Etching Capabilities
at
Harvard CNS

March 2008

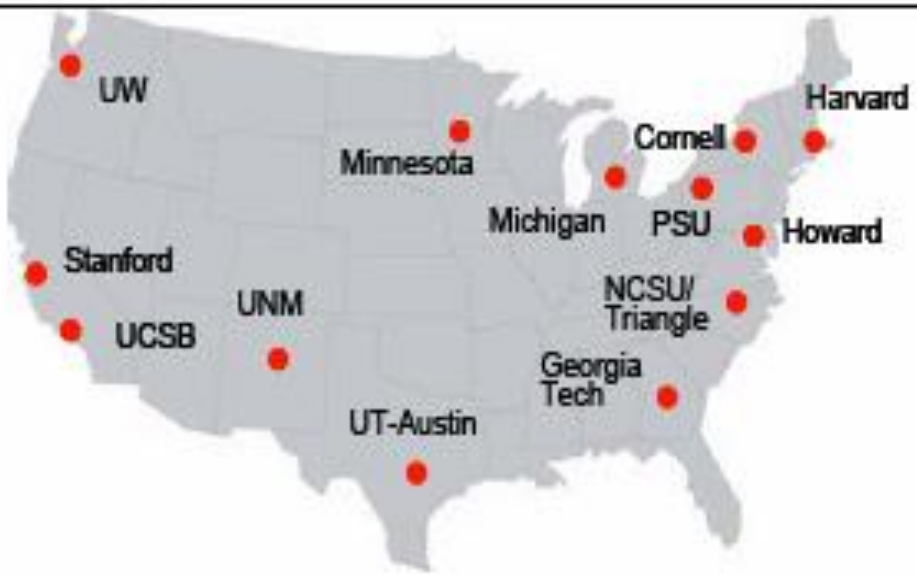
CNS: A shared use facility for Harvard Community and New England

CNS

- Provides technical support, equipment and staff.
- Explicitly multi-disciplinary w/ material diversity.
- Environment for collaborative research.

Nanotechnology Infrastructure Network

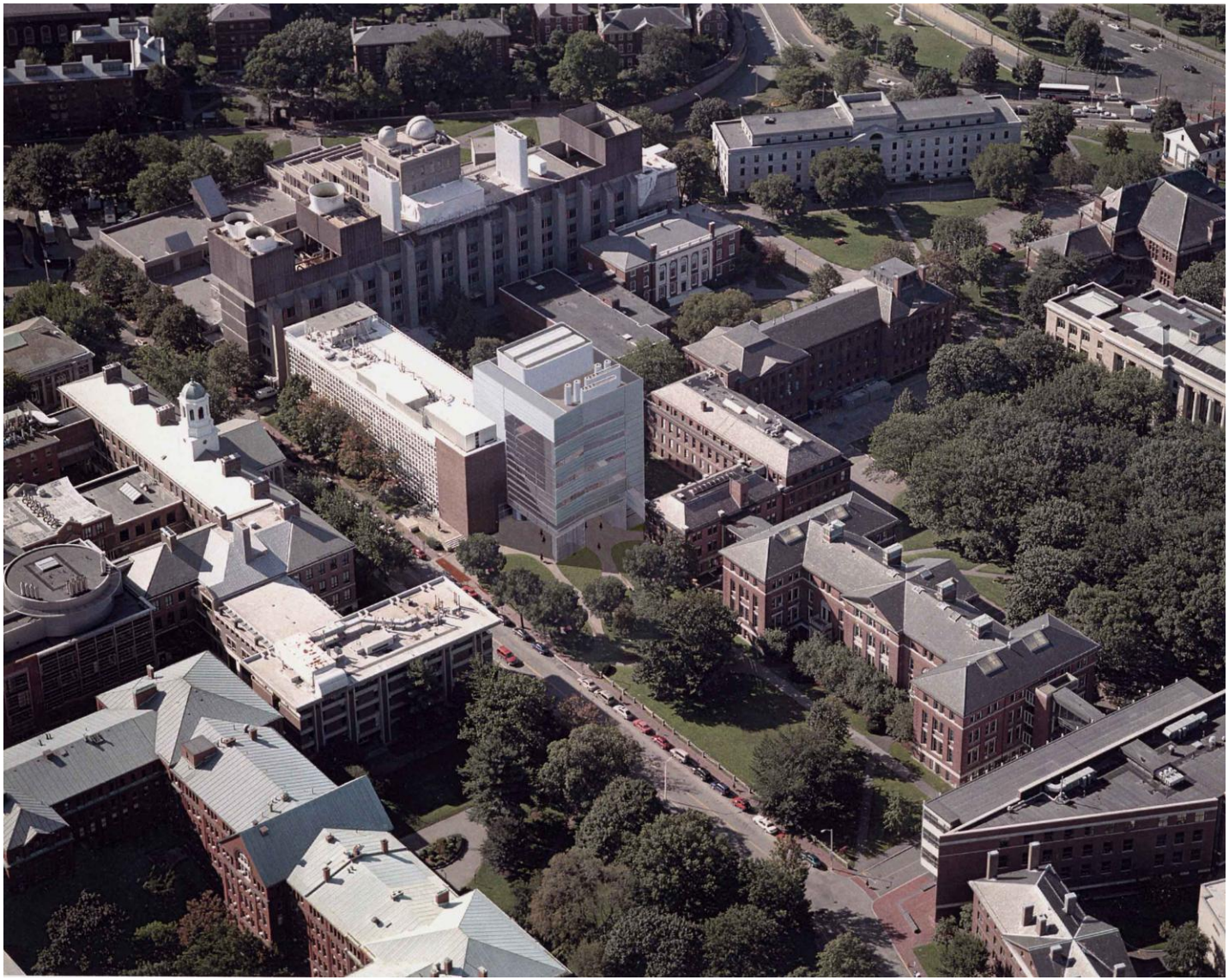
Figure 1: Member institutions of NNIN.



NSF

NNIN
Nanoscale Science,
Engineering & Technology

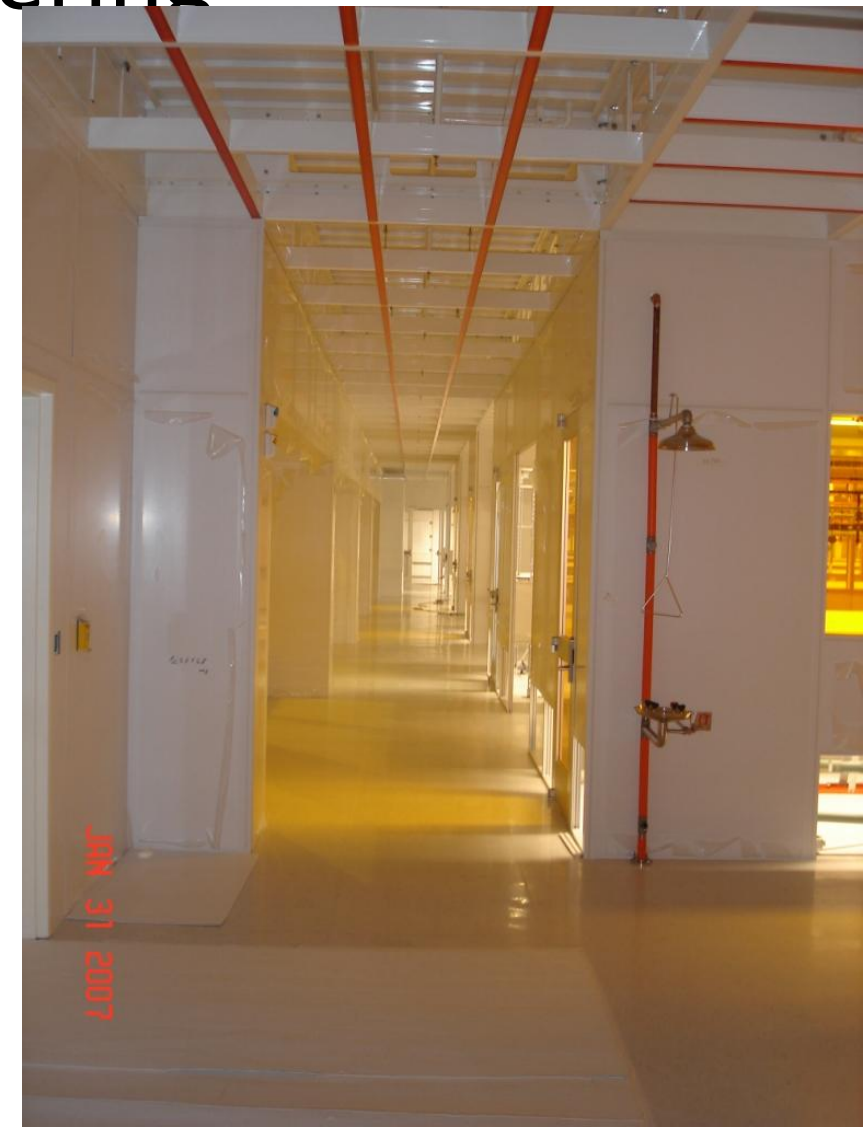
LISE Nestled into Oxford Street



Laboratory for Integrated Scien Engineering

Harvard University
Center for Nanoscale Systems

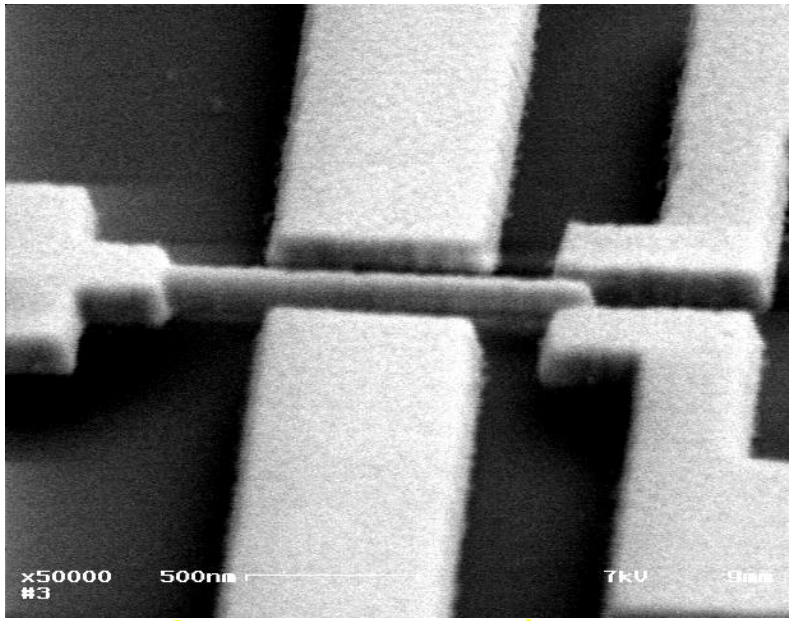
- 10,000 sq ft class 100 Nanofab
- 6000 sq feet low-vibration imaging suites
- 6000 sq feet material synthesis labs



Nanofabrication

- Operating two temporary cleanrooms in McKay Laboratory
- Migrating all operations to LISE G07 cleanroom (7/08e)
- Emphasis on Material Diversity
- Emphasis on small feature size

AJA Sputter System



27 nm gate transistor

CNS Staff member training a user on SUSS MA6 Aligner

Plasma Etching Systems

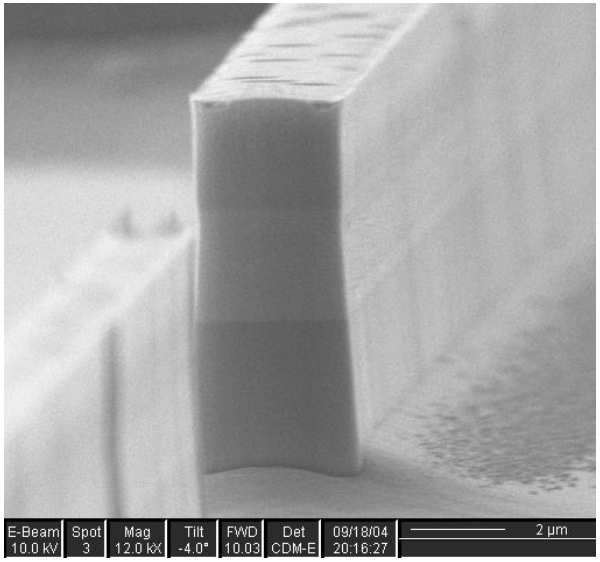
- STS Lpx ICP RIE
  - Si based materials
- Unaxis Shuttline ICP RIE
  - GaAs, AlGaAs, GaN, InP, InP/AlInAs-GaInAs/InP
- Nexx ECR RIE
  - Si based, metals, polymers
- SouthBay RIE
- Technics

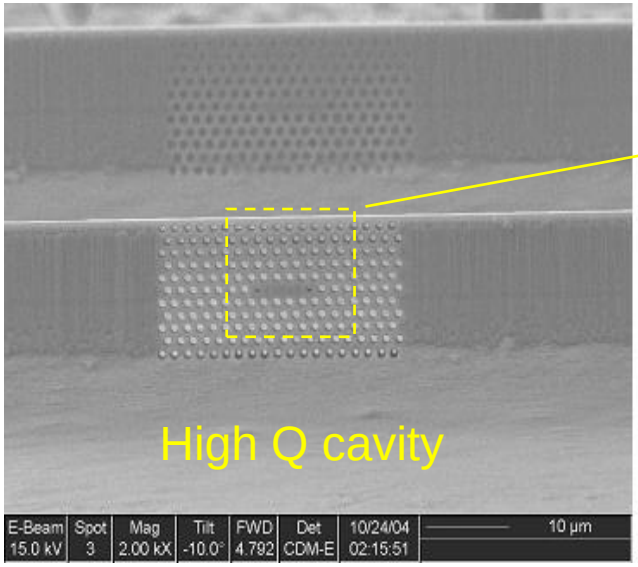
Nexx Systems Cirrus 150

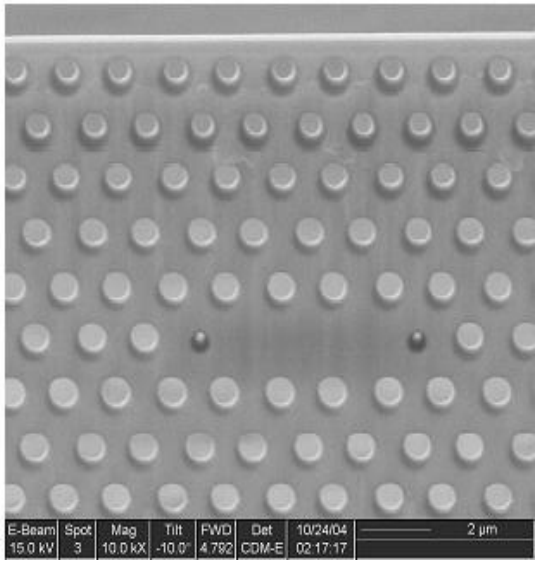
Specifications:

- Electron Cyclotron Resonance Reactive Ion Etch
- ASTeX 1500 W microwave power supply
- RFPP 13.56 MHz 500 W RF generator
- Stainless reactor, 12.75 in O.D, process up to 6” wafers
- Balzers turbo pump
- Substrate clamping with backside helium thermal control
- Available gases: Cl_2, CF_4, CHF_3, CH_4, H_2, Ar, O_2, and He
- Loadlock equipped
- Computer control

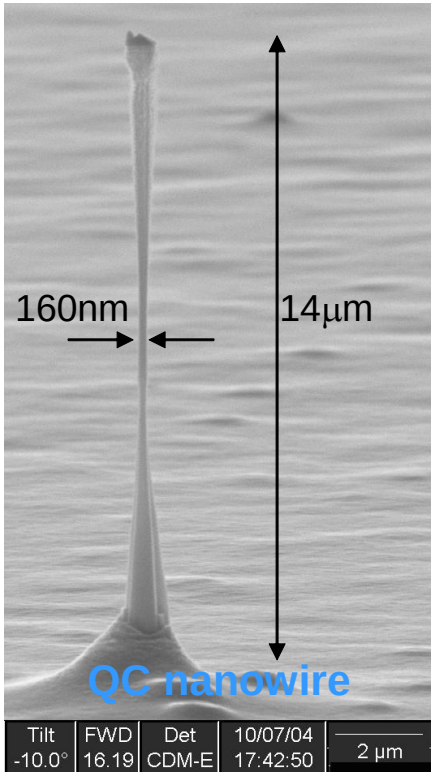
Deep InP Etch with Nexx ICP

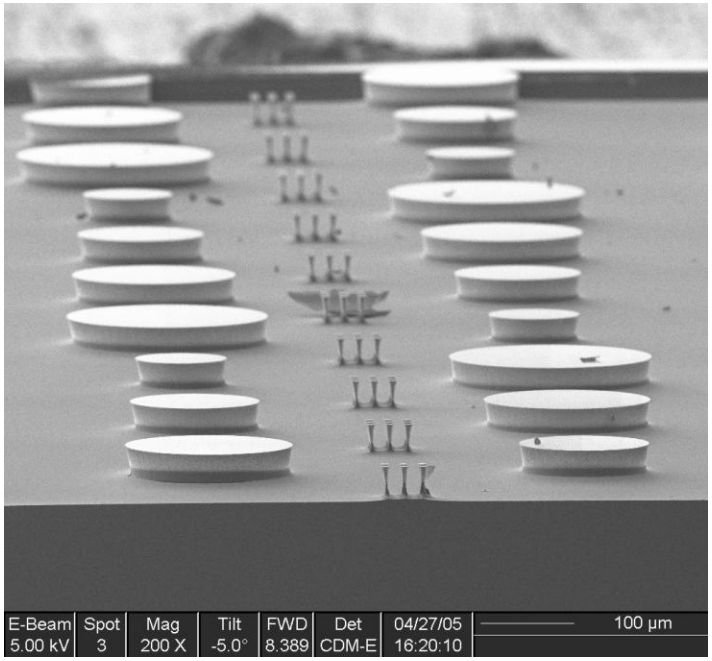






Deep InP Etch with Nexx ECR





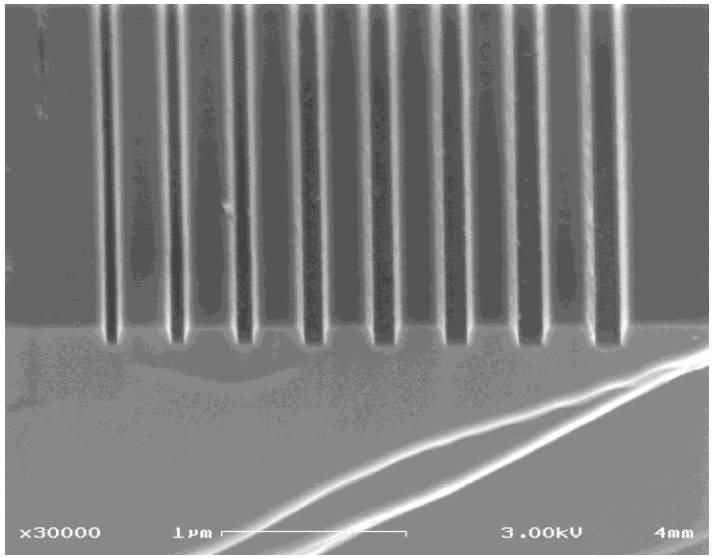
Unaxis Shuttline™ Syste

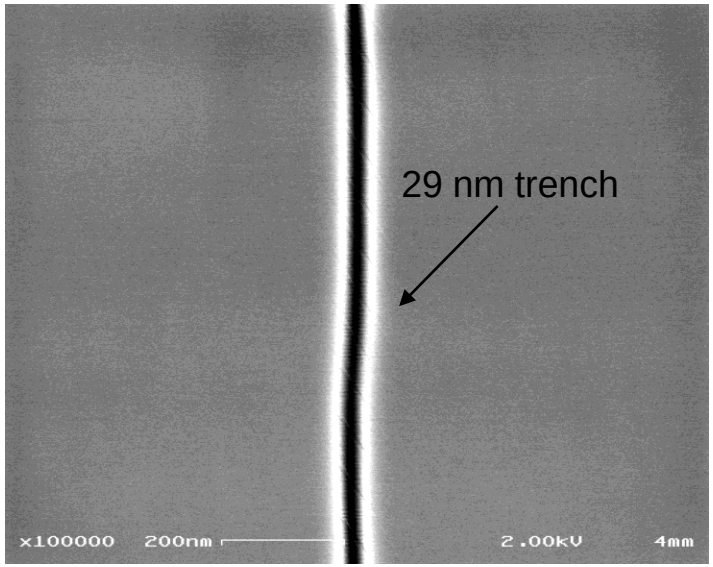
Harvard University
Center for Nanoscale Systems

Specification:

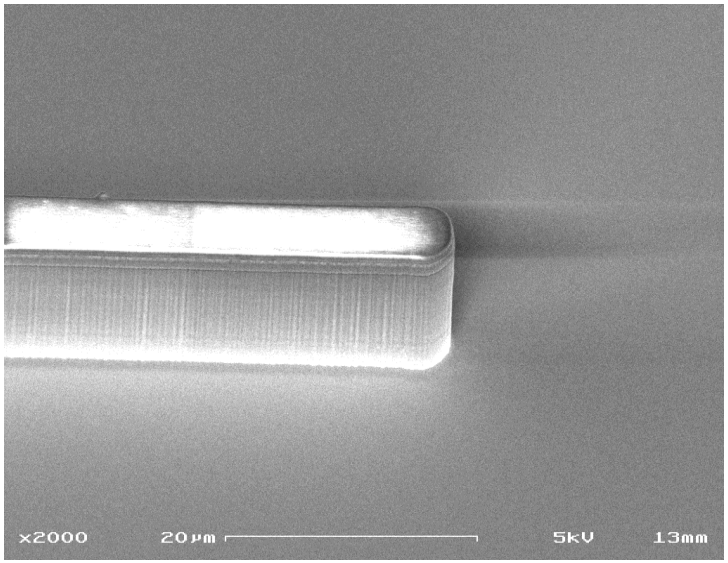
- Inductively Coupled Plasma Etching (ICP)
- 2.5 kW ICP source power supply @ 2 MHz
- RF generator up to 300W @ 13.56 MHz
- Substrate clamping with backside helium thermal control
- Substrate heating system up to 200°C
- Available gases: HBr, Cl_2, BCl_3, CH_4, H_2, Ar, N_2, O_2
- Laser endpoint detector
- Loadlock equipped
- Computer control

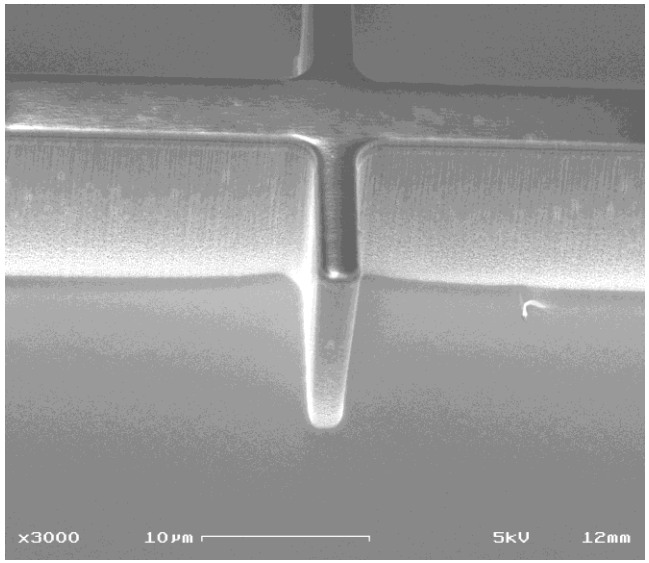
Chemistry:	BCl3, Ar, N2
Mask:	PMMA
Selectivity:	1.22
Etch rate:	0.5 um/min



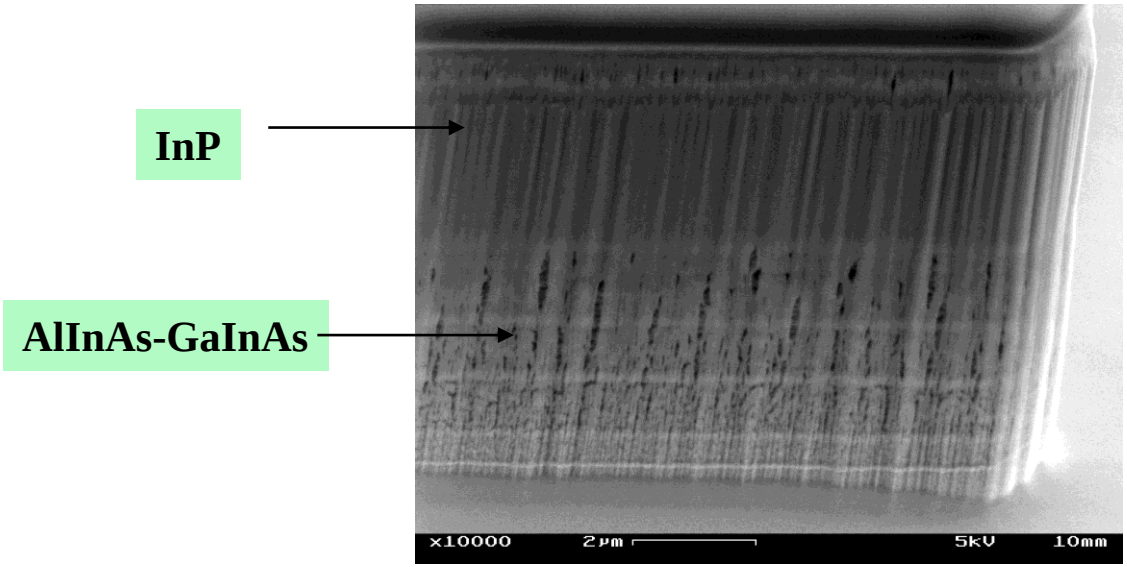


Chemistry:	HBr, N2
Mask:	SU8
Selectivity:	> 10:1
Etch rate:	~ 2.0 um/min

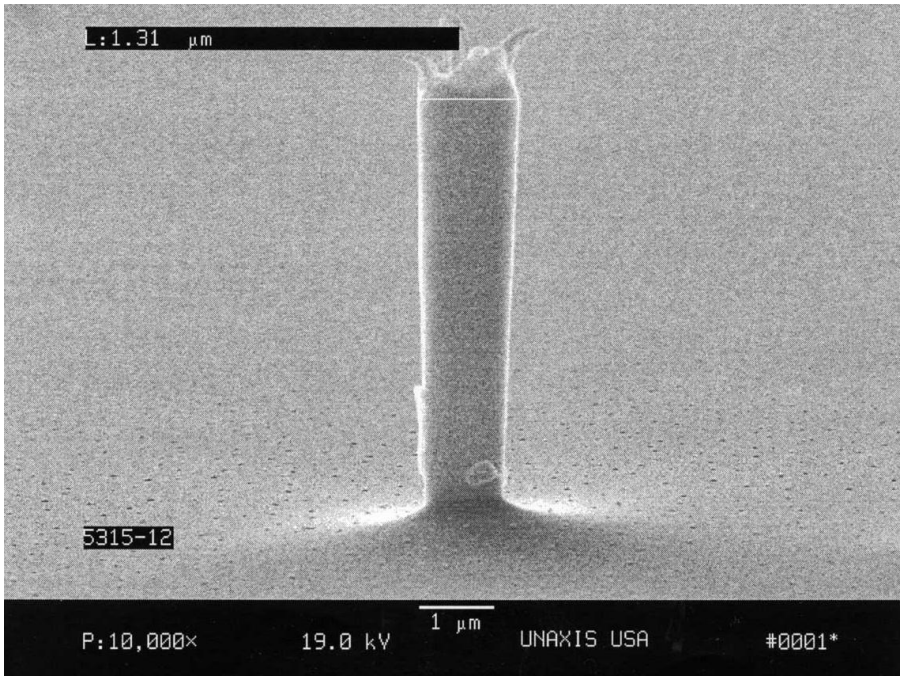




Chemistry:	HBr, N2
Mask:	SU-8
Selectivity:	> 10:1
Etch rate:	~ 2.0 um/min



GaN Etch with Unaxis ICP



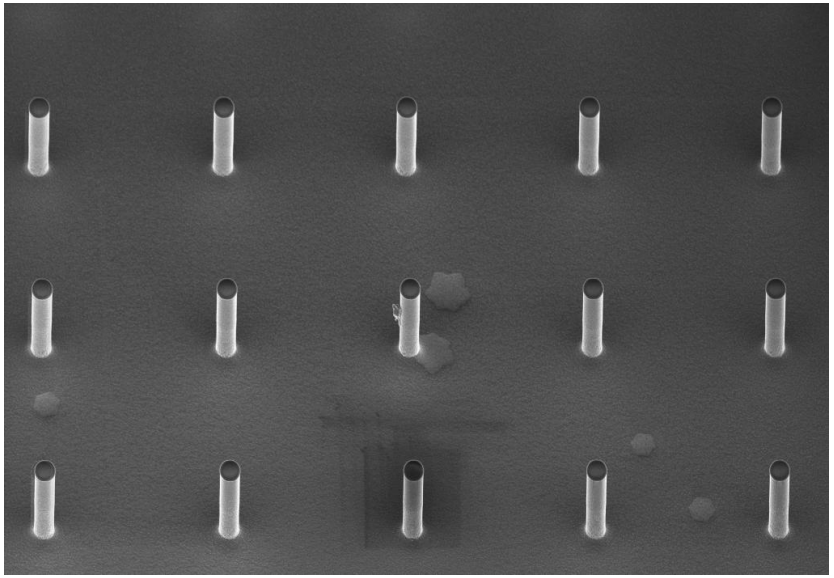
Chemistry: BCl_3, N_2, **and Ar**

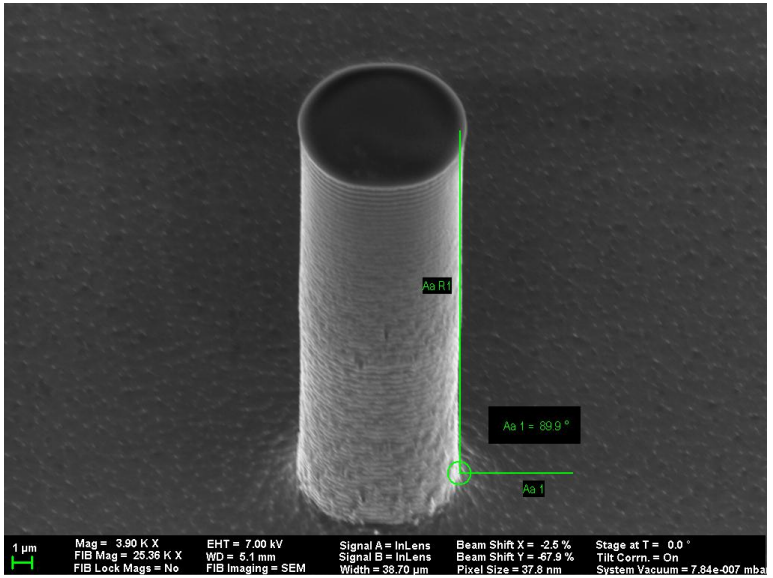
Characteristics: Vertical wall, smooth sidewall and floor surfaces

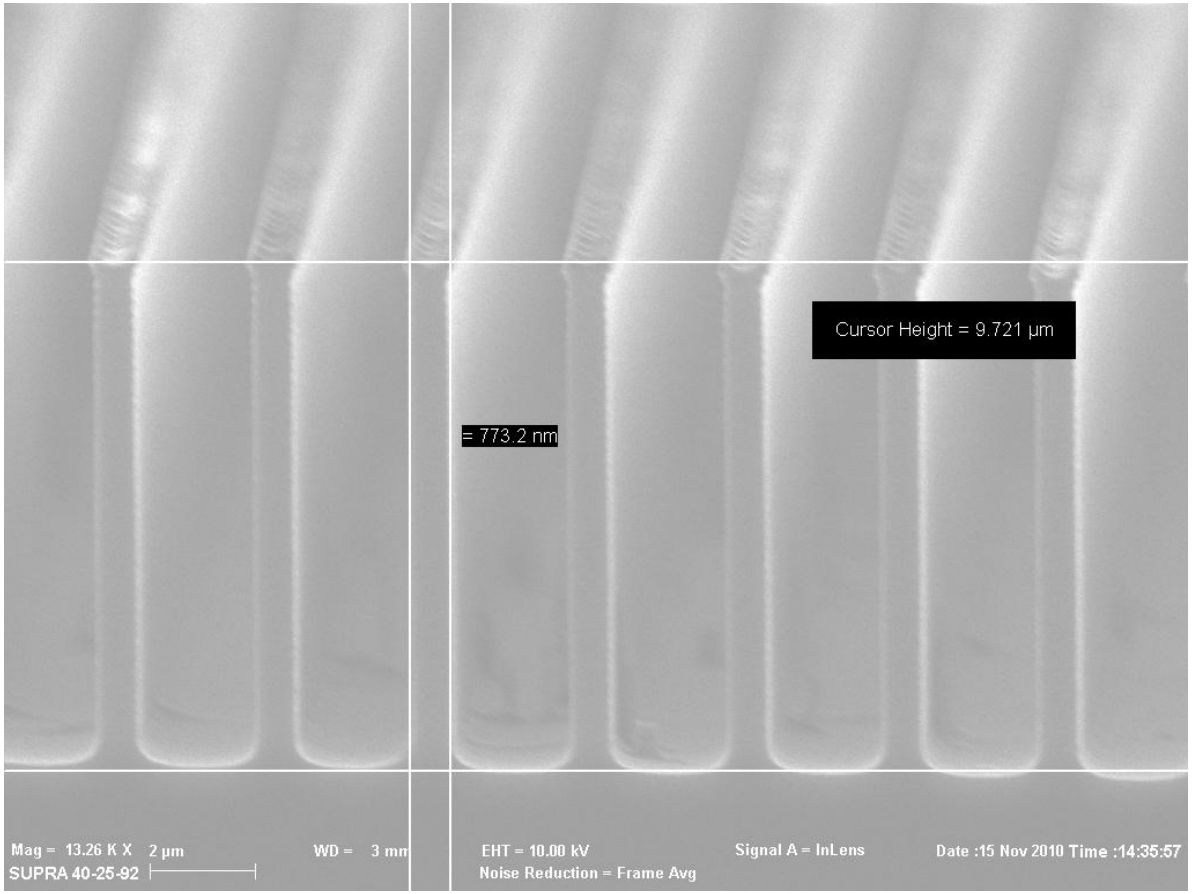
Etch Rate: 0.5 µm/min

Selectivity: 40:1 to Ni

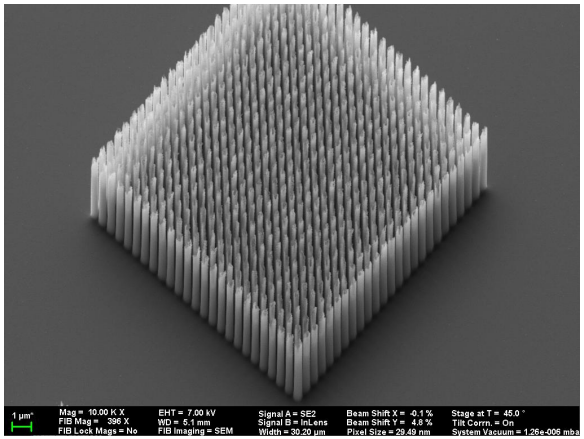
- ICP assembly upper electrode 1500W
- rf biased lower electrode,
  chilled to 4 – 30°C, 300 W
- Single wafer loadlock up to 6” wafer
- High vacuum chamber - turbo pump
- Windows 2000 PC
- Internet remote control



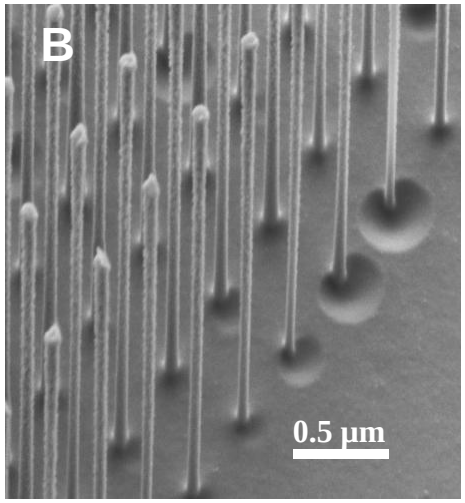

Aa R 1
Aa 1 = 89.9 °
Aa 1
1 µm
Mag = 3.90 K X
FIB Mag = 25.36 K X
FIB Lock Mags = No
EHT = 7.00 kV
WD = 5.1 mm
FIB Imaging = SEM
Signal A = InLens
Signal B = InLens
Width = 38.70 µm
Beam Shift X = -2.5 %
Beam Shift Y = -67.9 %
Pixel Size = 37.8 nm
Stage at T = 0.0 °
Tilt Corrn. = On
System Vacuum = 7.84e-007 mba



2 um wide trenches and 770 nm wide brdges
Etch Conditions: 15 mtorr, 120 sccm C4F8 for deposition, 130 sccm SF6 and 13sccm O2 for etching
Dep/Etch Time: 5/7 s, 600W ICP, 12 W rf, 15 min etch



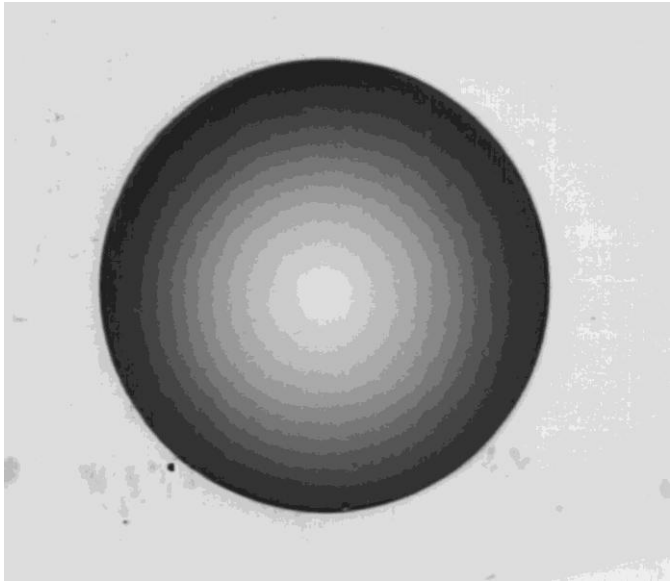
Reactive ion etch to obtain NWs length 300nm in diameter and 5 microns in depth Si NW arrays

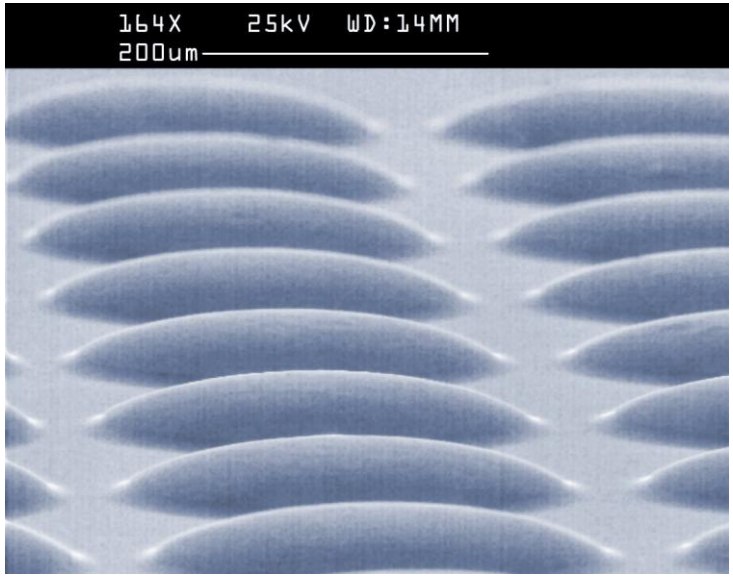


FESEM image of Si NW by RIE
The rough surface was possibly the fluoropolymer layer formed during etch.

Si Lens Etch with STS

- **Chemistry** — **Fluorine based**
- **System** — **ICP^{HR}**
- **Process** — **Pattern Transfer**
- **Etch Rate:** — **1-2 µm/min**
- **Selectivity to resist:** — **0.5:1 to 3:1**
- **Maximum etch depth:** — **70 µm**
- **Etch uniformity:** — **<±5%**



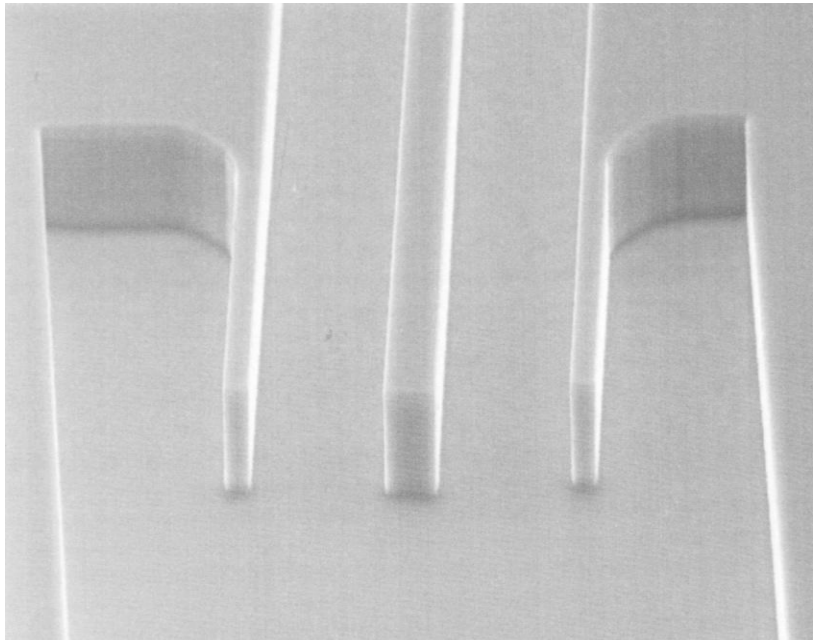


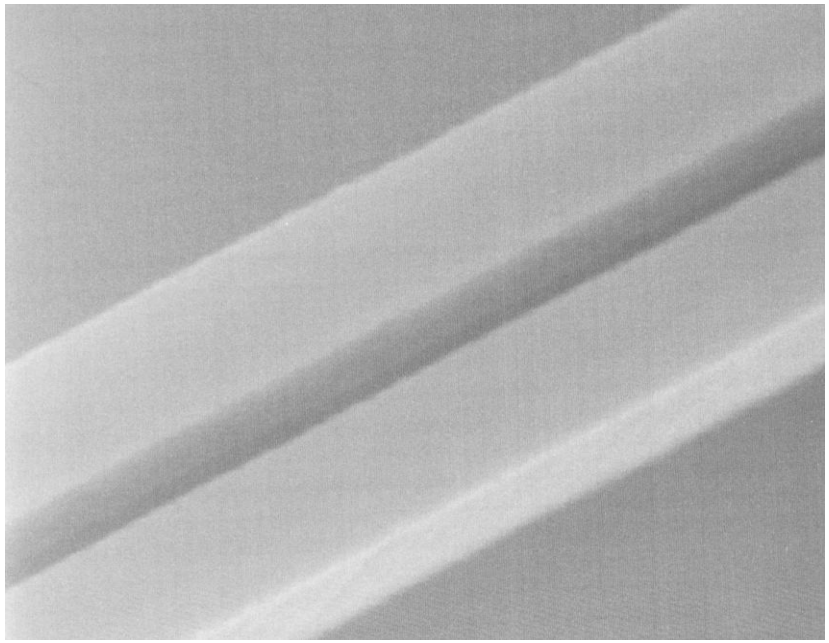
Silicon Waveguide Technology

Harvard University
Center for Nanoscale Systems

- **Etch Depth** 2.7 μm
- **Depth Capability** 10 μm
- **Etch is Smooth & residue free**

- **Chemistry** Fluorine based
- **Er** up to 5000 Å/min
- **Selectivity to resist** = 10:1
- **Selectivity to oxide** = 15:1
- **Sidewall angle** = 90°
- **Uniformity** <+/- 2.5%

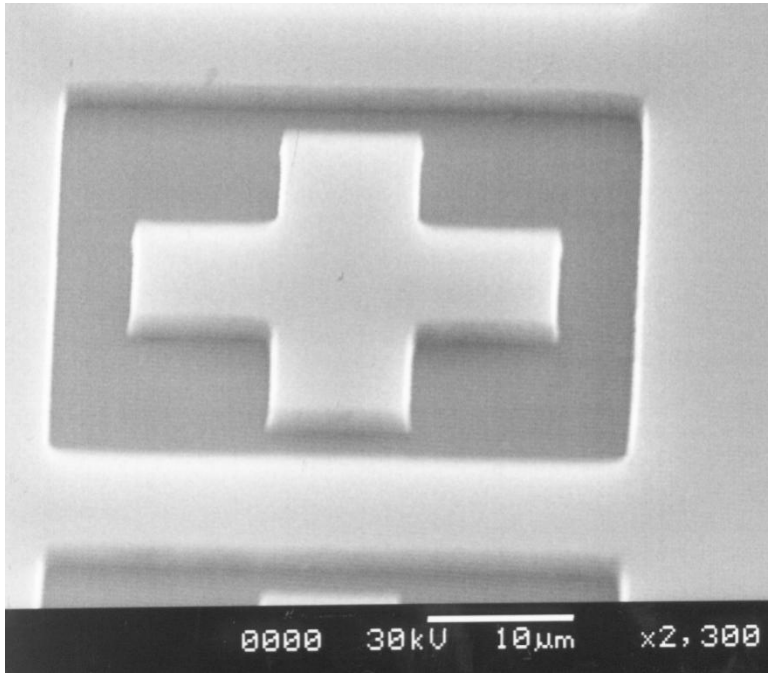


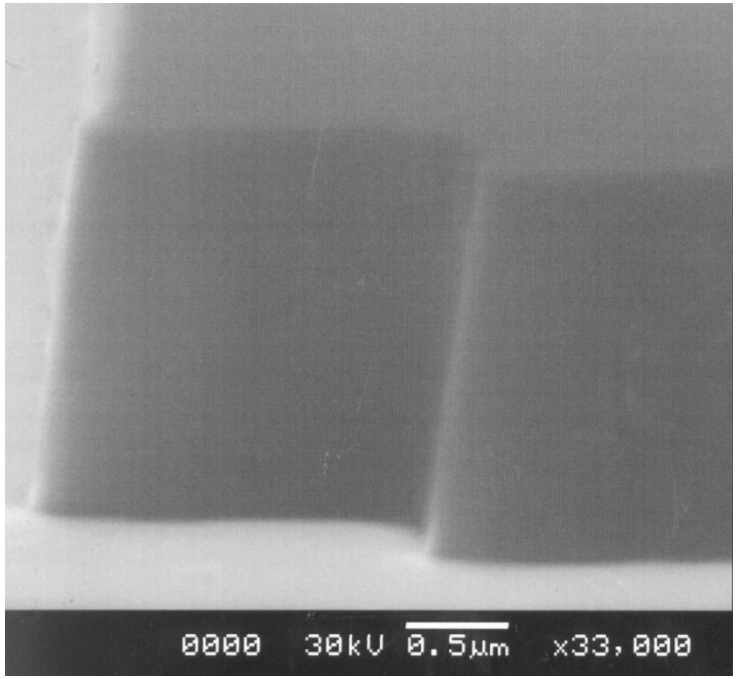


Shallow SiO_2 Etching with ST

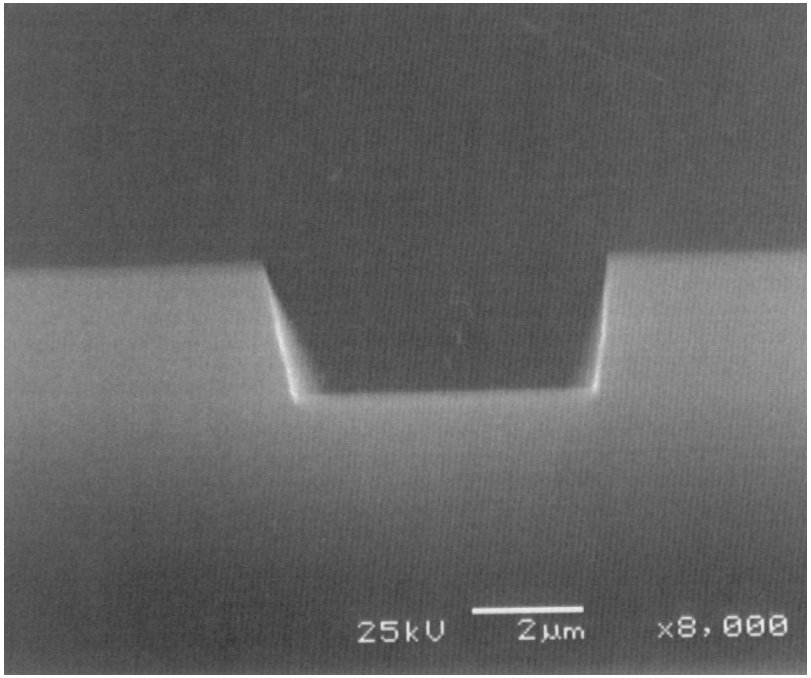
Harvard University
Center for Nanoscale Systems

• Chemistry	Fluorine based
• Er	= 1000 - 4000Å / min
• Selectivity to PR	= 1:1 - 2:1
• Sidewall angle	> 85°
• Uniformity	<+/- 5.0%



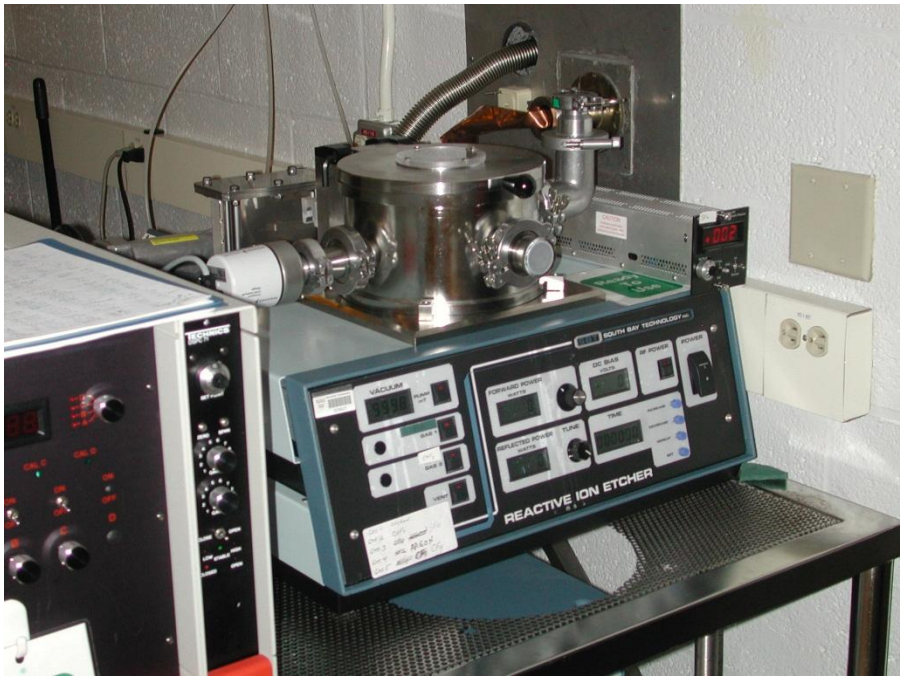


SiN_x Etching with STS



- **Feature etch:** **0.5 µm deep**
- **Chemistry:** **CF_4 / CH_4**
- **Mask** **Photoresist**
- **Etch Rate:** **3917 Å/min**
- **S_{PR}:** **2.8:1**
- **S_{Si}:** **1.8:1**
- **Profile:** **82°**
- **Unifomity:** **+/- 1.4%**
- **Smooth residue free etch**

SouthBay RIE 2000



Specification:

- Standard parallel-plate rf plasma
- 13.56 MHz RF power up to 200 W
- 8” chamber diameter
- Water cooled sample stage
- Sample size up to 6”
- Turbo pump to10^{-6} Torr base pressure
- Available gases: SF_6, CHF_3, CF_4, Ar, O_2
- Manual controls

Under consideration

Deep Si Etch

STS ICP System

XeF2 Release

Xetch® X3B and X3C