Texas Nanofabrication Facility (TNF) node of the National Nanotechnology Coordinated Infrastructure

DRY ETCHING CAPABILITIES

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Plasma etching systems at TNF

12 chambers for dry etching
    Fluorine & Chlorine based gas chemistries

Silicon based device etchers
    Plasma Therm N° 2 (2 chambers)
    Bachtop (1 chamber)
    STS ICP (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)
    LAM Exelan 2300 (1 chamber)

Descum: Inductive and microwave plasma

Sedona Visual Controls, Inc.

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

STS etcher

Description: ICP Etcher

Compatible Materials: Si compatible like Si / SiGe / Hi K

Incompatible Materials: III-V / Polymers / Indium/ Metal

Features: HBr, Ar, Cl_2, O_2, CF_4.

Equipped with Platen (1200W) and Coil (600W) generators.

He backside cooling

Single wafer manual loadlock up to 8" wafer

Optimize SiO2 etch recipe at 82nm/min (PR selectivity 0.5):

Platen 150W

Coil:600W

CF4=60-80sccm

Pressure: 75mTorr

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
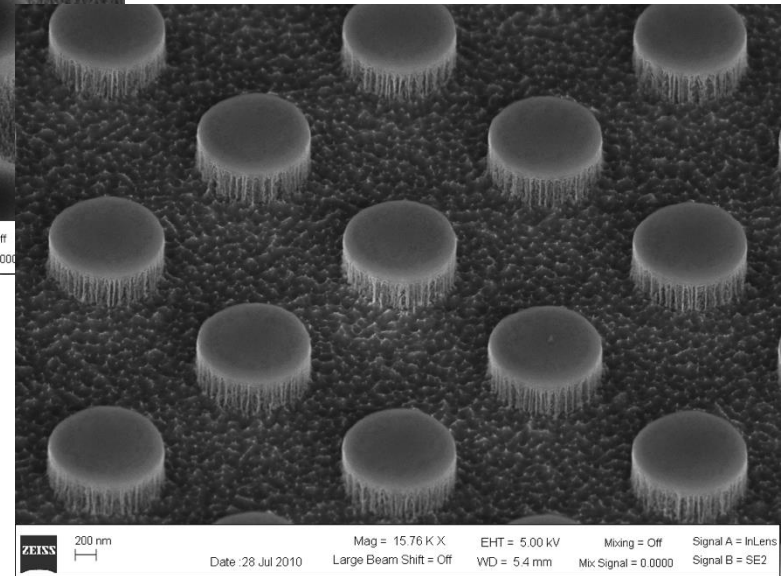   group at Methodist Hospital Houston**

Porous Silicon Medical Devices
Methodist Hospital (M Ferrari)
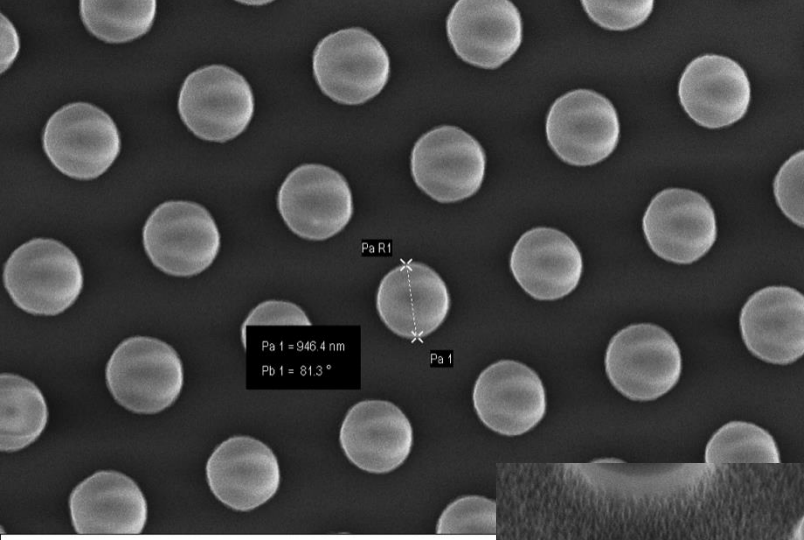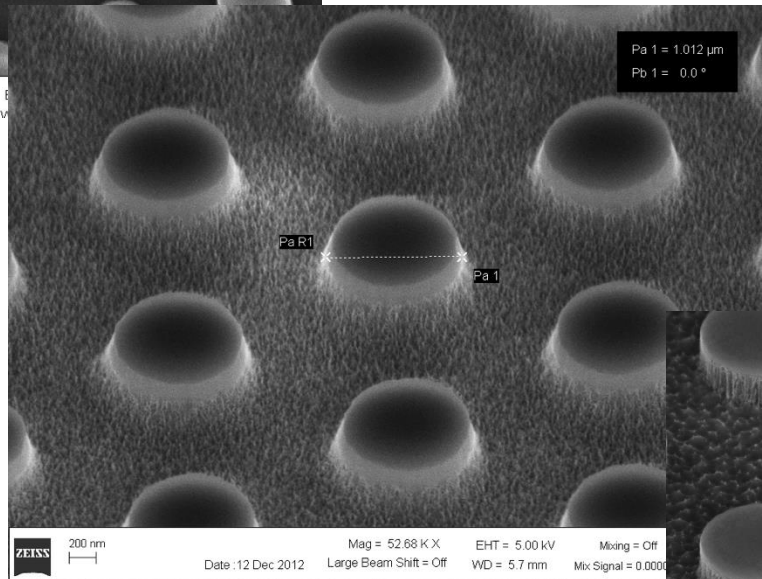
1um

PR _Futurex

Thermal Oxide

Porous Si

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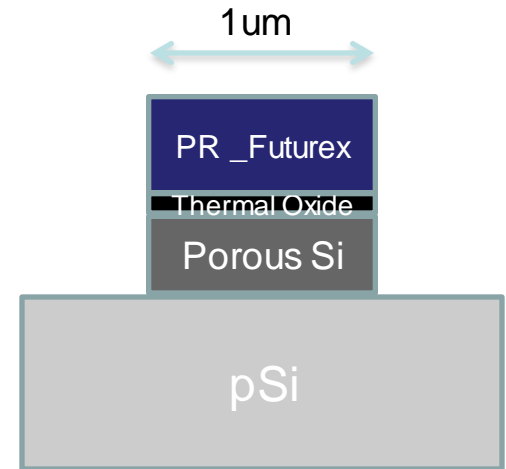
Top view of the patterned resist (500nm) (#1).   Progression of the etch through the oxide (80nm) and just into the porous layer (400nm) (#2) and then etched through to the bottom of the porous layer, showing full particles still on the wafer (#3).

- ## 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

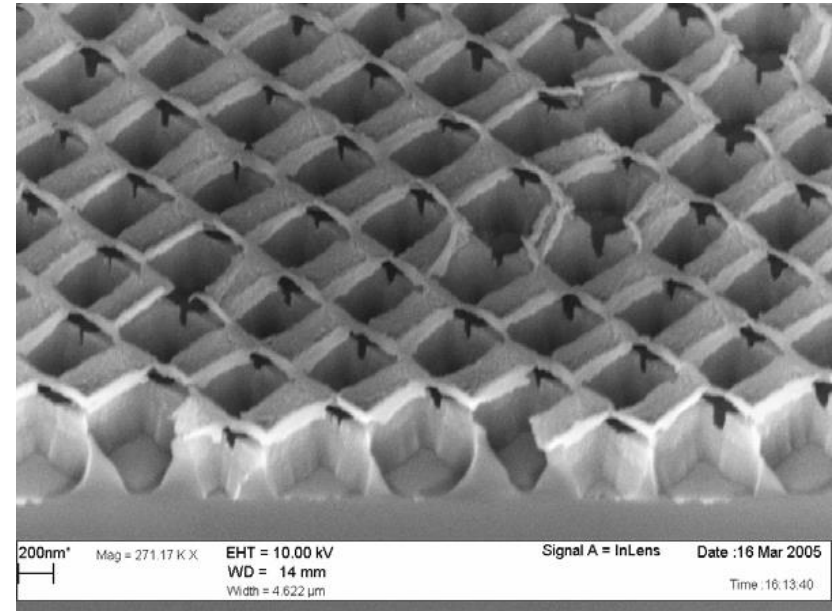Turbo pump for base pressure of 10^{-5} Torr Si etch without balckening effects

- ## Plasma Therm n° 2

  Silicon: HBr=25sccm, Cl$_2$=4sccm,
  DC=250V (RF=128W),
  Pressure=40mTorr
  Etch rate 37nm/min
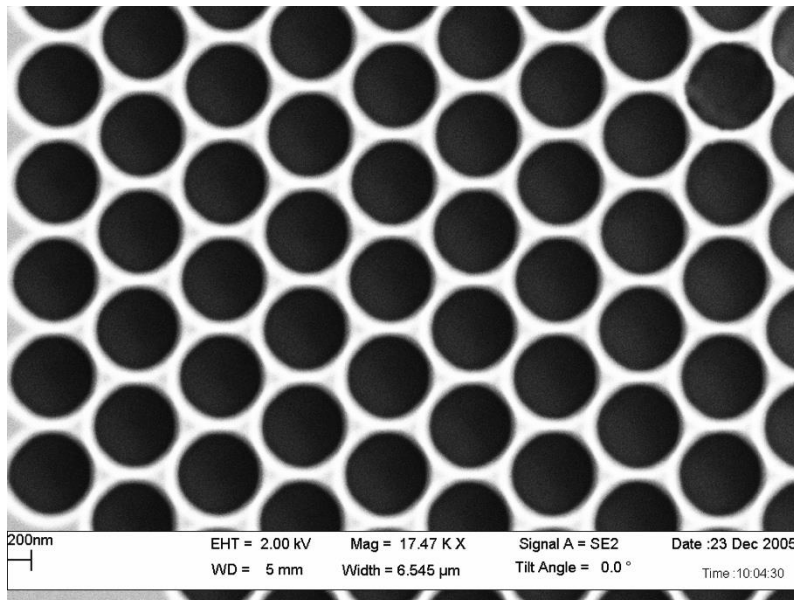
**Photronics Crystal on SOI
Diameter 700nm, Spacing 900nm**

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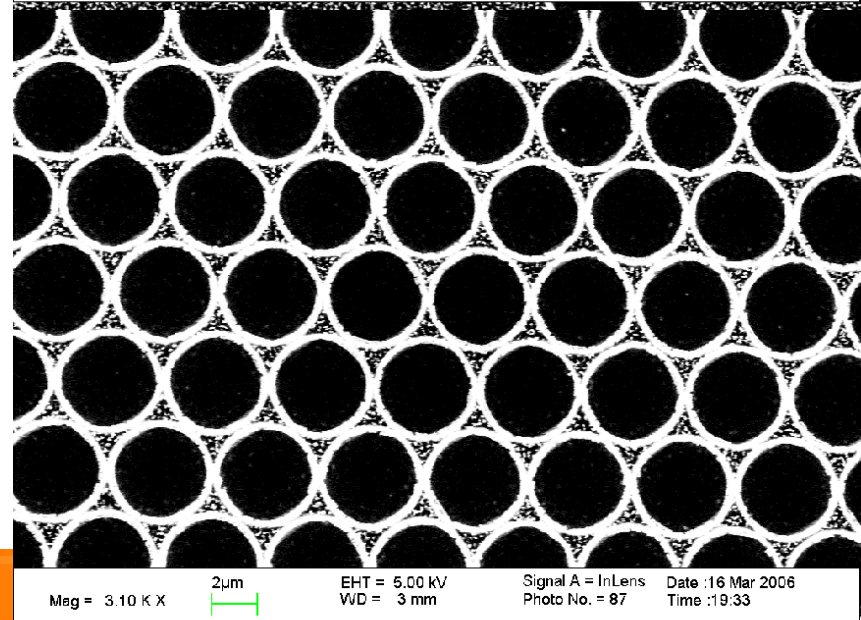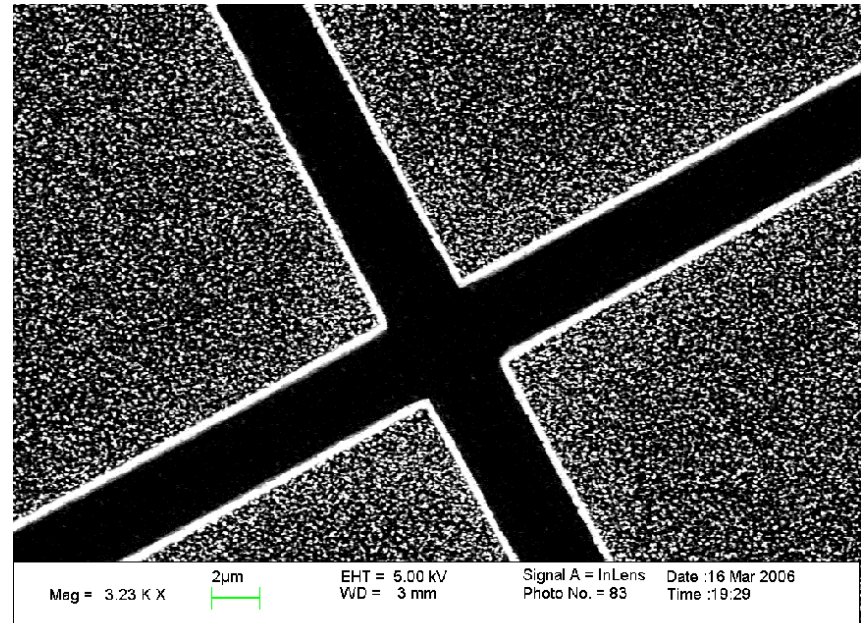Etch depth on Silicon=405nm**

- **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?)

Mag = 3.23 K X   2µm   EHT = 5.00 kV   Signal A = InLens   Date :16 Mar 2006
WD = 3 mm   Photo No. = 83   Time :19:29

Mag = 3.10 K X   2µm   EHT = 5.00 kV   Signal A = InLens   Date :16 Mar 2006
WD = 3 mm   Photo No. = 87   Time :19:33

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

Etch Barrier dispensed from IMPRIO

Quartz Template (TRION etcher)

Fluorinated Release Layer

1. Dispense

Organic spin-coated Transfer Layer

Substrate (silicon etc)

2. Imprint

3. Expose

UV Cure

WD9　　　　　　10-MAY-02

40 nm 8:1 aspect ratio

15.0kV　X70.0K　429nm

4. Separate

5. "Breakthrough" Etch

Spin-coated Si-containing polymer

6. Transfer Etch
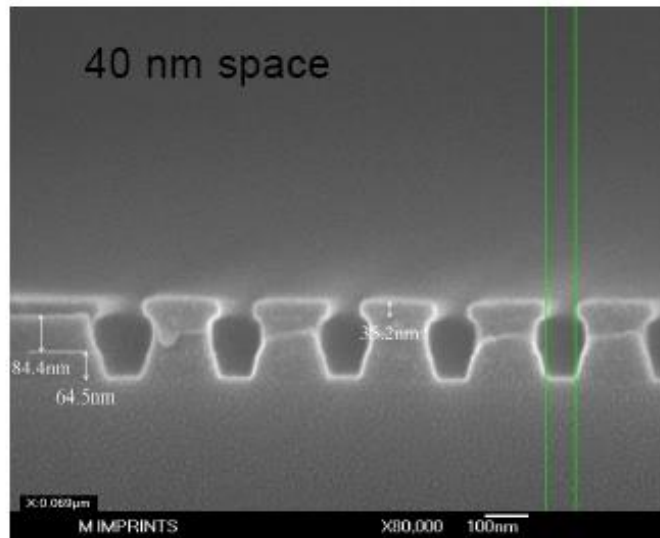
(enhances feature aspect ratio)

Oxford Plasma Lab
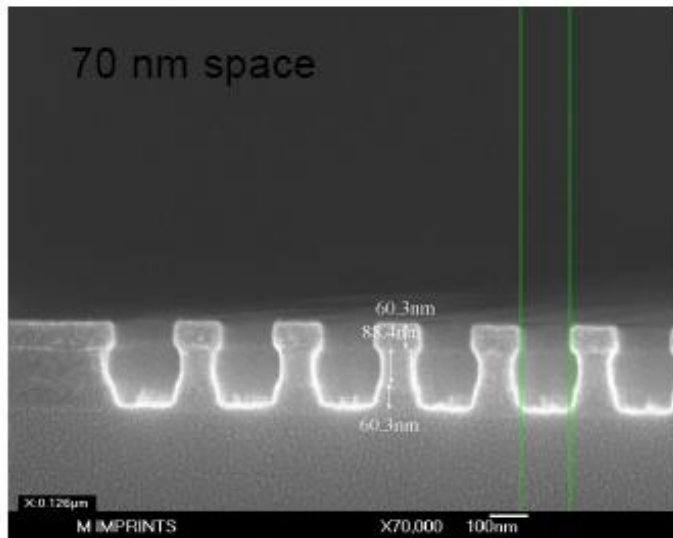
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AT AUSTIN
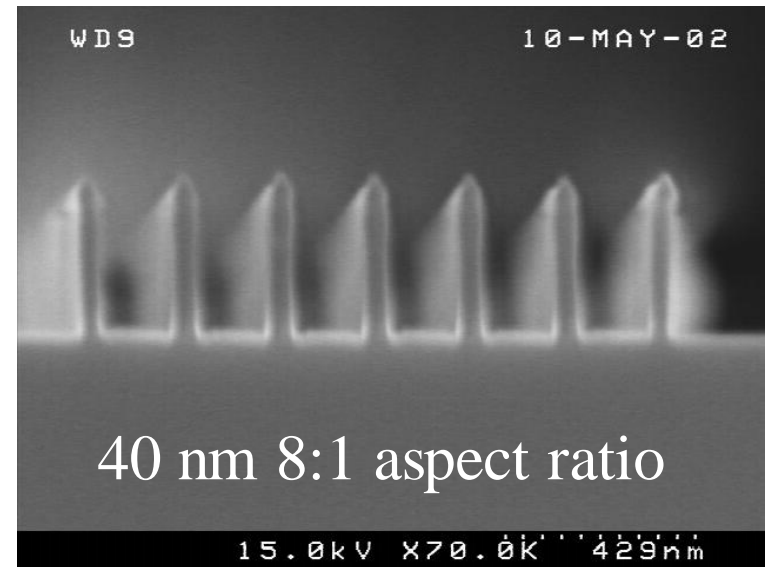
SFIL plasma etching profiles

After the etch-back of the SilSpin and subsequent etch of the MonoMat, the pattern profiles illustrated below are obtained:
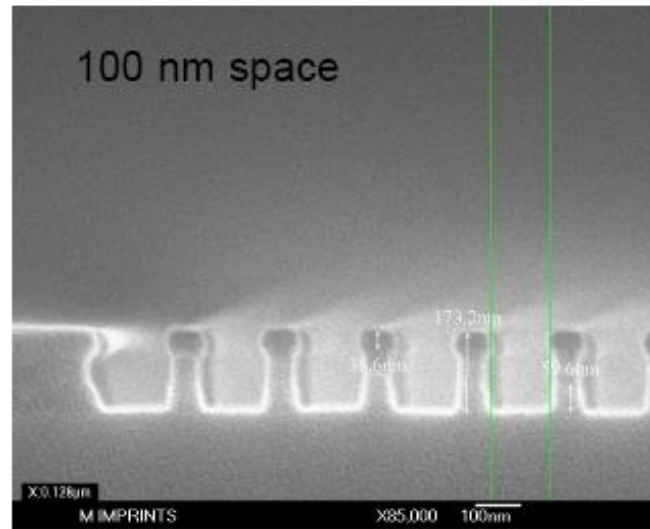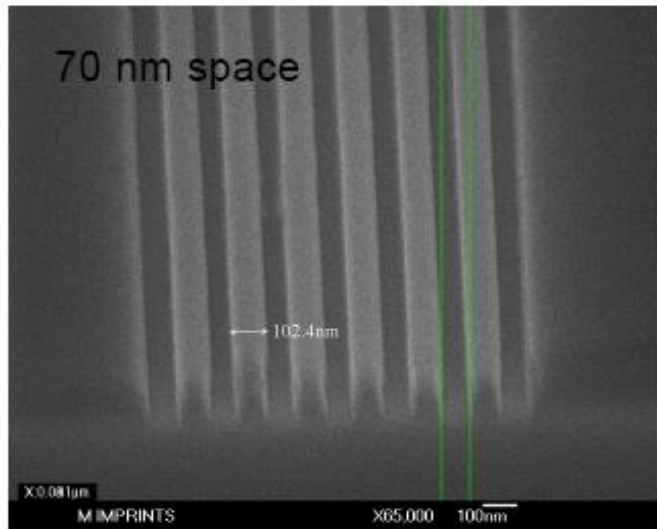
Residual resist layer: O_2=8sccm, DC=200V, P=5mTorr
Etch rate 46nm/min

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:
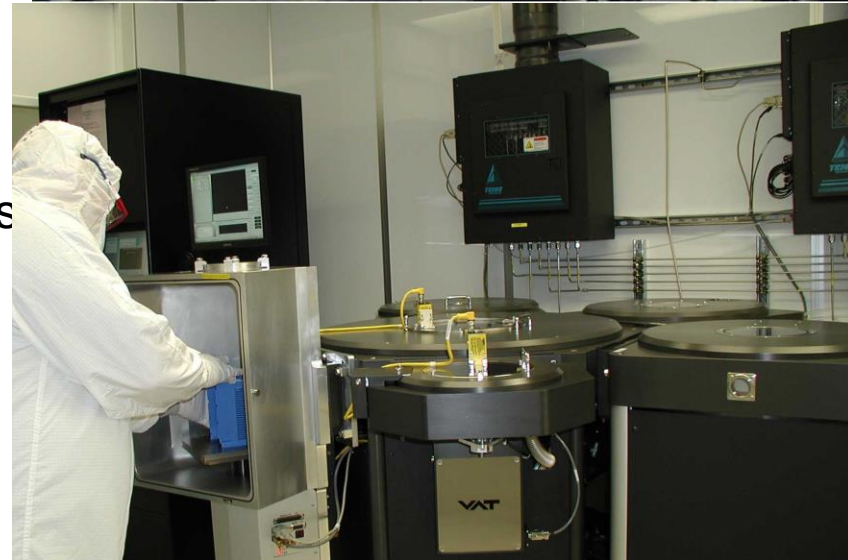
Features:

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
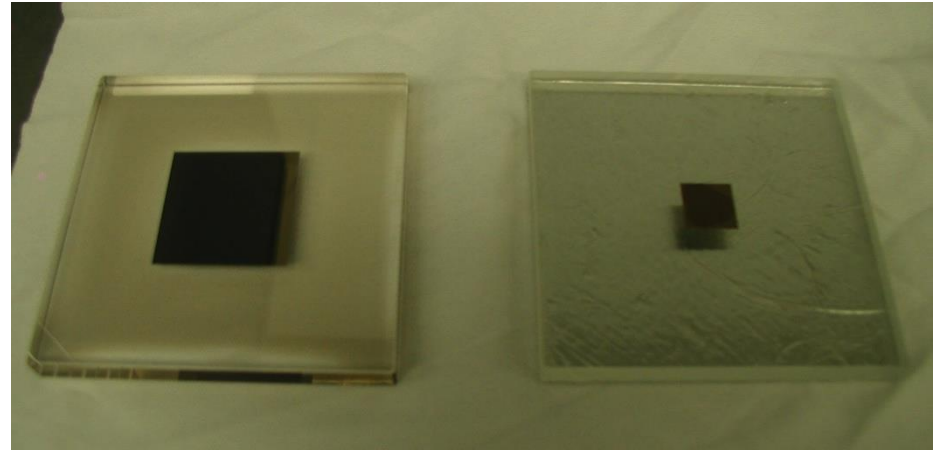Reactor 3: Cl_2, He, CF_4,
Electrostatic Chuck with Helium back s
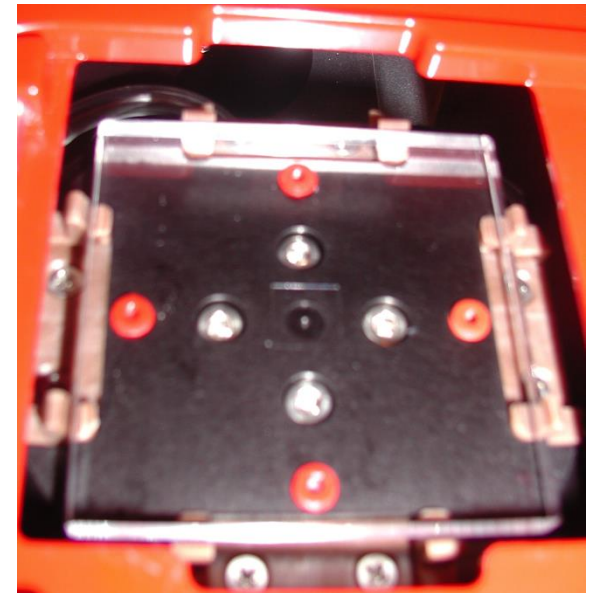cooling (**-30° C**)

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

LAM Exelan 2300:

Description: CCP Etcher
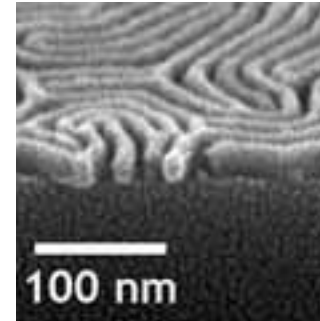**Compatible Materials:** nano-patterning transfer capability
Incompatible Materials: TBD

Features: **12in (300mm) chamber**

Gases: C_4F_8, CF_4, O_2, Ar, CO, CO_2 CHF_3, HBr, N_2, SF_6, H_2
3 RF generators: 27Mhz to 60Mhz
with different ion distribution energy.
turbo pump

100 nm

15 April 2016, SPIE Newsroom, Willson & al.

Deep Silicon Etching

• Plasma Therm, Versaline

Description: Deep Si Etcher – Bosh, LL 4inch

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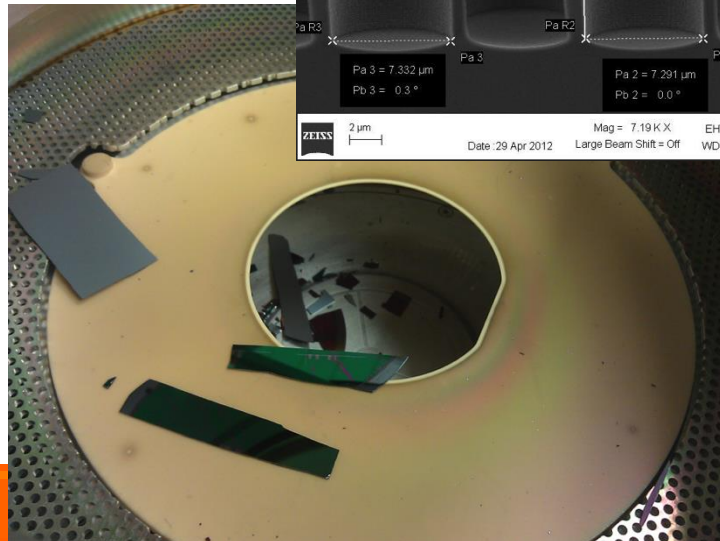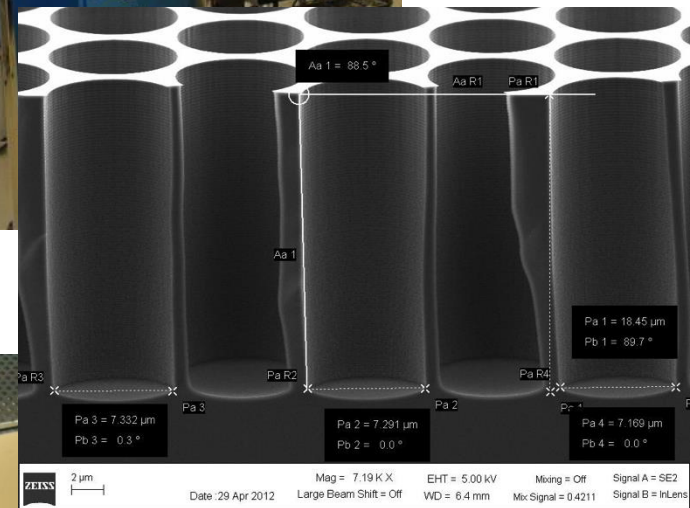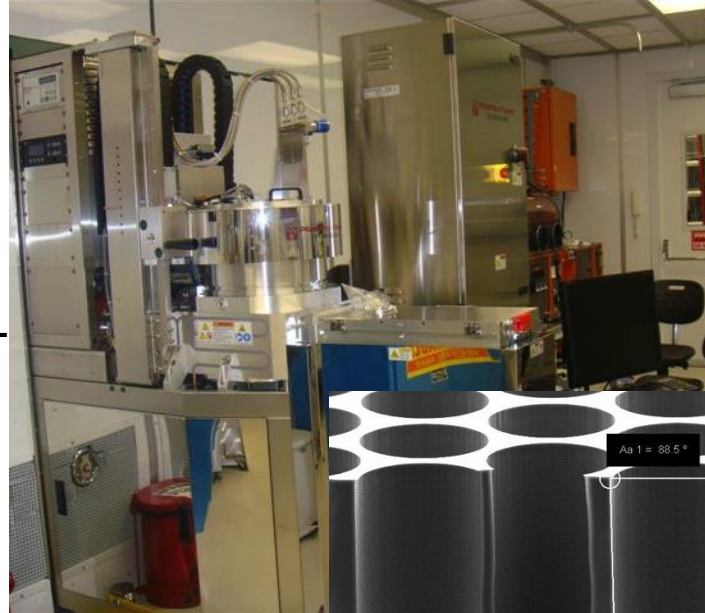**Incompatible Materials:** Metal / III-V

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.

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- **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
- Develop standard recipe set (one for each etching material) and monitor the drift of these recipes.
- Invite users to use the set of standard recipes (only time should change)

Data collection
- Recipes Portfolio to extend and test
- DOE