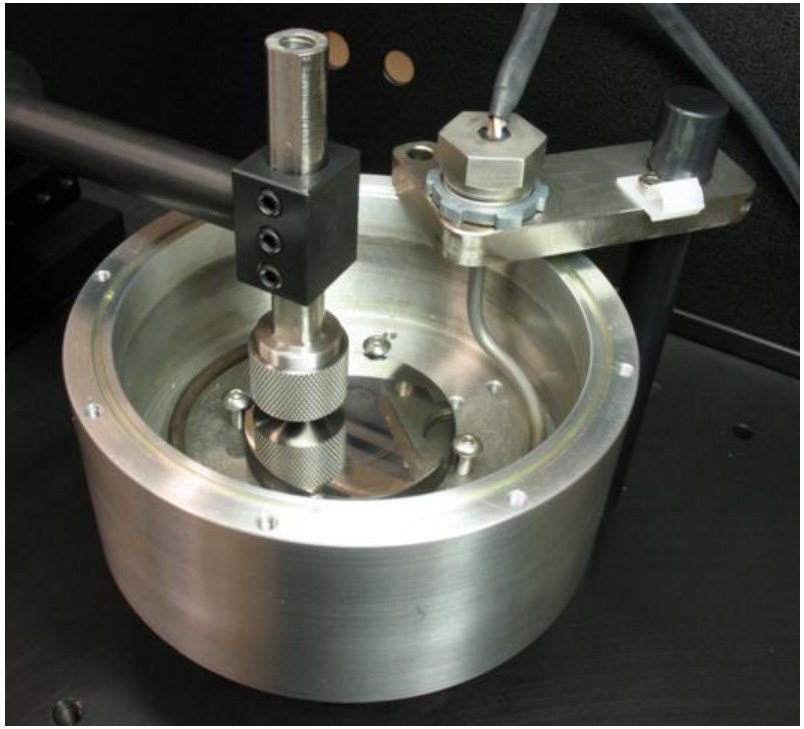




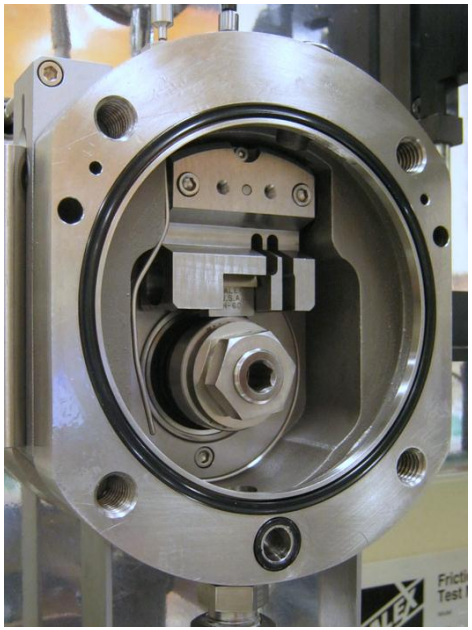
Nanovea ball on disk with heater

- Controlled environment, N_2, air
- 0.1 - 2000 rpm
- 2-20 N load
- Liquid heating to 150°C
- Data acquisition of friction force, temperature, RPM, angular position

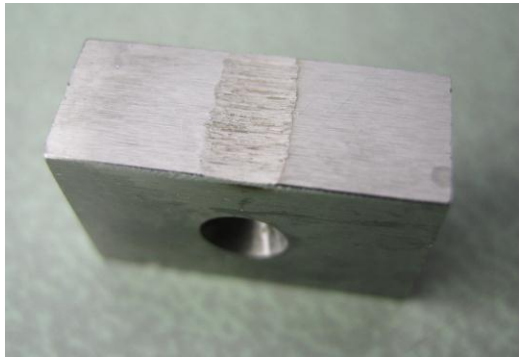


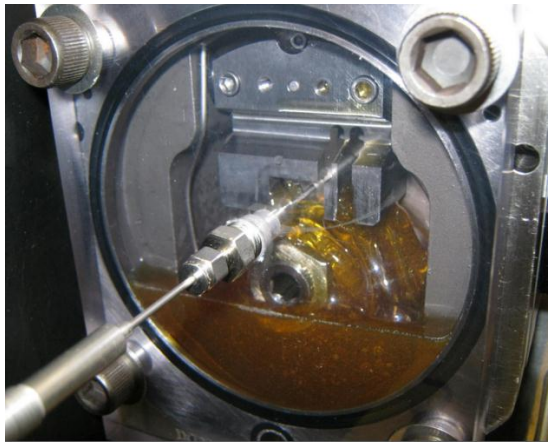


Falex high load block on ring



- Standard blocks and rings
- 0-5000 N
- Heating to 100°C
- Data acquisition of friction force, temperature, cycles, wear



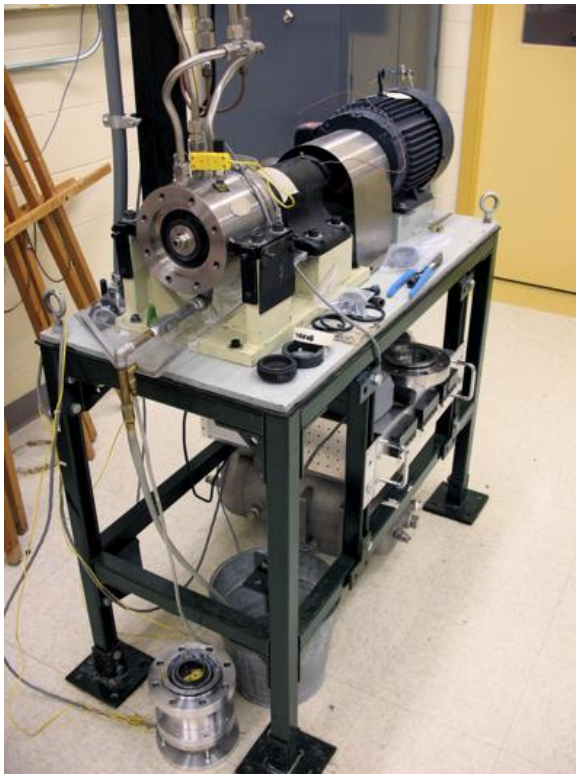


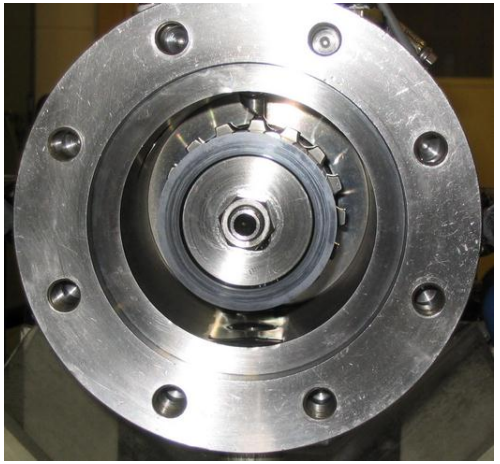
CSM high-temperature ball-on-disk

- 700C, air or N_2
- 1-20 N, 0.1-200 rpm
- X-ray enclosure (not used)

Mechanical Face Seal Testing

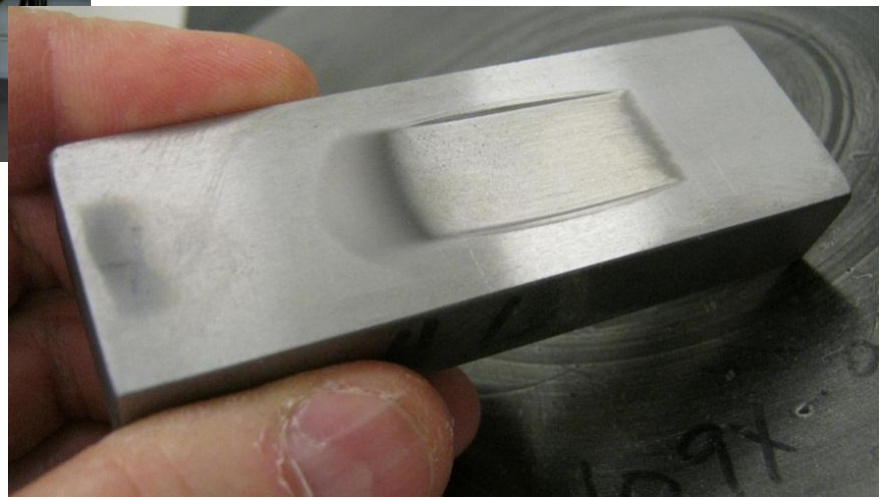
- Opposed seal geometry (two pairs of seals) operating in water at 100 psi with recording of rotation speed and friction coefficient





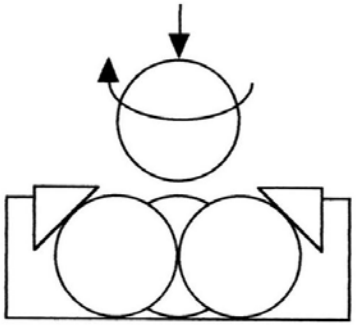
Falex Sand Abrasion

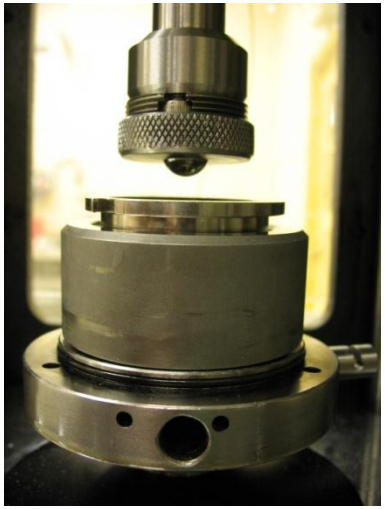
- Dry or wet sand abrasion
- Standard 1 hr test
- Special once-through graded sand
- Wear determined by weight loss



Falex 4-ball test

- 4-ball test of gear lubricants with data acquisition of temperature, torque, and speed
  - Effect of contaminants, particulate additives, and fuel dilution



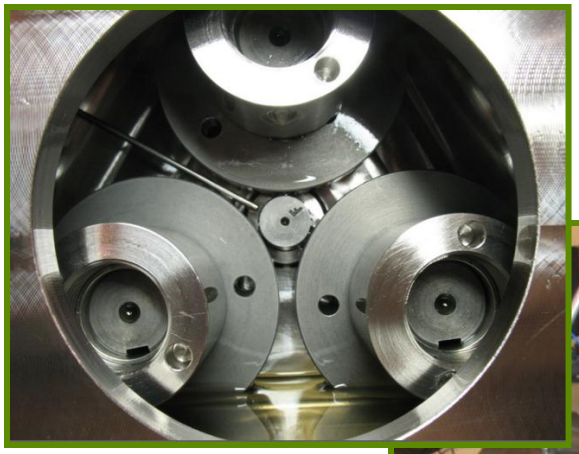


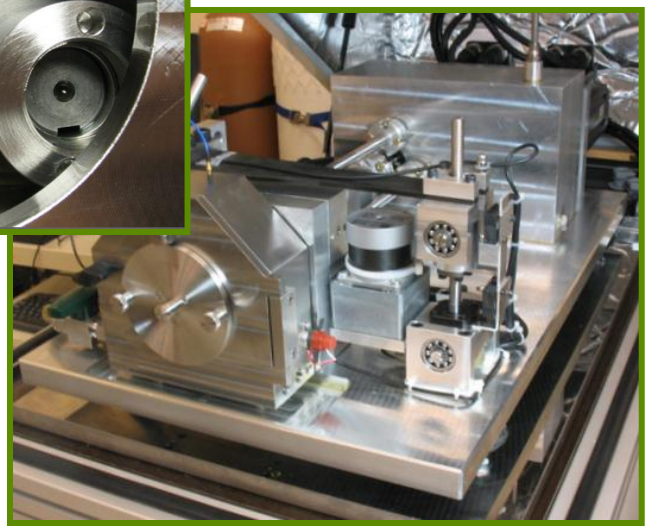
CETR universal tribometer

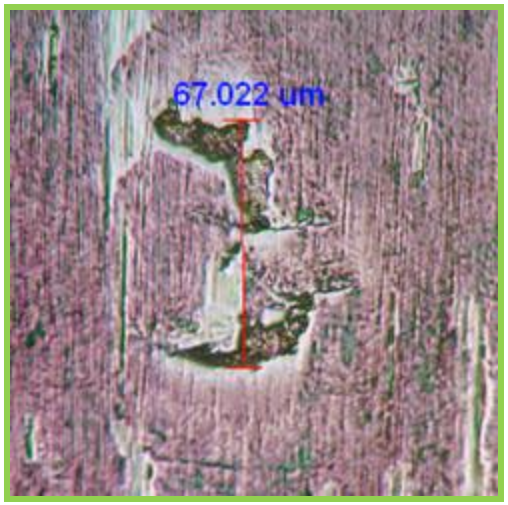
- Reciprocating, ball on disk or block on ring geometries
  - High speed data acquisition possible

PCS micropitting machine

- 3-roller design to promote accelerated fatigue testing- micropitting
- 1,000,000 cycles in 1 hr
- High load
- Variable slide/roll ratio

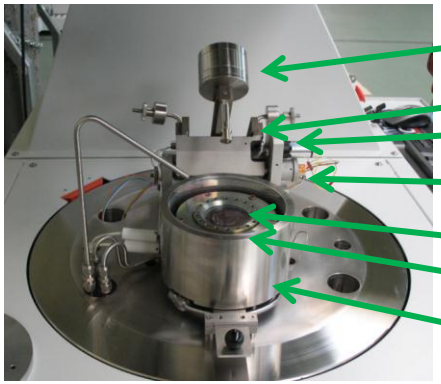






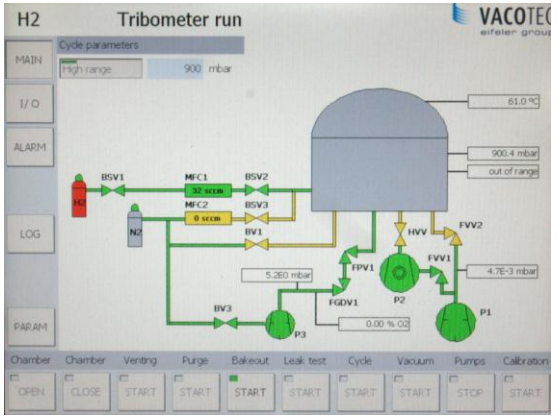
CSM high temperature vacuum and H_2 tribometer

- Ball sliding against rotating disk
- Up to 800 C at 2000 rpm



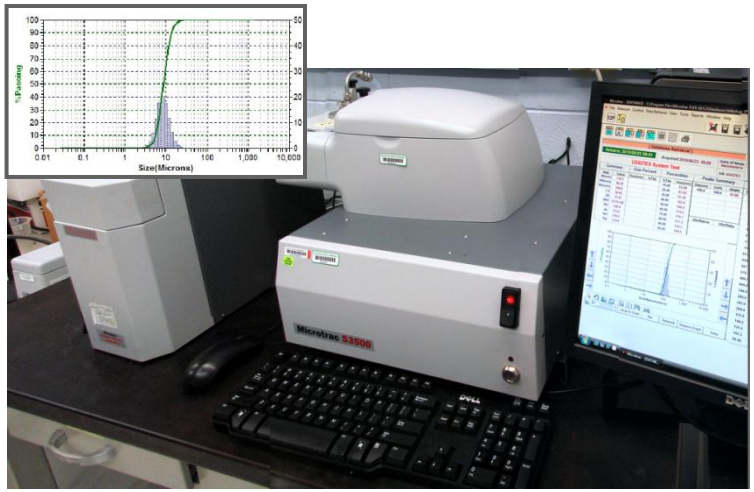
Load
Arm
Friction sensor
Displacement sensor
Disk holder/clamp
Heater
Cooling shroud

Internal view of tribometer



Characterization and Property Measurement

Cannon-Fenske Capillary Viscometer



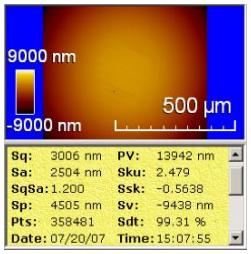
Laser Diffraction Particle size analyzer
Dynamic Light Scattering PSA

Coating thickness Calotest

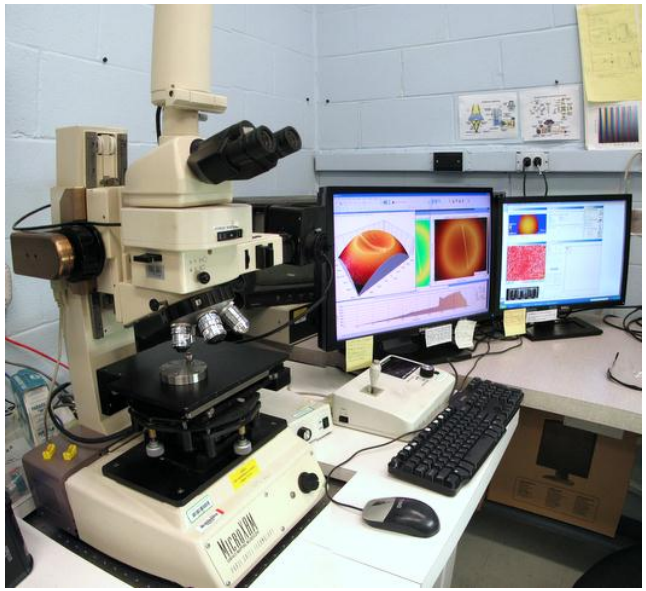
Macro Hardness

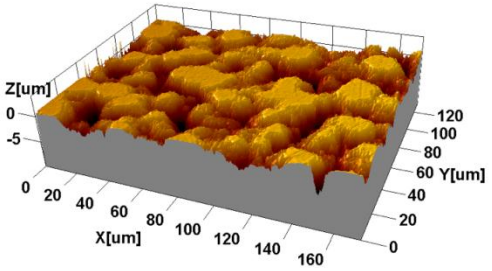
Microhardness

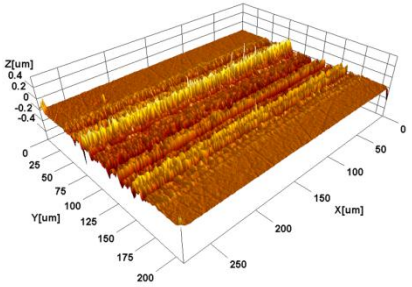
Optical profilometer (MicroXAM)



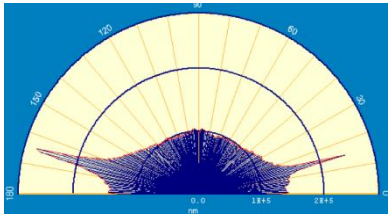
Metrology



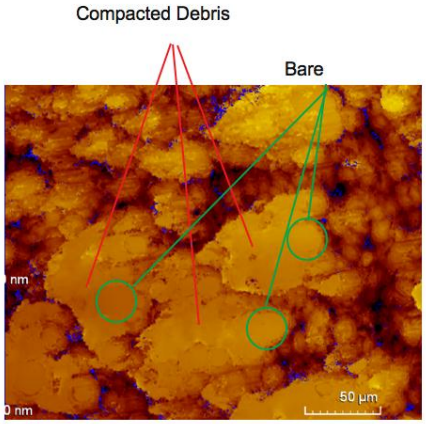




Track analysis



Texture distribution



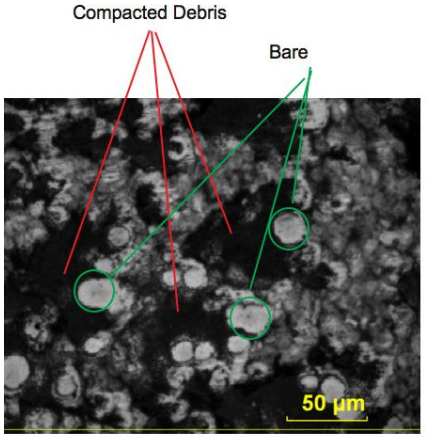
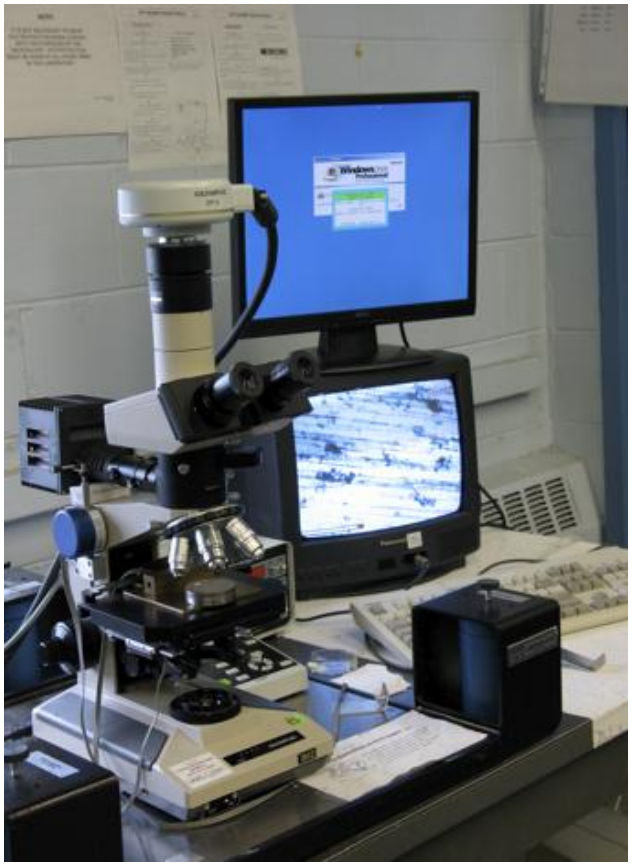


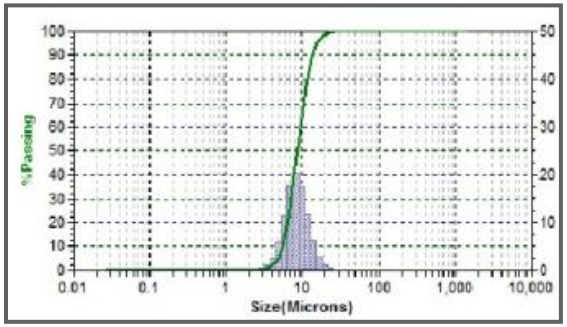
Image comparison

Optical microscopy



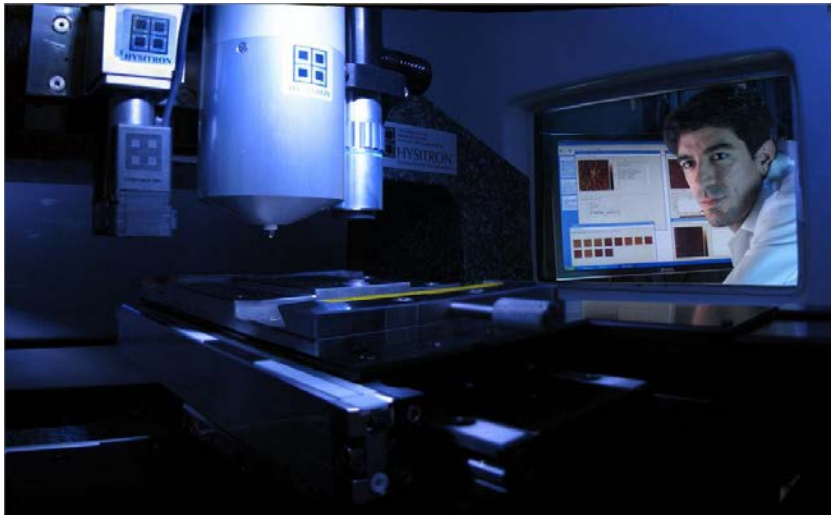
Size Distribution of Solid Particles in Liquid

- Laser diffraction – 100 nm to 1 mm
- Dynamic light scattering - 10-1000 nm



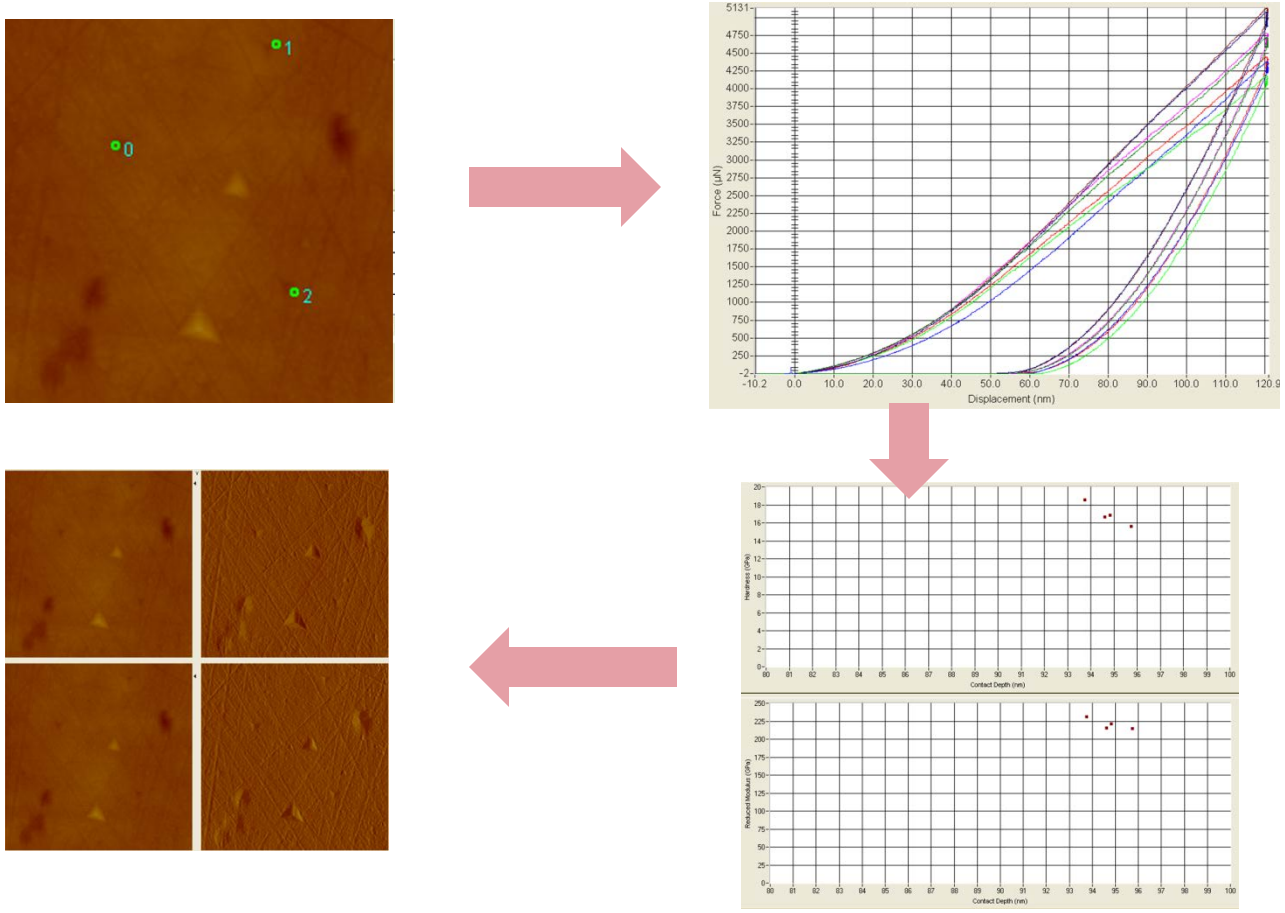
Hysitron nanoindenter

- Hardness/modulus/surface topography of thin films
- Nanoindentation, nanoscratch, high-load indentation, high-load scratch

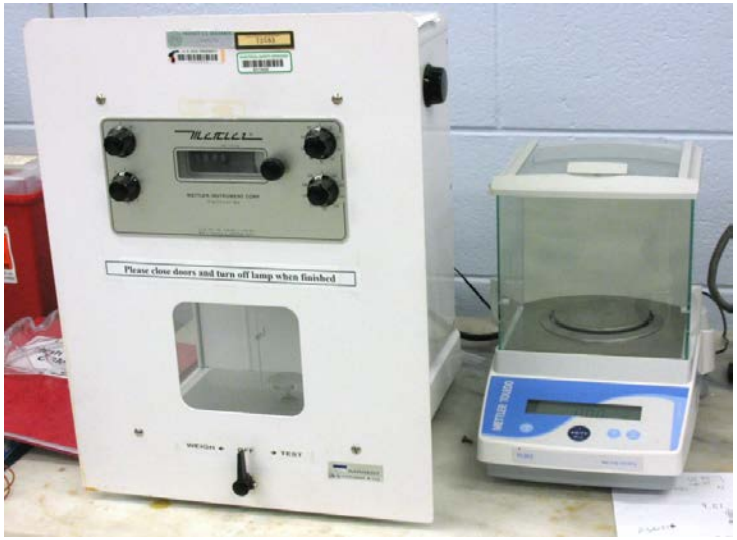


Nanoindenter (cont.)

- Hardness / Modulus / nanoscratch / high load scratch
- Typical indendation depth 100 nm



Preparation



Microbalances

Cutoff Wheel

Nitrogen glovebox for moisture-sensitive or oxygen sensitive materials

Preparation

Struers Citopress hot press machine for sample mounting

Struers Tegrapol Automated Sample Prep System

Ultrasonic Disruptor/Cavitator

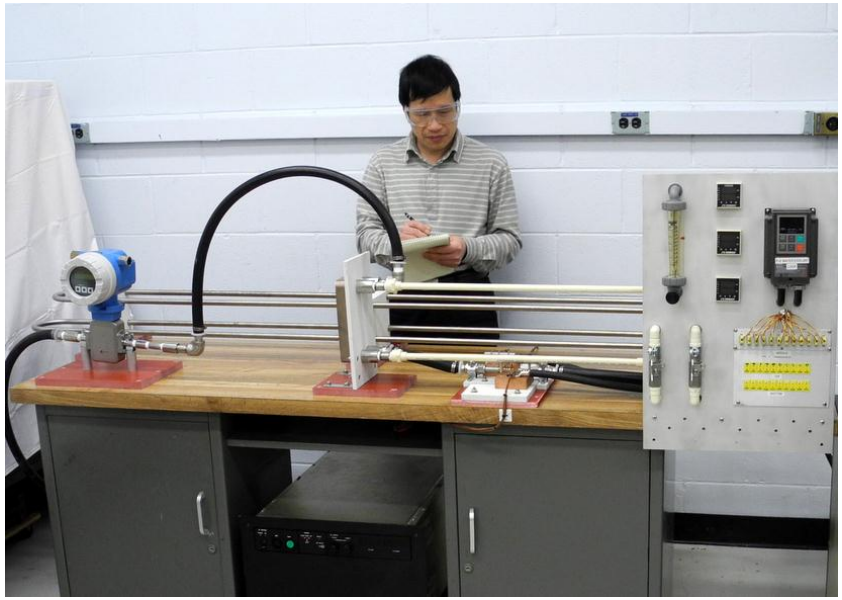
Can be used to mix liquids, or can be used to produce cavitation damage on steel surfaces per ASTM standards

Preparation

Eiger high-speed ball mill – blends in and reduces size of solid particles in liquids from micron to nanometer range

Section Facility – Coolant test loops

Used to measure transfer coefficients for industrial or transportation radiator/heat-transfer improvement



Section Facility – Surface treatment furnace

Pilot-plant scale **electro**chemical furnace produces surface treatment much faster than conventional industrial thermo-chemical treatment

Questions on:

Thin film deposition
Tribological testing
Characterization
Sample preparation
Other facilities