University of Texas Microelectronics Research Center
node of the
National Nanotechnology Infrastructure Network

DRY ETCHING CAPABILITIES

Ricardo Garcia
Marylène Palard
MRC UT Austin

Plasma etching systems at MRC

12 chambers for dry etching

Fluorine & Chlorine based gas chemistries

Silicon based device etchers

Plasma Therm N°2 (2 chambers)
Bachtop (1 chamber)
Orange RIE (1 chamber)
Versaline Deep RIE (1 chamber)

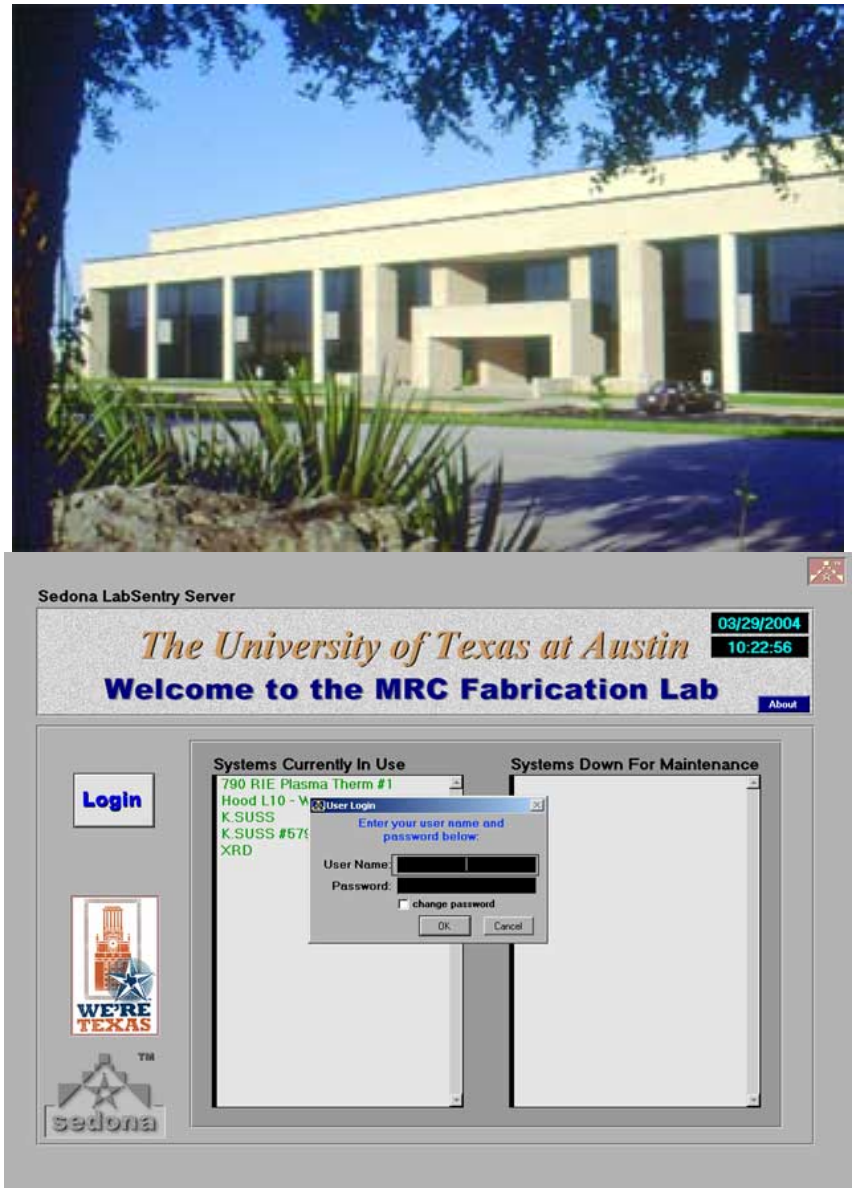
III-V's based device etchers

Plasma Therm N°1 (1 chamber)
Oxford 100 ICP(1 Chamber)

Polymer etchers

Oxford RIE 80 (1 chamber)
Trion (3 chambers)

Descum: Inductive and microwave plasma



Web site information on Equipment

www.mrc.utexas.edu/nnin.html

Description of each equipment
Location in the cleanroom
Procedure to operate

O2 plasma required for cleaning the reactor prior and after the etch run

Silicon Etch Bay

RIE Etcher (790 Plasma Therm #2) - Plasma Therm
Location: 1.738

Description: Reactive Ion Etcher
Compatible Materials: Si (to etch with Cr mask, use the ORANGE RIE)
Incompatible Materials: III-V / Hi K / Metal
Features: 2 etching chambers
up to 8" wafers
right chamber gases: CHF3, O2, H2, Ar
left chamber gases: Cl2, HBr, O2, CF4, He
turbo pump

1. Log on to the tool using the LabAccess terminal.
2. Log into the system software.
3. Select the chamber to be used.
""Utilities"=> "Select Active Chamber"=> chose either the left or right chamber"
4. Vent chamber : "Utilities"=> "Vent"
5. Clean the chamber before the first process is started. Wipe the walls and any quartz wafer holders with Acetone and then IPA. Wipe the graphite susceptor with IPA.
6. Run a 10 to 30 minute oxygen clean, Pressure = 200mTorr, O2=18sccm, power = 300W.
7.Vent chamber : "Utilities"=> "Vent"
8.Place your wafer in the chamber.
9.Firmly hold the lid to the chamber down and evacuate the chamber by choosing: "Utilities"=> "Pump Chamber"=> "LoVacuum". Once the chamber is under vacuum you may stop holding the lid down. System status will now be ON & STANDBY.
10.To edit a recipe choose: "Process"=>"Edit", now choose the recipe from the list. Edit the recipe and save it before exiting.
11. To load a recipe choose: "Process"=>"Load", now choose the recipe. System Status will change to ON & READY. The loaded recipe will show in the Process box at the lower right.
12. Run the loaded recipe by clicking the RUN button at the lower right.
13. Once your recipe is finished, vent the chamber, remove your sample and pump the chamber down again.
14. ALWAYS CLOSE GATES. Always close the gate between the chamber and the pumps before logging off or when leaving the system idle for over 10 minutes. When the gate is left open pump oil back streams into
the chamber. Choose: "Utilities"=>"Close Gates".
15. Log off of the system software.
16. Log off of the tool using the LabAccess terminal.

Silicon based device etchers - I

Orange RIE (foot print will be replaced by STS etcher)

Description: RIE Etcher
Compatible Materials: Si compatible tool like Si / SiGe / Hi K / CMOS metal
Incompatible Materials: III-V / Polymers / Indium/ Metal
Features: 1 chamber / gases: Cl_2, O_2, CHF_3, CF_4, He or Ar (depending on the cylinder).

HFO_2, TaN Will be transfer to Bachtop RIE
Quartz/SiO_2: CHF_3 (67%) 0_2 (33%)
RF MAX=150W
32nm/min

Silicon based device etchers - II

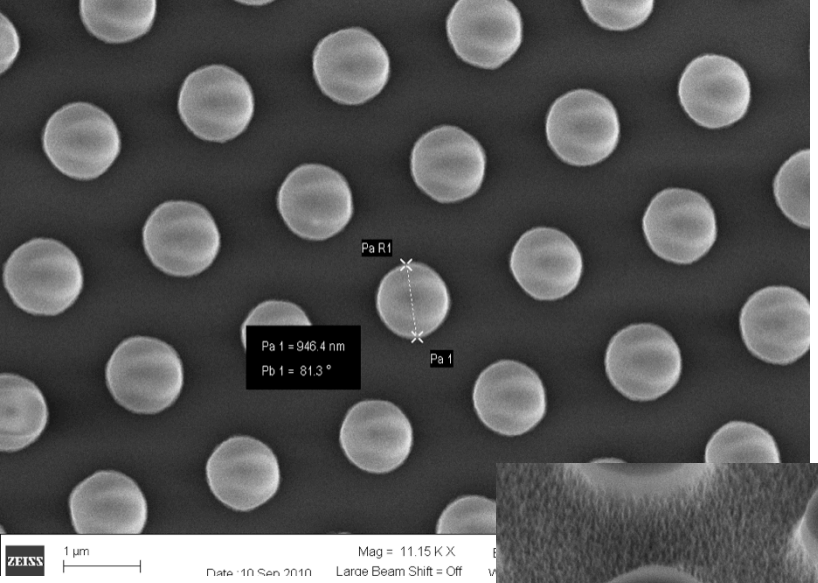
- **Plasma Therm Batchtop**

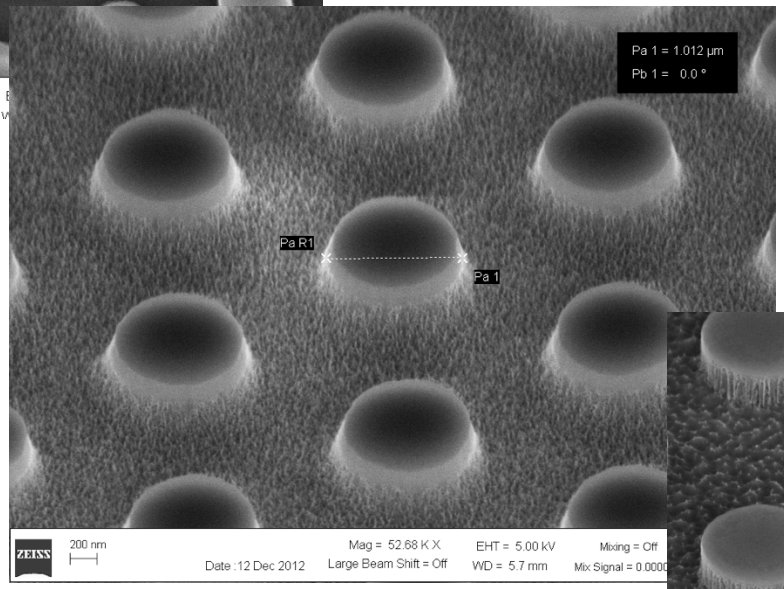
Description: RIE Etcher
Compatible Materials: Si compatible tool like Si / SiGe / Hi K / Metal (except Au)
Incompatible Materials: III-V / Polymers / Indium
Features: up to 6" wafer
Cl_2 (10 sccm), HBr (20sccm), O_2 (20 sccm), CF_4 (44 sccm),
Min pressure: 10mTorr
Max RF Power=400W

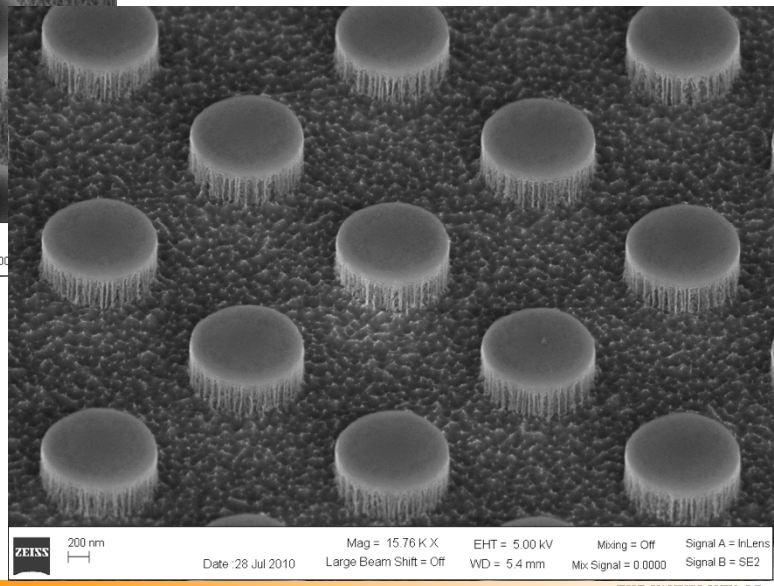
Medical device prototyping: Ferrari's group at Methodist Hospital Houston

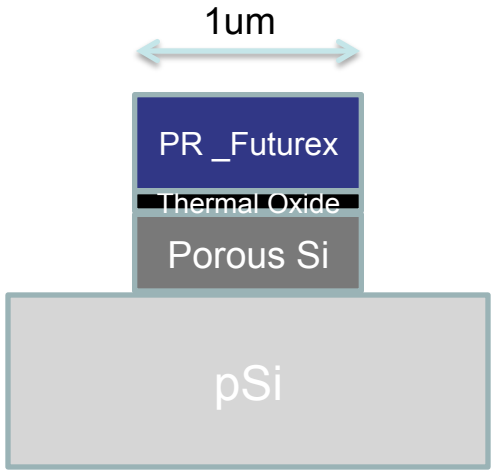
Porous Silicon Medical Devices

Methodist Hospital (M Ferrari)









Top view of the patterned resist (500nm) (#1). Progression of the etch through the oxide (80nm) and just into the porous layer (400nm) (#2) and then etched through to the bottom of the porous layer, showing full particles still on the wafer (#3).

Silicon based device etchers - III

- **Plasma Therm n°2, 790 series**

  Description: RIE Etcher

  Compatible Materials: Si (to etch with Cr mask, use the ORANGE RIE or Batchtop)

  Incompatible Materials: III-V / Hi K / Metal

  Features: up to 8“ wafers

  right chamber: CHF_3 (54sccm), O_2 (20sccm), H_2 (20sccm), Ar (50sccm)

  left chamber: Cl_2 (20sccm), HBr (100sccm), O_2 (20sccm), CF_4 (50 sccm), He (100sccm)

  turbo pump (10^{-5} Torr)

  SiO_2: CHF_3=40sccm, O_2=3sccm, DC=400V (RF=182W), P=40mTorr Etch rate 32nm/min

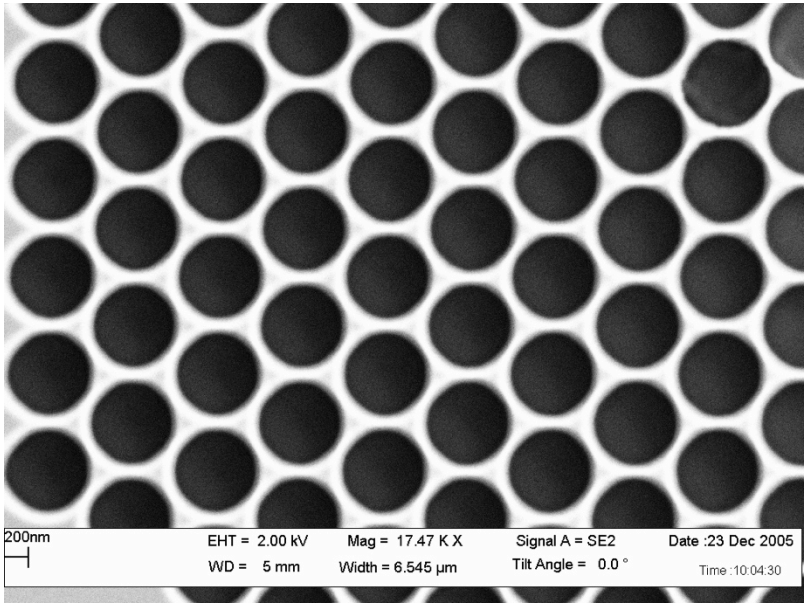
  Poly Silicon: 20sccm HBr, 5.5sccm Cl_2/70DC Bias/70mTorr

Turbo pump for base pressure of 10^{-5} Torr Si etch without balckening effects

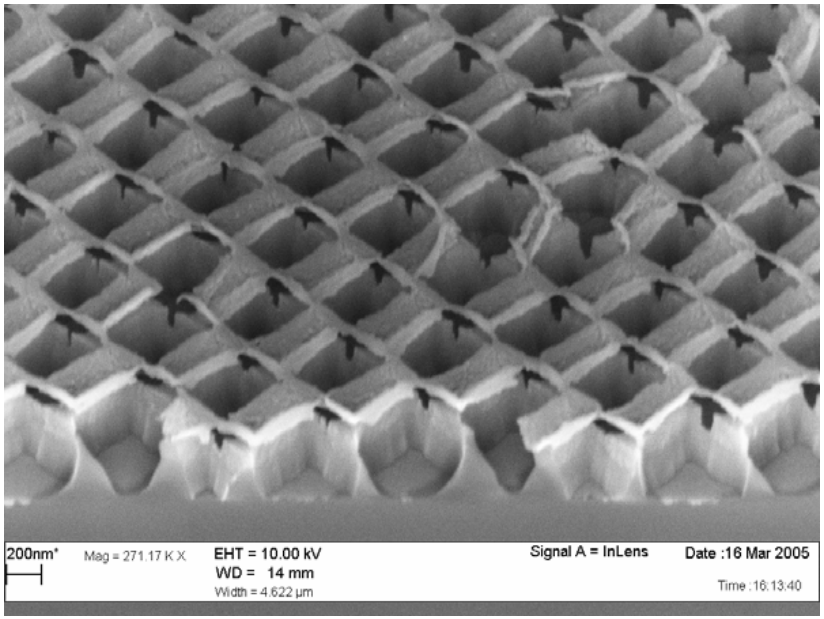
Silicon based device etchers - III

- **Plasma Therm n°2**

Silicon: HBr=25sccm, Cl_2=4sccm,
DC=250V (RF=128W),
Pressure=40mTorr
Etch rate 37nm/min



Photronics Crystal on SOI
Diameter 700nm, Spacing 900nm



Column diameter: 230nm
Spacing: 400nm
Etch depth on Silicon=405nm

III-V's based device etchers - I

- **Plasma Therm, 790 serie n°1**

Description: RIE Etcher

Compatible Materials: III-V

Incompatible Materials: Metal / Hi K

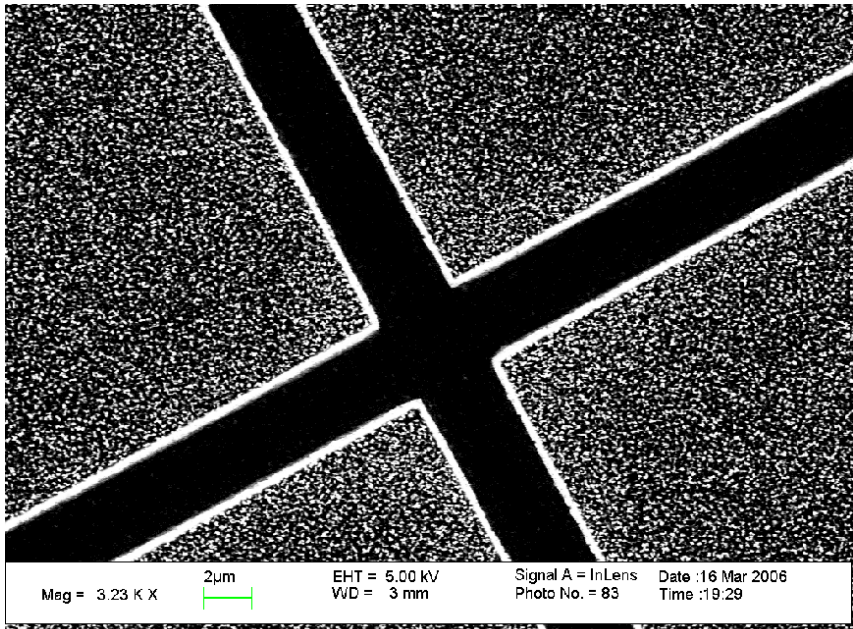
Features: CF_4, BCl_3, $SiCl_4$, O_2, CH_4, SF_6, H_2,

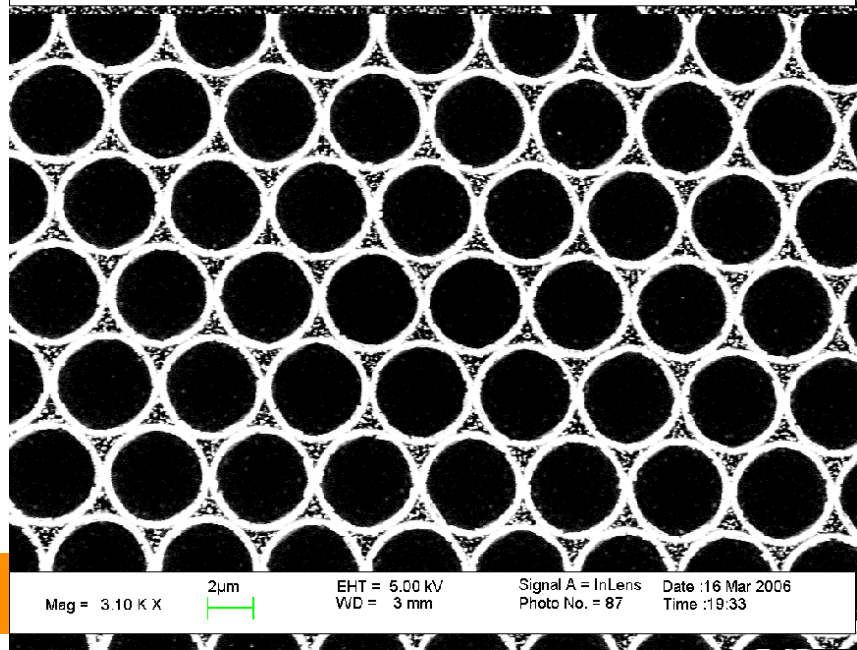
GaAs: BCl_3=8sccm, $SiCl_4$=8sccm, RF=100W, P=33mTorr

Etch rate 280nm/min

Selectivity: ZEP520 : SiO2 (3:2?)

SiO_2 : GaAs (>20?)





Polymer etchers - I

- **Oxford Plasma Lab 80**

Description: RIE Etcher

Compatible Materials: Si / SiGe / III-V / Polymer

Incompatible Materials: Metals

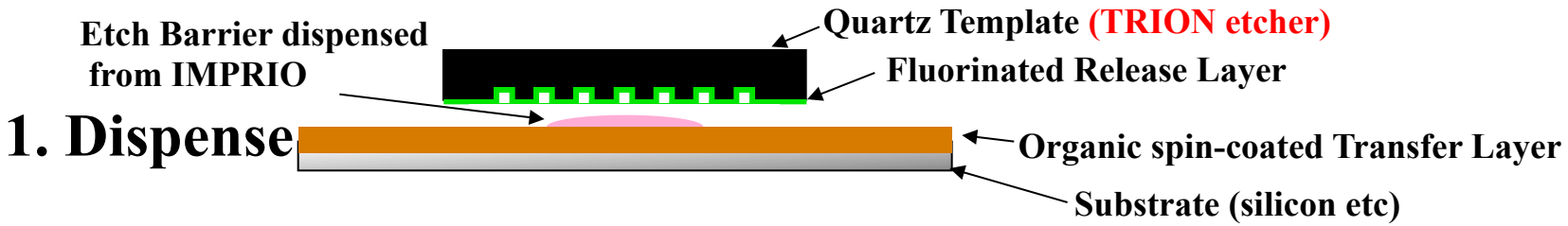
Features: up to 8" wafers

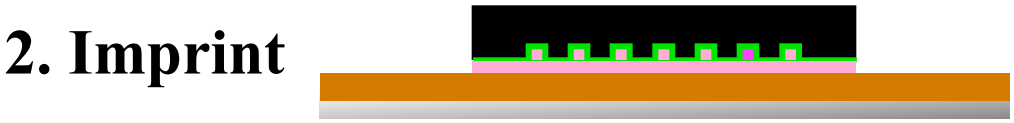
chamber gases: CH_4, N_2, H_2, Ar, CHF_3, Cl_2, SF_6, Ar

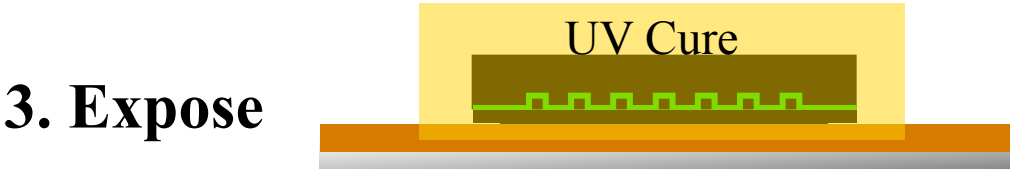
cold chuck (-9°C)

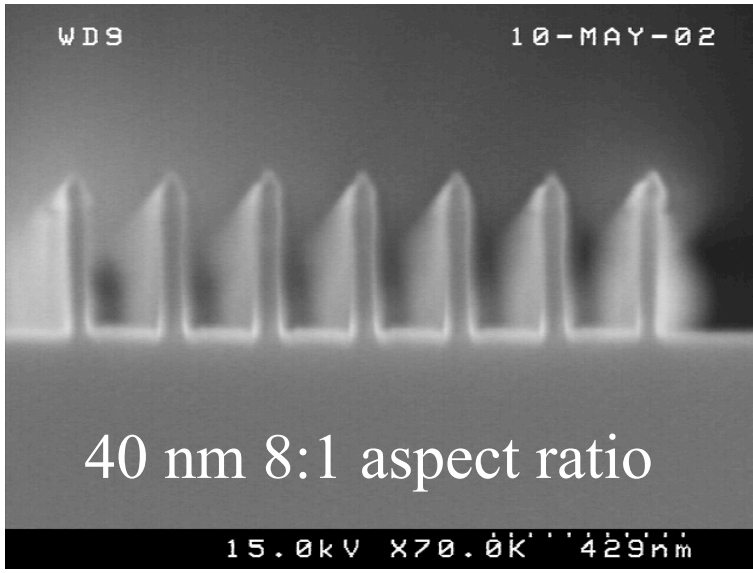
turbo pump

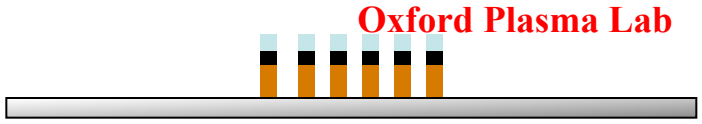
SFIL: Process





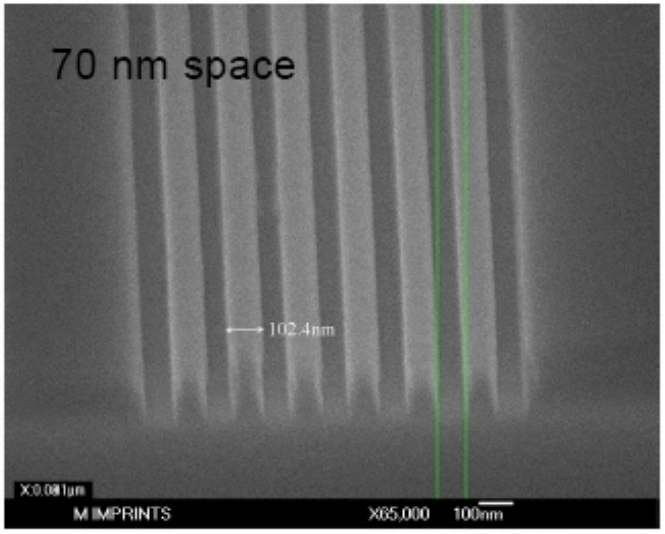


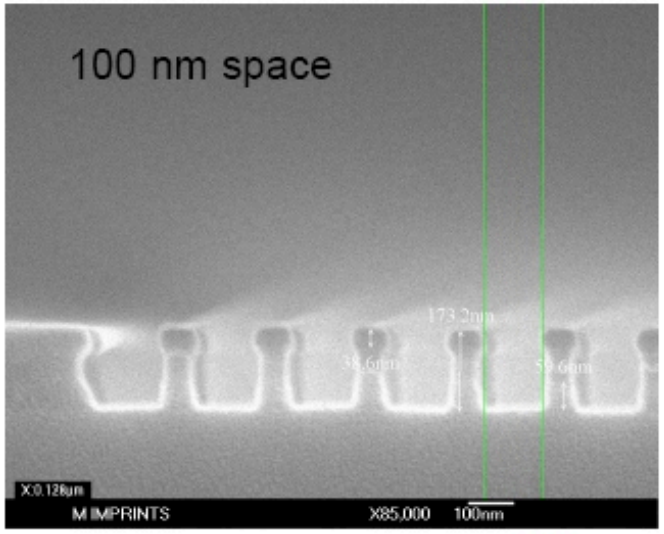


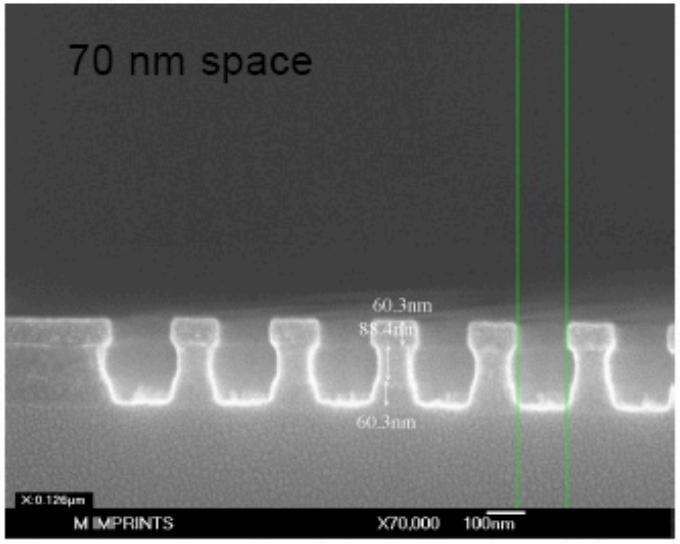


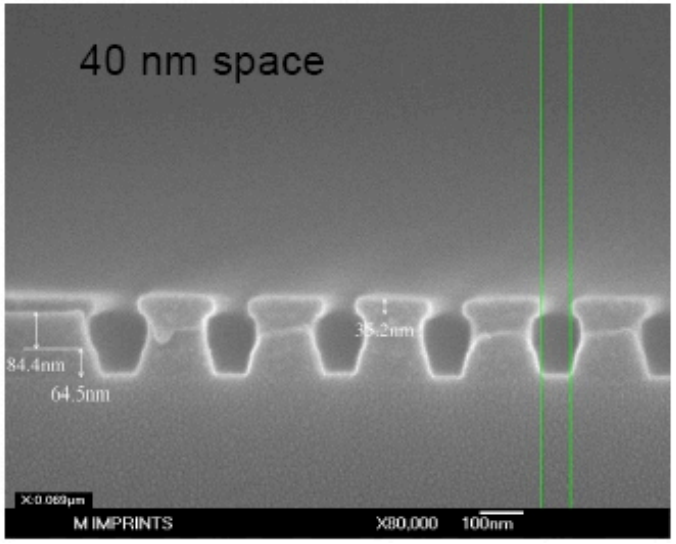
SFIL plasma etching profiles

After the etch-back of the SilSpin and subsequent etch of the MonoMat, the pattern profiles illustrated below are obtained:









Residual resist layer: O_2=8sccm, DC=200V, P=5mTorr
Etch rate 46nm/min

Barc-DUV30J:
CHF_3=15sccm,
O_2=7.5sccm,
DC=200V,
P=25mTorr
Etch rate 60nm/min

Polymer etchers - II

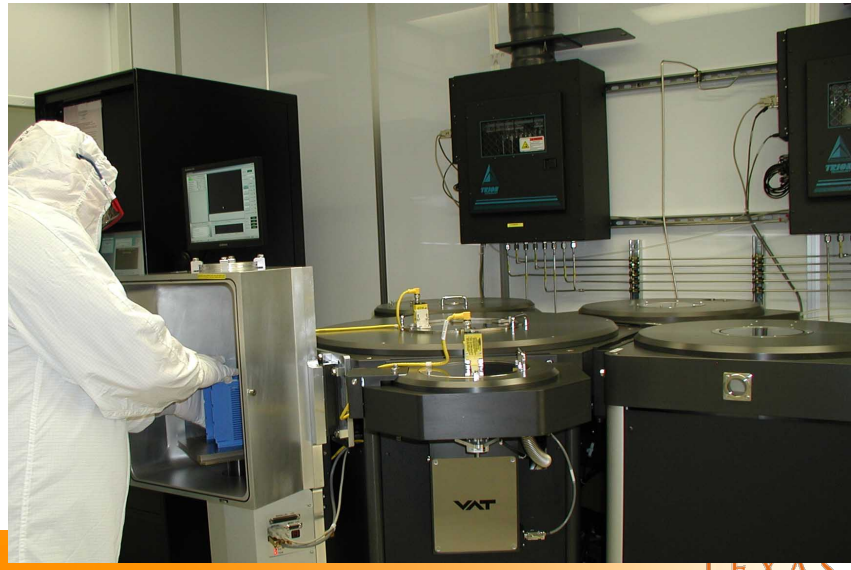
Trion - Oracle cluster

Description: RIE Etcher
Compatible Materials: IMPRIO related project
Incompatible Materials:

Features: **Central Vacuum Transport**
LL

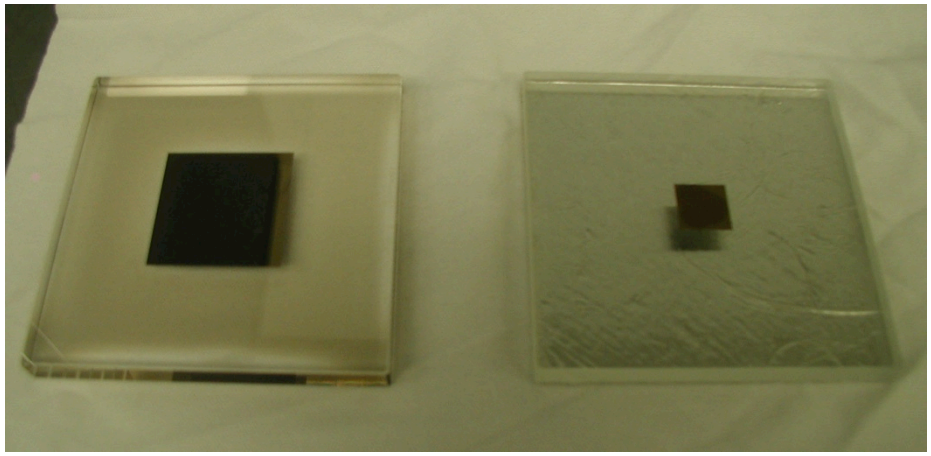
Reactor 1: CF_4, SF_6, O_2, Ar, N_2, CHF_3, He
Reactor 2: SO_2, O_2, CO_2, Ar, N_2, C_2H_6, He
Reactor 3: Cl_2, He, CF_4,
Electrostatic Chuck with Helium back side cooling (-**30°C**)

turbo pump on each chambers



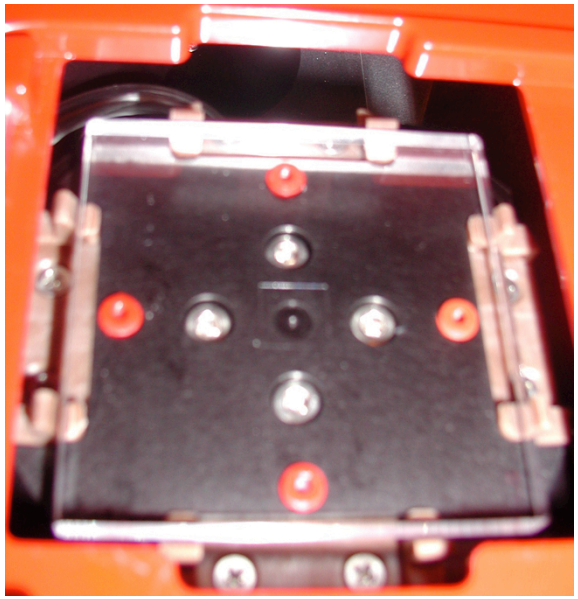
Template process: Trion etcher

Quartz: CF_4=15sccm, He=40sccm, RF=130W, Pressure=40mTorr
Etch rate 31nm/min



Quartz molds with 25mm² and 10mm² mesa

Chrome: Cl_2=40sccm, RF=80W, Pressure=30mTorr, 150sec for 15nm



Template in the IMPRIO pocket ready to be loadid for SFIL

Deep Silicon Etching

- **Plasma Therm, Versaline**

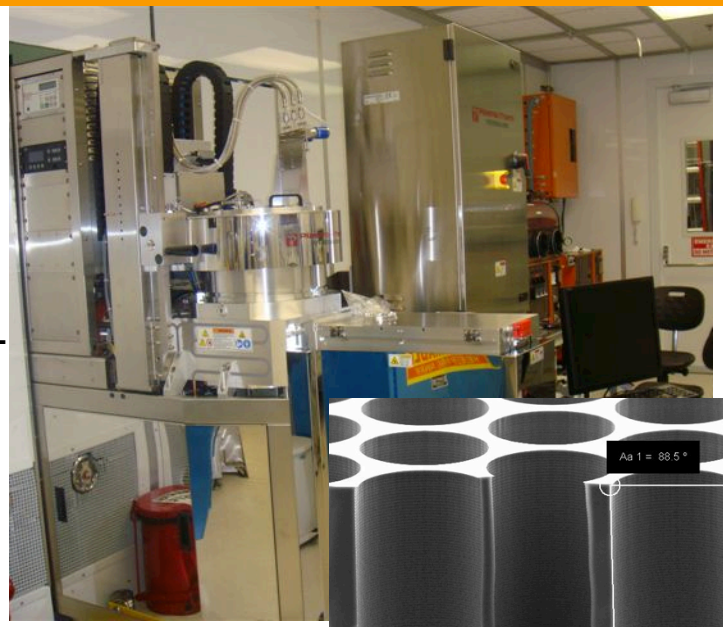
Description: Deep Si Etcher – Bosh, LL 4inch

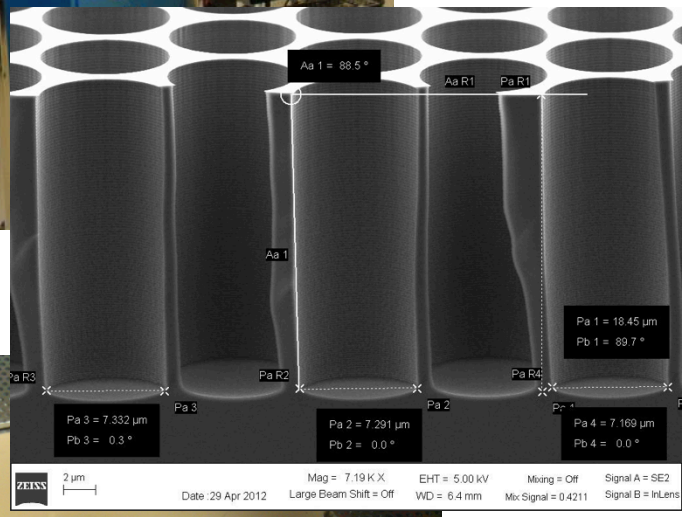
Compatible Materials: Si
Incompatible Materials: Metal / III-V

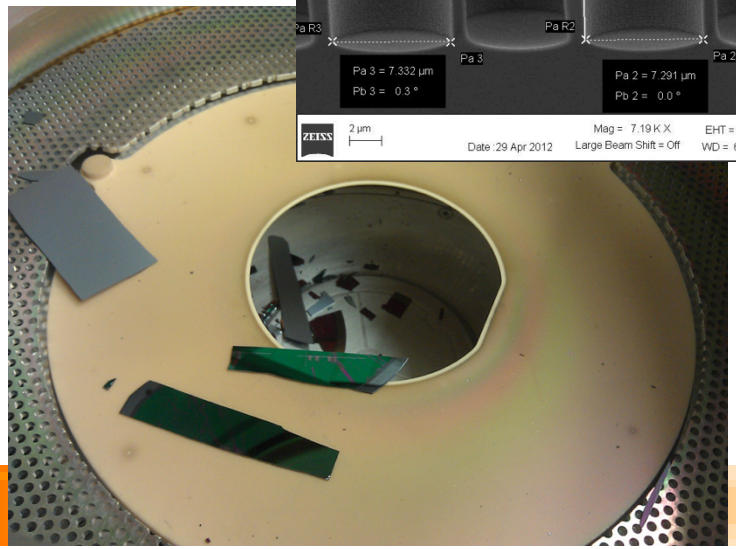
Features: C_4F_8, SF_6, H_2, O_2

Deposition / Etch of SOI:
SF_6=50sccm, C_4F_8=125/40sccm,
ICP=1600/1400W, P=40/30mTorr
Etch rate 120cycles ->7.2um

Do not forget edge beads removal on full 4inch wafer.







III-V ICP etching

- **Oxford 100 ICP**

Description: Deep Etcher, 4inch, LL

Compatible Materials: III-V
Incompatible Materials:

Features: HBr, HBr, Cl_2, BCl_3, CH_4, SF_6, and $SiCl_4$, O_2, Ar, N_2, H_2

Future Plans

Actions

- Test the Oxford Ion Fab 300 Ar miller for metal (Ru, Pt, Au,…) etch. Potentially an Ar miller tool needs to be budgeted
- Installation of the stand alone Si etcher (STS)

Data collection

- Recipes Portfolio to extend
- DOE