

Etching Systems in NUFAB



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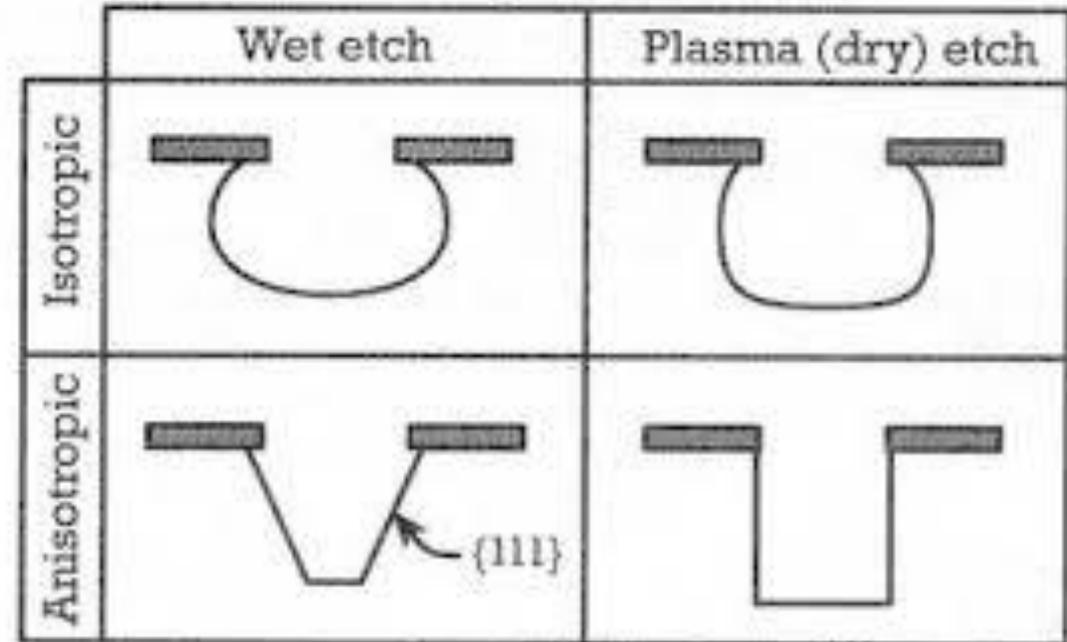
Outline

- ▶ Introduction—Etching in micro/nanofabrication
 - ▶ What does etching do?
 - ▶ Etch classification and features
- ▶ NUFAB etch equipment
 - ▶ Wet chemical fume hoods
 - ▶ RIE
 - ▶ DRIE
 - ▶ Others: XeF₂ etch, O₂ plasma asher
- ▶ Incoming new system and useful systems in wish list
 - ▶ Automatic Acid Etch Station
 - ▶ New DRIE
 - ▶ Chlorine based ICP
 - ▶ Ion Mill



Etch Introduction

- ▶ Transfer nano/microscale pattern from one “masking” film to another film or bulk material
- ▶ Etch classification
 - ▶ Chemical –Physical
 - ▶ Dry—Wet
 - ▶ Isotropic—Anisotropic



Wet Chemical Bay

—3 fume hoods for different wet processes



Chemical Process Capabilities

- ▶ #1: Si bulk etch with—KOH, TMAH (anisotropic), hot water bath available, 1-1.5um/min
- ▶ #2: SiO₂ etch (HF 49% and BOEs), Gold etch, and etc.
- ▶ #3: Metal etch (Cr, Cu, Au, FeO, Pt, Al, Ni, etc.); Organic film strip or cleaning (Nanostrip)
- ▶ Takes care over 70% etch work in NUFAB

Au	28A/sec
Cu	~100-200nm/sec
Cr	40A/sec
FeO	50A/sec
SiO ₂ (wet thermal)	23nm/min (BOE 10:1) 100nm/min (BOE 5:1)



Dry Etch –RIE (Samco)

- ▶ 10 recipes available to users
- ▶ Fluorine based chemistry, versatile for many films: Si, SiO₂, Si₃N₄, poly-Si, etc.
- ▶ O₂ plasma for cleaning
- ▶ Parallel plate electrodes, ideally anisotropic, not that “anisotropic” as DRIE, works for certain range
- ▶ Ar plasma for physical etch

Recipe Number	Description	Etch Rate
1		
2	P-Si (Fine) #1	580 Å/min
3	P-Si (Fine) #2	900 Å/min
4	Si Etch (Vertical Walls)	2950 Å/min
5	SiO ₂ Etch Mask Formation	210 Å/min
6	Polyimide	210 Å/min
7	SiN Etch (CF ₄)	1000 Å/min
8	SiN Etch	890 Å/min
9	SiO ₂ Etch (CF ₄)	270 Å/min
10	Chamber Clean	

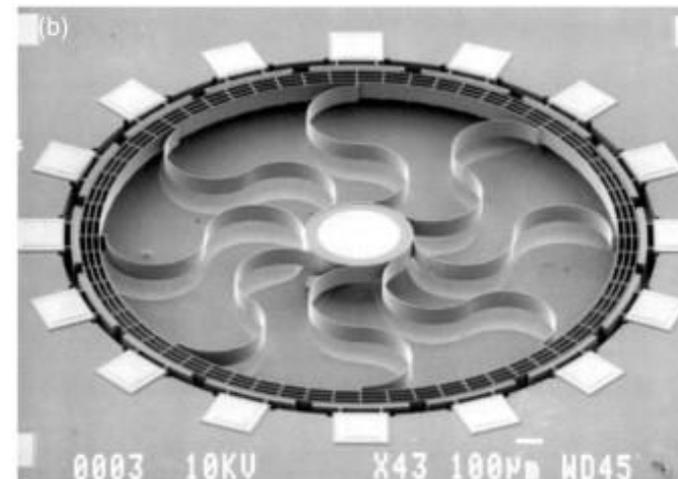
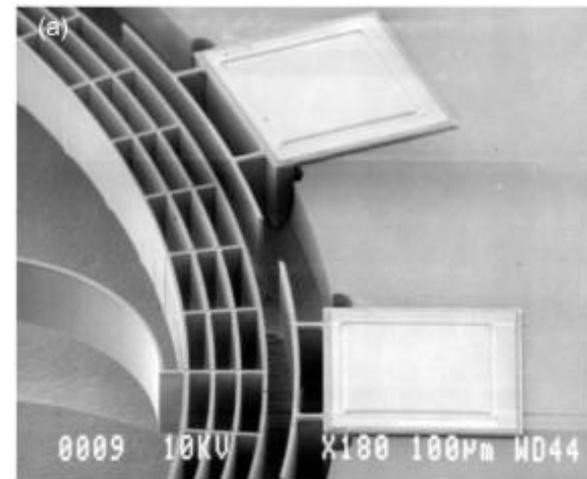
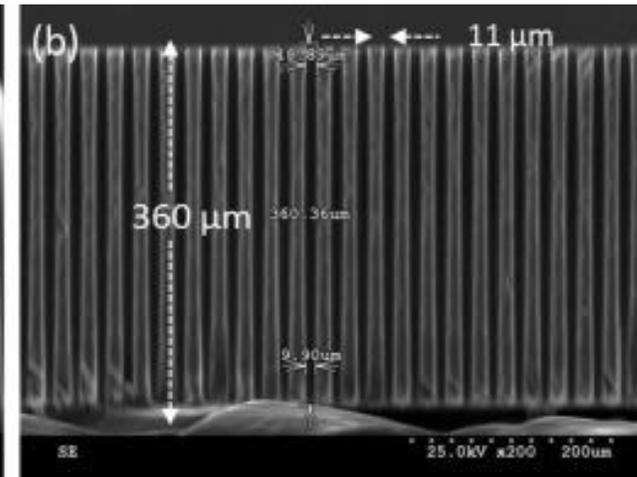
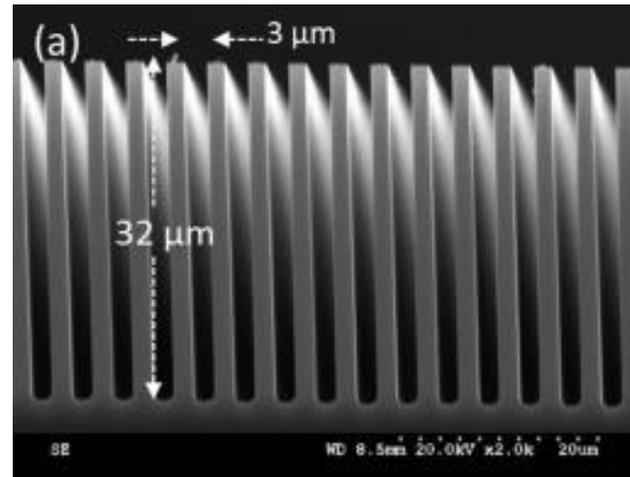


Dry Etch—DRIE (STS) High Aspect Ratio Si Structures

- ▶ Bosch process— alternating etch and passivation cycles
- ▶ Straight side wall, highly anisotropic
- ▶ Feature depth—hundreds nanometers to 1mm
- ▶ Highly automated machine, easy to operate, but need careful pattern layout design for desired etch profile
- ▶ Fluorine based ICP process for submicron scale Poly-Si etch (under development on current DRIE)



DRIE etch profiles



Custom DRIE process

- ▶ 3 standard recipes with different etch rate, ranging from ~2.5-15 $\mu\text{m}/\text{min}$
- ▶ Arrays of nanoscale patterns at subzero platen temperature
- ▶ Pillars/mounds with gradual positive slope
- ▶ Extreme deep trench (600-1000 μm) with gradual slope and coating for easy PDMS demolding



Trench ~several μm to hundreds μm , custom array of hundreds nm dia. holes



Positively sloped pillar/mounds, up to tens-~300 μm tall

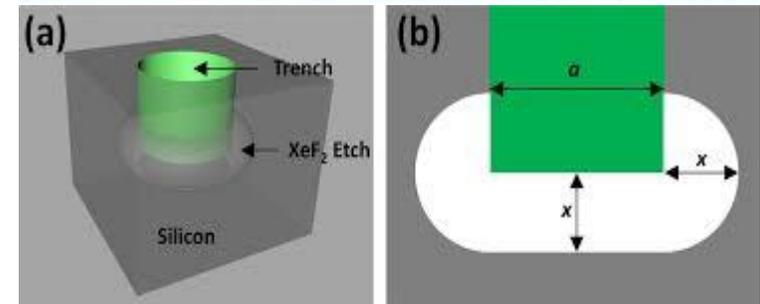


Very small positively sloped extreme high aspect ratio trench, up to 600 μm —1 mm deep



Other etching equipment

- ▶ O₂ plasma cleaner – Samco PC300
- ▶ CF₄ etch (under development)
- ▶ XeF₂ etcher – Si release, can etch other materials too



Incoming Osiris Automatic Acid Station

- ▶ Dry-in dry-out process
- ▶ Highly controlled process
- ▶ Much safer and no cleaning work for users
- ▶ Lots of time saving for photomask and many other pattern etching
- ▶ Expandable in the future for more chemicals



Suggestion for New Capabilities

- ▶ NEW DRIE (to accommodate increasing use)
- ▶ ICP
 - ▶ Chlorine based ICP for metal etch
- ▶ Ion Mill



Conclusion

- ▶ NUFAB has a wide variety of choice for users' etch needs
- ▶ We are working toward more state-of-the-art equipment to serve nano/microfabrication in research
- ▶ Please feel free to contact staff for your application questions or process development

Thank you for watching our video.

