Micro Fabrication
A Brief Overview of Projects and Tools

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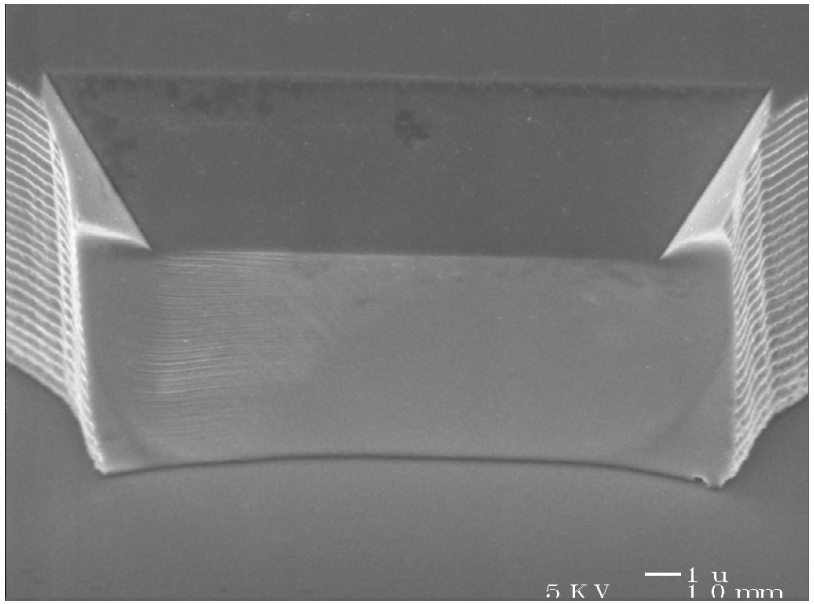
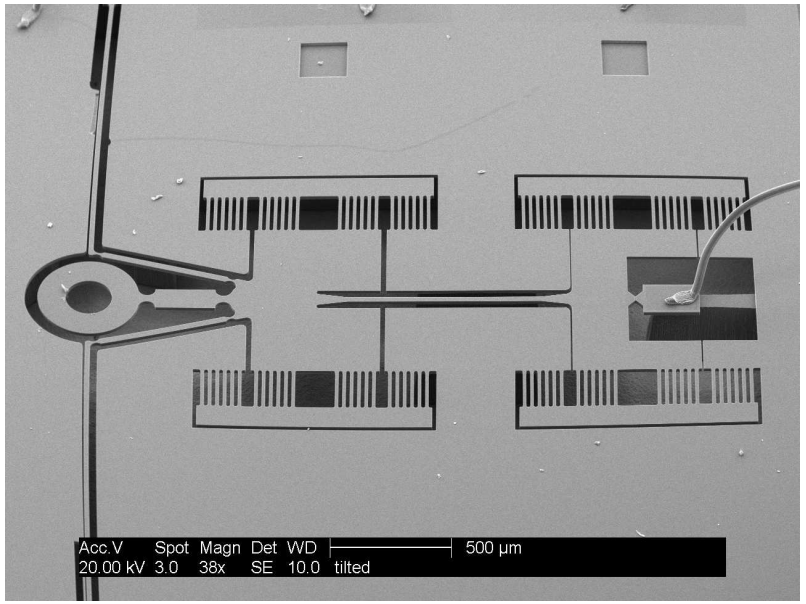
Projects

- Fracture-Gate
- Silicon Insert Molded Plastics
- Growing Carbon Nanotubes
- Micro Fabrication Tools

FractureGate

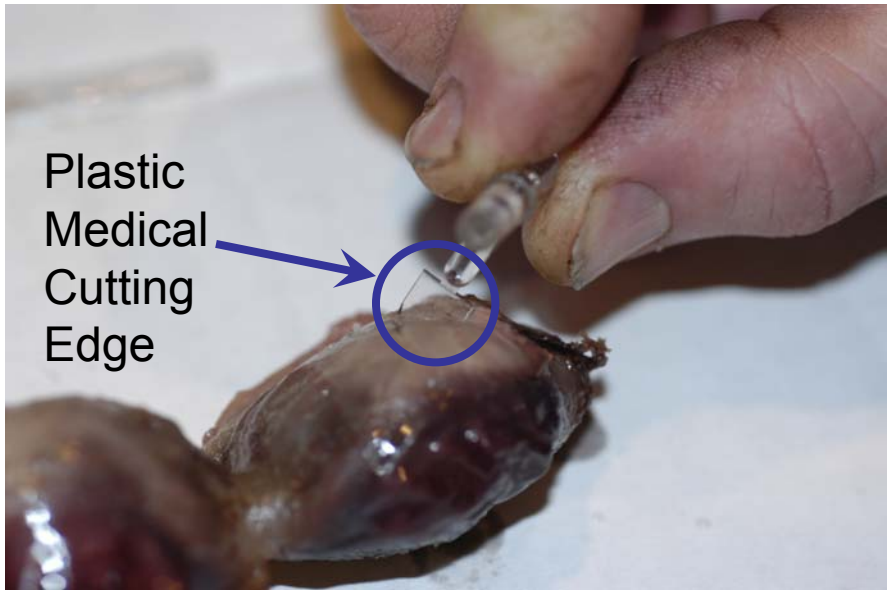


Deliberately fracture a weakened portion of a larger single crystal silicon structure to create complementary or atomically flat surfaces supported by a precision flexure bearing. Perfect brittleness of crystalline silicon at room temperature ensures mating surfaces.



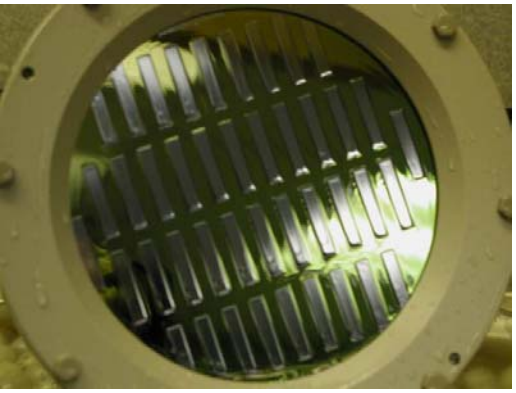
A variable capacitor with pairs of fracture surfaces for parallel plates. The gap between the plates is varied down to nanometer scale.

Silicon Insert Molded Plastics



- Used anisotropic etched silicon pieces in an injection molding machine to produce plastic medical cutting edges.

Silicon wafer



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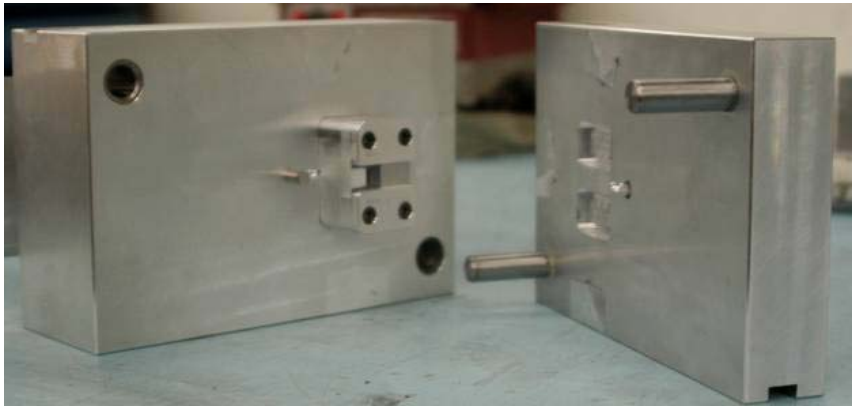
Mold Base



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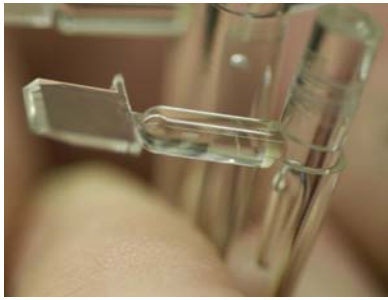
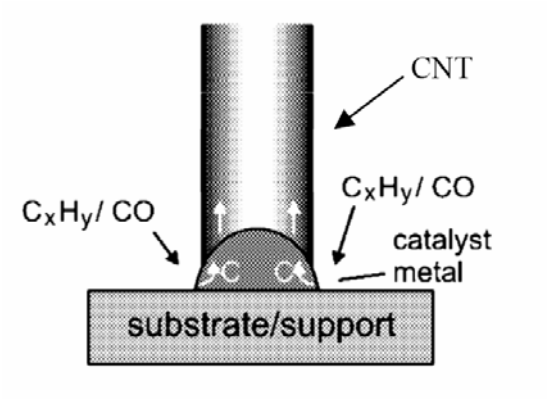
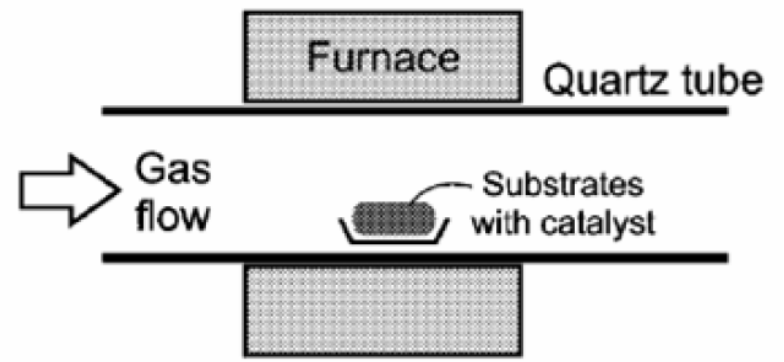
Plastic Medical
Cutting Edge

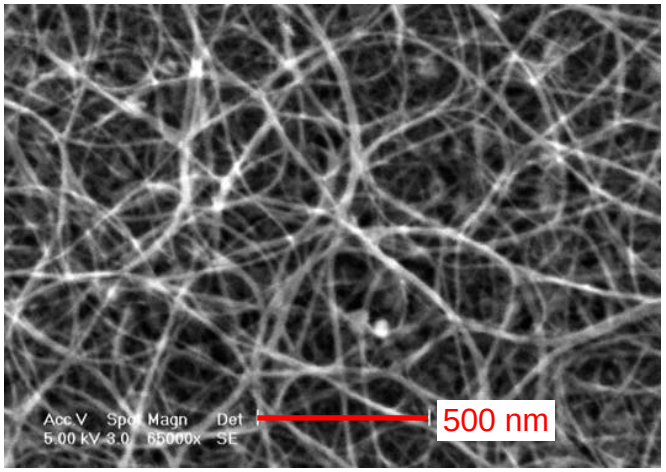


Growing Carbon Nanotubes

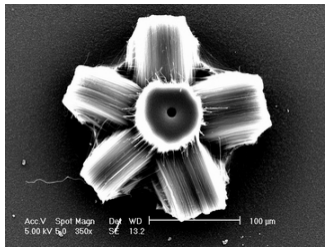
- Carbon nanotubes (CNTs) can have up to 250 times the strength-weight ratio of steel – 1/5 the density, and 50 times the strength!
- CNTs grow from nm-sized metal particles at ~700 ^{o}C, by decomposition of carbon-containing gases (e.g. methane).
- The catalysts are like seeds and the nanotubes grow upwards!

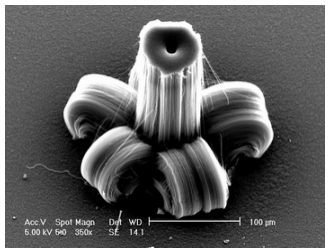






SEM image of tangled carbon nanotubes grown from methane (CH_4) and hydrogen (H_2) gases.

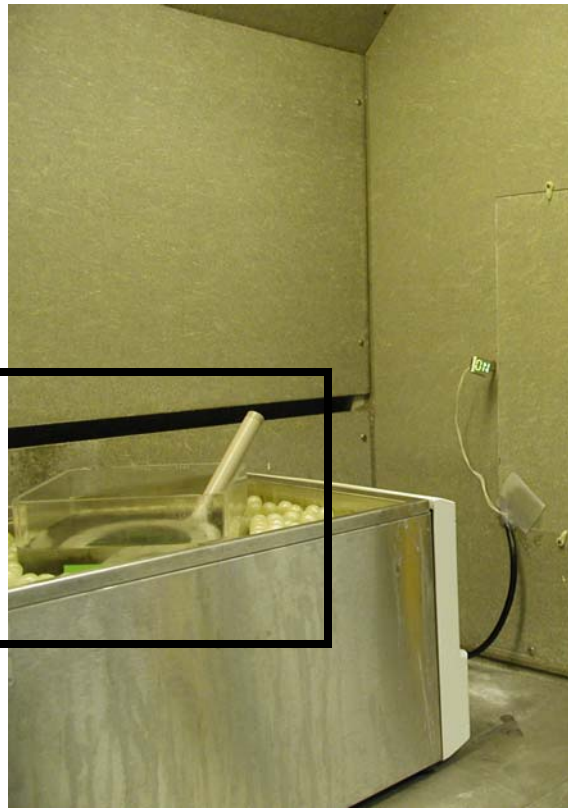




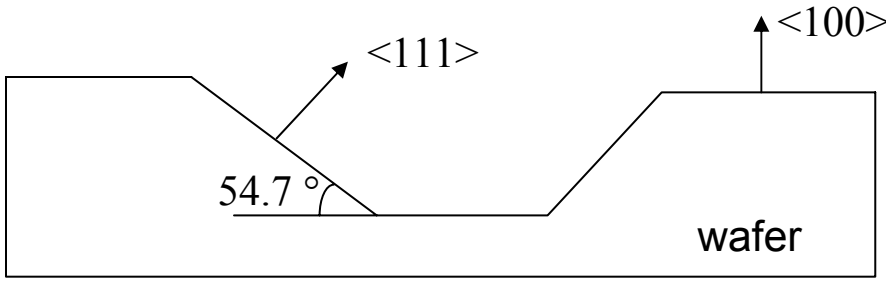
AME5000

•The AME 5000 is a Radio Frequency (RF) magnetically coupled etching system.
•Etches Thermal Oxide, Boron Phosphorus Silicate Glass, and Silicon Nitride.
•The system is completely controlled by a computer, and wafers are transported via robotic arm movement.
•Wafers are mechanically clamped onto a platform during the etching process and helium cools the backside of the wafer to keep the photoresist from burning.
•A load lock system lets the user load their wafers into a central chamber without breaking the etching chamber vacuum.

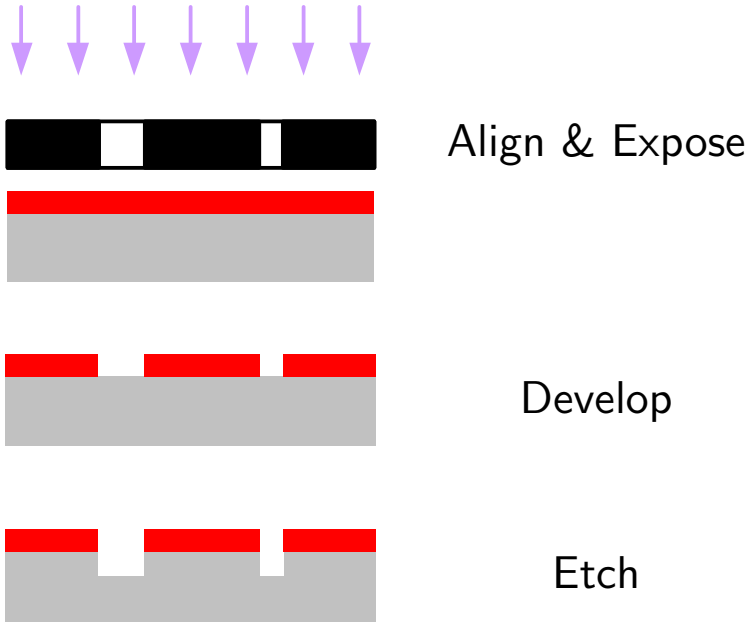
KOH/TMAH Hood



- This machine is used for Potassium hydroxide (KOH) and (Tetramethylammonium hydroxide (TMAH) etching.
- TMAH and KOH anisotropically etches silicon to give a 54.7º angle with the <100> plane.
- Masks can be oxide, nitride, or in some cases, aluminum,
- A circular surface feature would etch rapidly in an inverted pyramid shape.

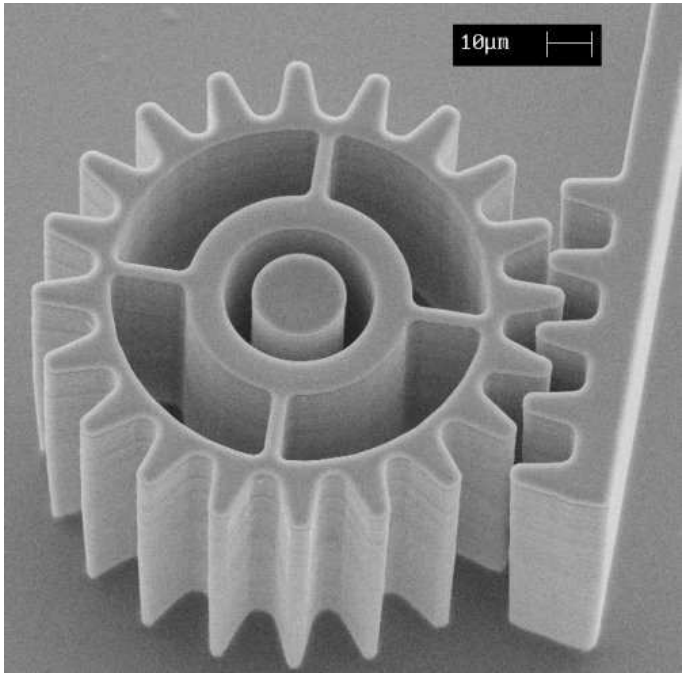


Electronic Visions 620 — Mask Aligner



1. Align masks to wafers for exposure
2. Exposure transfers the pattern on the mask to the wafer
3. Once the pattern has been developed, the wafer is etched

Surf. Tech. Sys. — Deep Reactive Ion Etcher



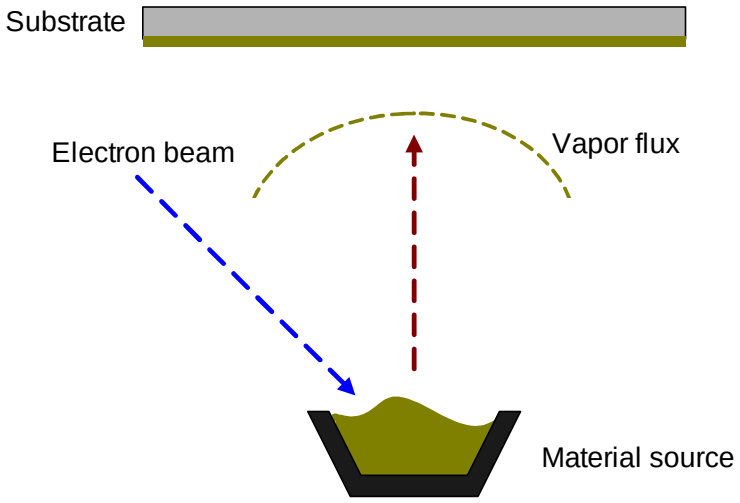
Deep, high aspect ratio structures can be etched, by alternately cycles of etching and coating the surface with teflon. Without the coating step, the etch would tend to go "out" almost as much as it goes "down." Alternating cycles leave scalloped sidewalls — visible as roughening in the SEM image.

Thermco — Furnace

Furnaces such as these are used to "grow" silicon dioxide (glass) or to deposit other thin films such as silicon nitride, polysilicon, or silicon carbide. The furnaces can maintain temperatures in excess of 1000°C (1832°F). The thin films are used as insulators or as the gates of transistors.

E-beam Evaporator

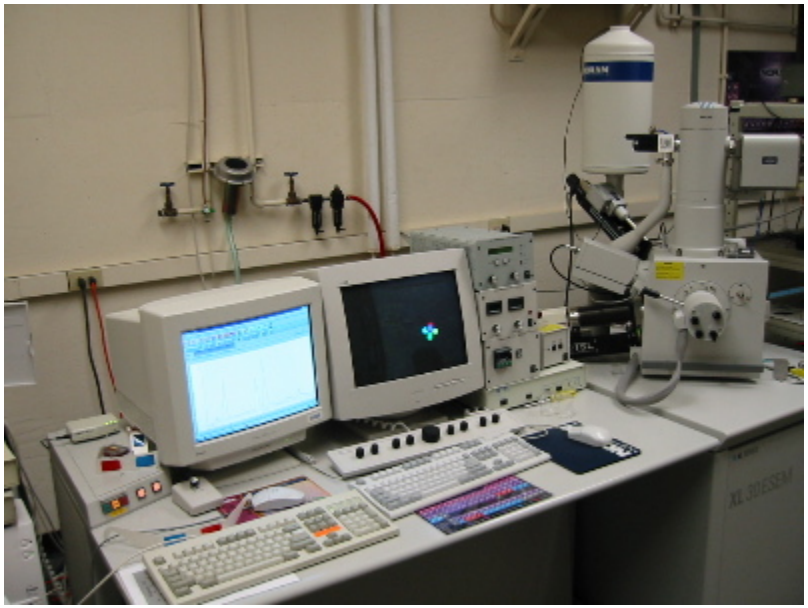
- Deposits very thin layers (nanometers to micrometers thick) of metals or insulators on substrates such as silicon wafers:
  - Electron beam heats a small container of solid material until it melts;
  - The metal vapor fills the vacuum chamber and sticks to the substrate;
  - Beam power is adjusted for the material and desired deposition rate.
- Applications of these materials:
  - Interconnects in circuits
  - Thin-film heaters and sensors
  - Catalysts in microreactors



Vacuum chamber

Scanning Electron Microscope (SEM)

- Uses a scanning electron beam to see features smaller than the wavelength of light.
- Electron optics: deflect and focus electron beam using magnetic fields.



Philips XL30 FEG-ESEM
(from http://vulcan2.cwru.edu/Groups/Ernst/xl30.html)

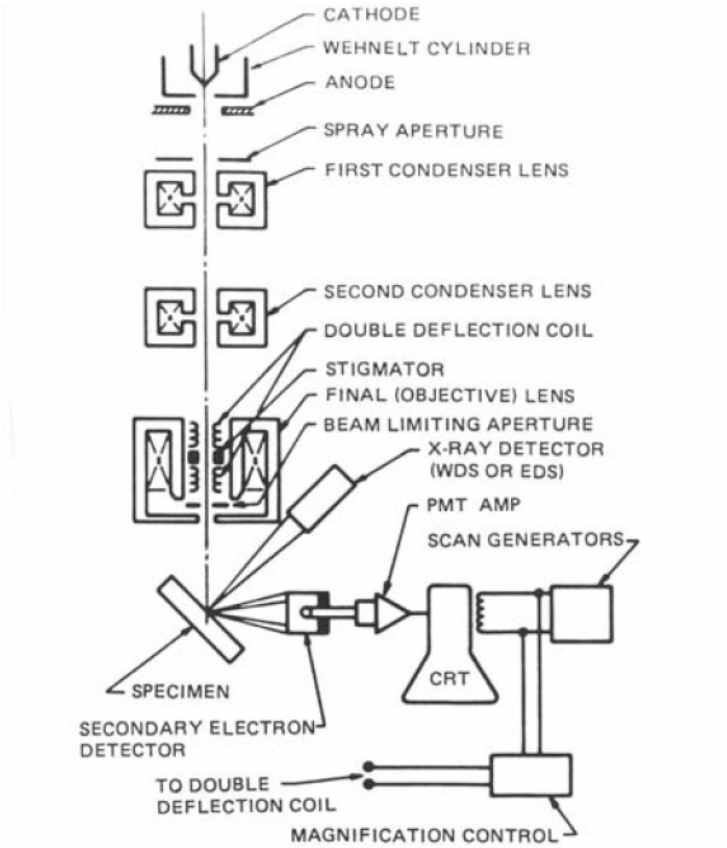


Figure 6-7. Schematic of the scanning electron microscope. (From Ref. 9, with permission from Plenum Publishing Corp.).