RTNN Etch capabilities

A Partnership Between NC State University, Duke University, and UNC Chapel Hill

- Trion Minilock II: III-V RIE
- Trion Phantom II: Oxide/Nitride/Polymer
- SPTS Pegasus DRIE

- Trion Minilock III: Al, GaAs
- Semigroup: oxide/nitride
- PlasmaTherm: Si, SiGe
- Alcatel AMS100 DRIE
- PM-600 Plasma Asher

- Alcatel AMS100 DRIE

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

CHANL

CHAPEL HILL ANALYTICS and NANOFABRICATION LABORATORY

CHANL is shared instrumentation laboratory in the Department of Applied Physical Sciences at UNC. CHANL is open to UNC researchers from all departments as well as to researchers from other universities, government labs, and industry. For more information visit our website (chanl.unc.edu).

Fabrication

DRIE (Alcatel AMS 100)
PECVD (Advanced Vacuum Vision 310)
ALD (Ultratech/CNT Savannah S200)
PLD (PVD Products NanoPLD-1000)
Metal Sputtering (Kurt Lesker PVD 75)
Electron Beam Evaporator (Thermionics V100)
Hot Embosser (Jenoptik HEX03)
Laser Ablation Micromill (Resonetics Rapid X250)
Mask Aligner (Karl Suss MA6/BA6)

Spectroscopy

XPS (Kratos Axis Ultra DLD)
UPS (Kratos Axis Ultra DLD)
EDS (Oxford Instruments on SEM and TEM)
Spectroscopic Ellipsometry (J.A. Woollam VASE)

Microscopy

SEM (Hitachi S-4700 Cold Cathode Field Emission)
ESEM (FEI Quanta 200 Field Emission Gun)
FIB ((FEI Helios 600 Nanolab Dual Beam System)
TEM (JEOL 100 CX II)
TEM (JEOL 2010F-FasTEM)
AFM (Asylum Research MFP3D)
Confocal (Olympus with CARVII spinning disc)
Ultramicrotome (Sorvall MT6000)
Microspectophotometer (CRAIC)

Staff

Carrie Donley – Director
Wallace Ambrose – Electron Microscopist
Amar Khumbar - Electron Microscopist
Jun Yan – Research Scientist
Bob Geil – Cleanroom Manager

RTNN

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Alcatel AMS100 DRIE

Specs:

- Wafer sizes: 4”, 6” and pieces mounted on handle wafer
- Power (Source): 3000 W
- Power (Platen): 300 W RF/500 W LF (50 kHz – 460 kHz)
- Gases: SF_6, C_4F_8, Ar, O_2, CH_4, He
- Temperature ranges: -10 °C to 30 °C
- Mechanical clamping
- Load locked
- ~ 12 years old

Materials and processes

Materials etched

- Si
- Quartz
- SiO2 and SiNx
- Photoresist ashing and descuming
- Metals (Ti, Ta, W)
  - Au and Pt on occasions

Masks

- SiO2 and SiNx
- Photoresists (AZ9260, S1813, SU8)
- Metals (Al, Cr)

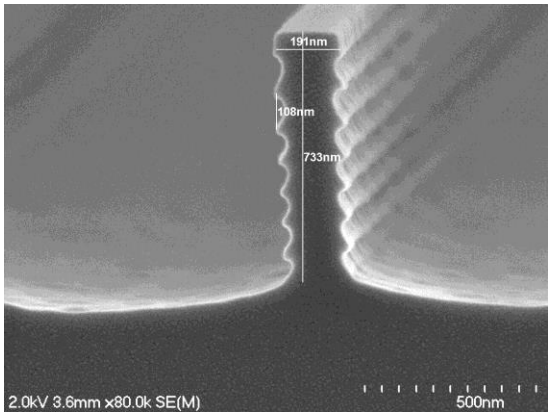
- Main application is Si Bosch etching for microfluidics and MEMS
- Primarily characterized with 6" Si
- Dilemma between accommodating users and maintaining integrity of the system

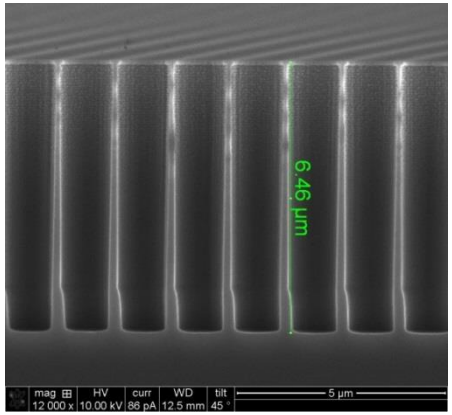
Si - Low Roughness

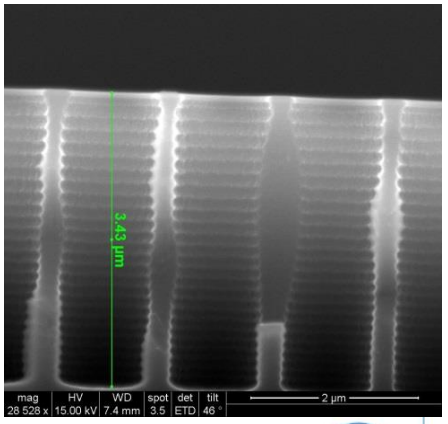
	Source	SH bias	SF6/C4F8	SF6/C4F8	Valve/press	Temp
4”	1200 W	60 W LF/10%	200/100 sccm	3/1 s	100%/~5mTorr	-10 °C
6”	1200 W	75 W LF/10%	200/100 sccm	3/1 s	100%/~5mTorr	20 °C

- Most common process – used for baselining after 15 min clean and season
- Substrate holder distance to source: 200 mm

	4”	6”
Si etch rate (% open area) (um/min)	1.7 (95%) - 2.3 (60%)	1.4 (100%) - 2.7 (20%)
Selectivity to mask	PR: >25	PR: 20 - 30







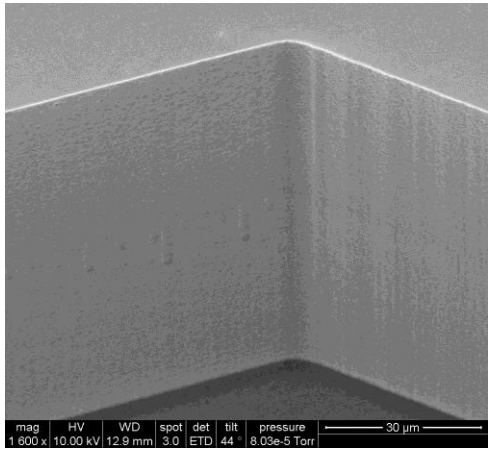
Scalloping ~100nm

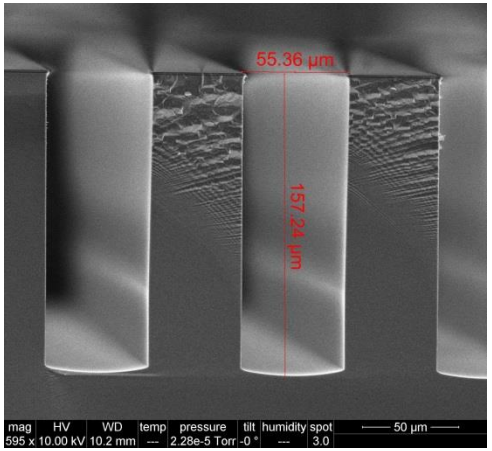
Si - Standard

	Source	SH bias	SF6/C4F8	SF6/C4F8	Valve/press	Temp
4”	1800 W	70 W LF/20%	320/160 sccm	7/2.2 s	25%/~30 mTorr	-10 °C
6”	1800 W	75 W LF/10%	320/160 sccm	7/2 s	25%/~30 mTorr	20 °C

- Substrate holder distance to source: 200 mm

	4”	6”
Si etch rate (% open area) (um/min)	3.4 (100%) - 6.3 (0%)	2.6 (100%) – 6.0 (0%)
Selectivity to mask	PR: 24 - 60	PR: 20 – 50





- Scalloping ~200 nm

Si - High Aspect Ratio

	Source	SH bias	SF6/C4F8/O2	SF6/C4F8	Valve/press	Temp
6”	1500 W	75 W LF/10%	300/200/100 sccm	4/2/1 s	100%/~5 mTorr	0 °C

- Substrate holder distance to source: 120 mm

	6”
Si etch rate (% open area) (um/min)	3.2 (40 %)
Selectivity to mask	PR: >21

- 30:1 is supposedly possible
- Above process not optimized

Si - High Etch Rate

	Source	SH bias	SF6/C4F8	SF6/C4F8	Valve/press	Temp
6”	2500 W	75 W LF/10%	700/100 sccm	7/2 s	25%/~30 mTorr	10 °C

- Substrate holder distance to source: 120 mm

	6”
Si etch rate (% open area) (um/min)	>10.0 (20%)
Selectivity to mask	PR: > 50

- Heated liner tends to overheat for long (~30 min) runs

Quartz etching

	Source	SH bias	Ar/C4F8	Ar/C4F8	Valve/press	Temp
6”	2500 W	150-350 W RF	150/20 sccm	const. flow	100%/~5 mTorr	0 °C

- Substrate moved closer to source (120 mm)
- Considerable FC in chamber
- User should perform O2 clean regularly

Metal Etching

Ti

Source	SH bias	SF6/O2/Ar	SF6/O2/Ar	Valve/press	Temp	Etch rate
500 W	75 W RF	150/20/50 sccm	const. flow	25%/~30 mTorr	20 °C	125 nm/min

W

Source	SH bias	SF6	SF6	Valve/press	Temp	Etch rate
1200 W	75 W RF	300 sccm	const. flow	100%/~10 mTorr	20 °C	440 nm/min

Pt

Source	SH bias	SF6/Ar	SF6/Ar	Valve/press	Temp	Etch rate
350 W	75 W RF	50/150 sccm	const. flow	100%/~5 mTorr	20 °C	18 nm/min

Ta

Source	SH bias	SF6/C4F8	SF6/C4F8	Valve/press	Temp	Etch rate
1200 W	75 W LF/10%	200/100 sccm	3/1 s	100%/~5mTorr	20 °C	0.5-0.8 um/min

More about this process tomorrow

Teflon deposition

Source	SH bias	C4F8	Valve/press	Temp	Etch rate
250-500 W	25 W RF	50 sccm	25%/~20 mTorr	20 °C	33 - 65 nm/min

- An alternative to PDMS mold silanization treatments

Maintenance Issues

- Polyurethane tubing is deteriorating and leaks water ~ once/month - Replace individual tubes as they fail
- Pneumatic lines and fittings also deteriorating – can be a subtle change and hard to find
- Device Net communication issues – usually solved with hard reset and lots of patience
- Occluded stainless pump exhaust line – replaced with shorter line
- Roughing pump failures – leaking oil usually solved with new seals and vanes