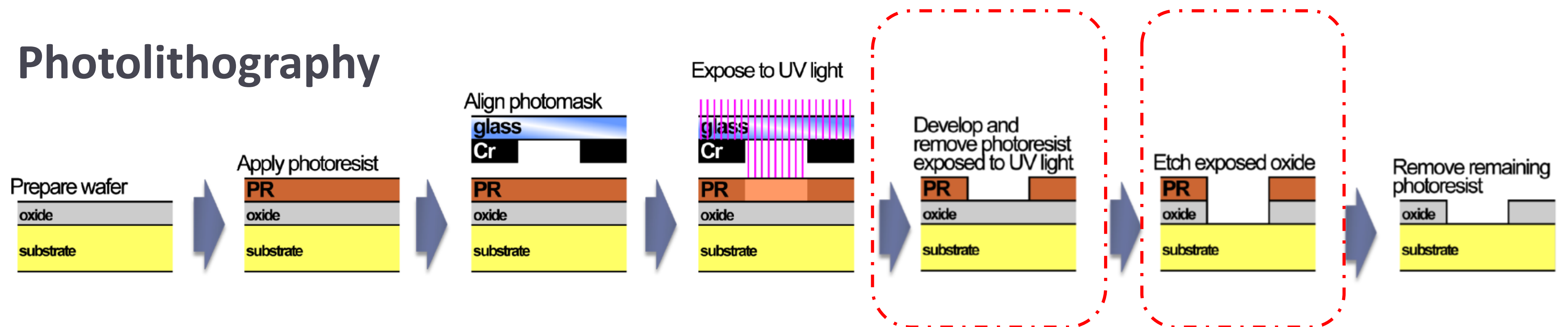
Automated Wet Chemical Processing@

By Shaoning Lu and Serkan Butun

In this talk…

- Typical wet processes used in NUFAB
- What new automation tools NUFAB offers for wet processing?
  - Developing
  - Photomask Etching

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY



NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Any process in which the substrate is in contact with a liquid chemical is considered wet process.

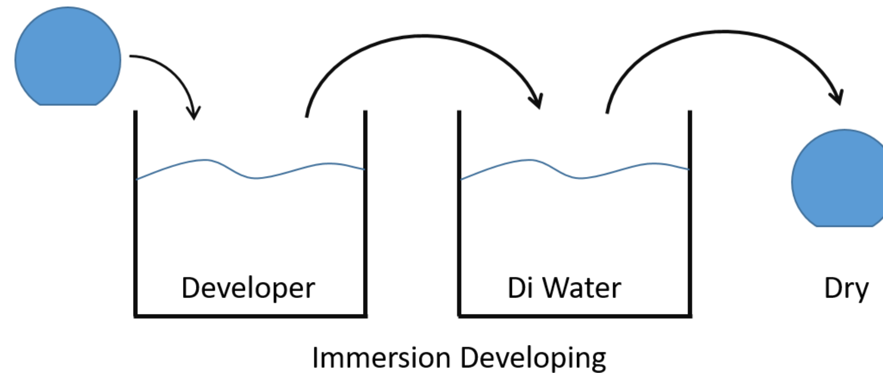
- **DI water rinsing**
- **Solvent cleaning** – Acetone, IPA, NMP
- **Photoresist Developing** – MIF, MIC, solvent developing
- **Acid etching** – Buffered oxide etching, photomask etching, HNO3, Nanostrip
- **Alkaline etching** – KOH, TMAH

Developers at NUFAB

Developer	Type	Main ingredient	Normality	Surfactant
AZ400K 1:4	MIC	KOH	0.278	no
AZ300 MIF	MIF	TMAH	0.261	no
AZ971 MIF	MIF	TMAH	0.261	yes
MF 319	MIF	TMAH	0.237	yes
SU8 Developer	solvent	PGMEA	n/a	no

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Typical developing process



NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Some tips..

- Always clean labware well before usage. – Consider having your own labware for critical processes.
- Rinse well after develop – rule of thumb: rinse at least as long as your develop time.
- Never let chemicals dry on your substrate – use N2 gun
- Know when to agitate
- There are advanced methods for high aspect ratio patterning – cold developing, hypersonic assist, upside down developing …
- Ask for help, we are here for you!

Problems ¯_(ツ)_/¯

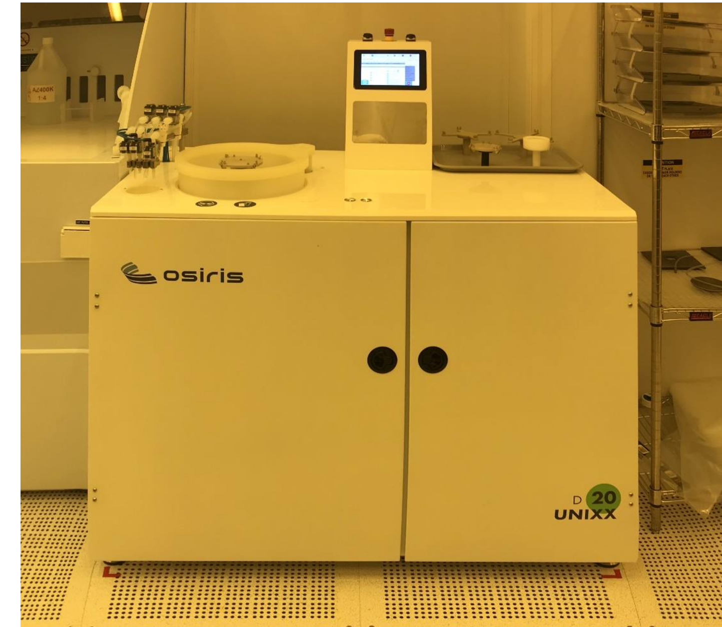
- Sample handling
  - Dropping sample, scratches, over-developing
- Unclean labware
  - Impurities alter the developing time even at ppb levels
- Safety
  - Contact with Hazardous chemicals
- Cost of materials/disposal
  - Environmental impact

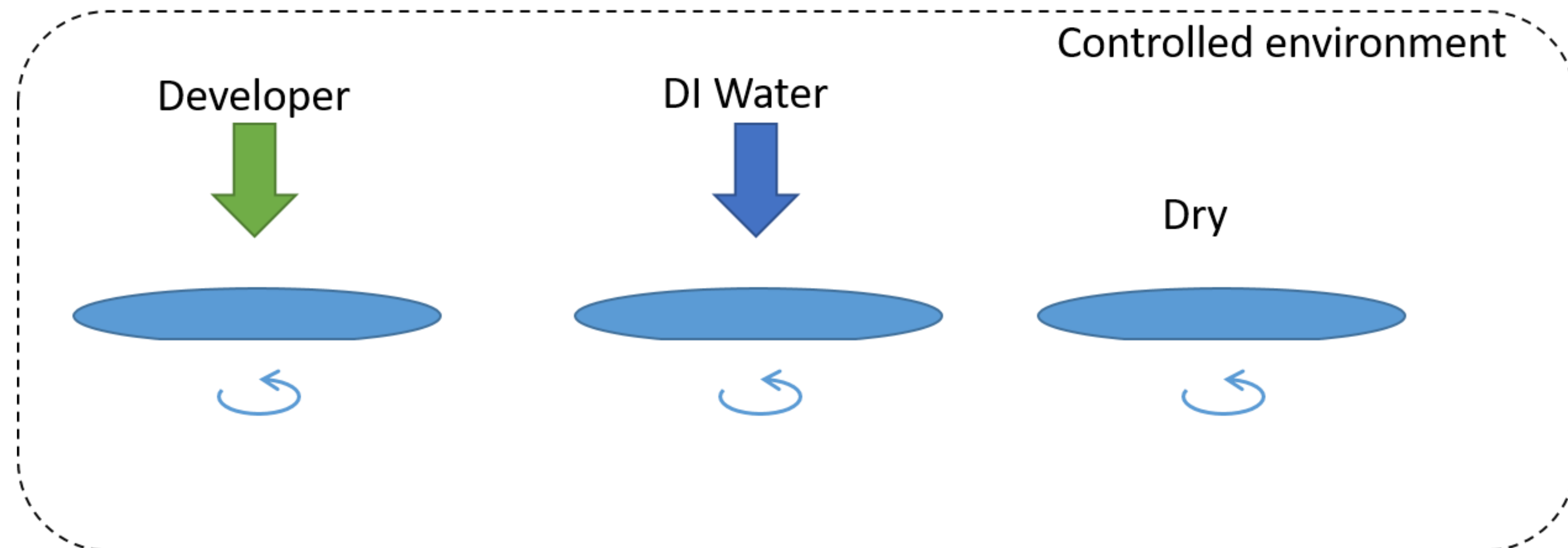
NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Introducing puddle developing

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

- Automated process
- Precise control
- Minimal user input
- Dry in / dry out
- Less developer/waste





Available chemicals and recipes

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

- AZ400K 1:4

- S1805
- S1813, AZ5214E*
- AZP4620

- SU8 Developer
- IPA

- SU8 2002
- SU8 3010

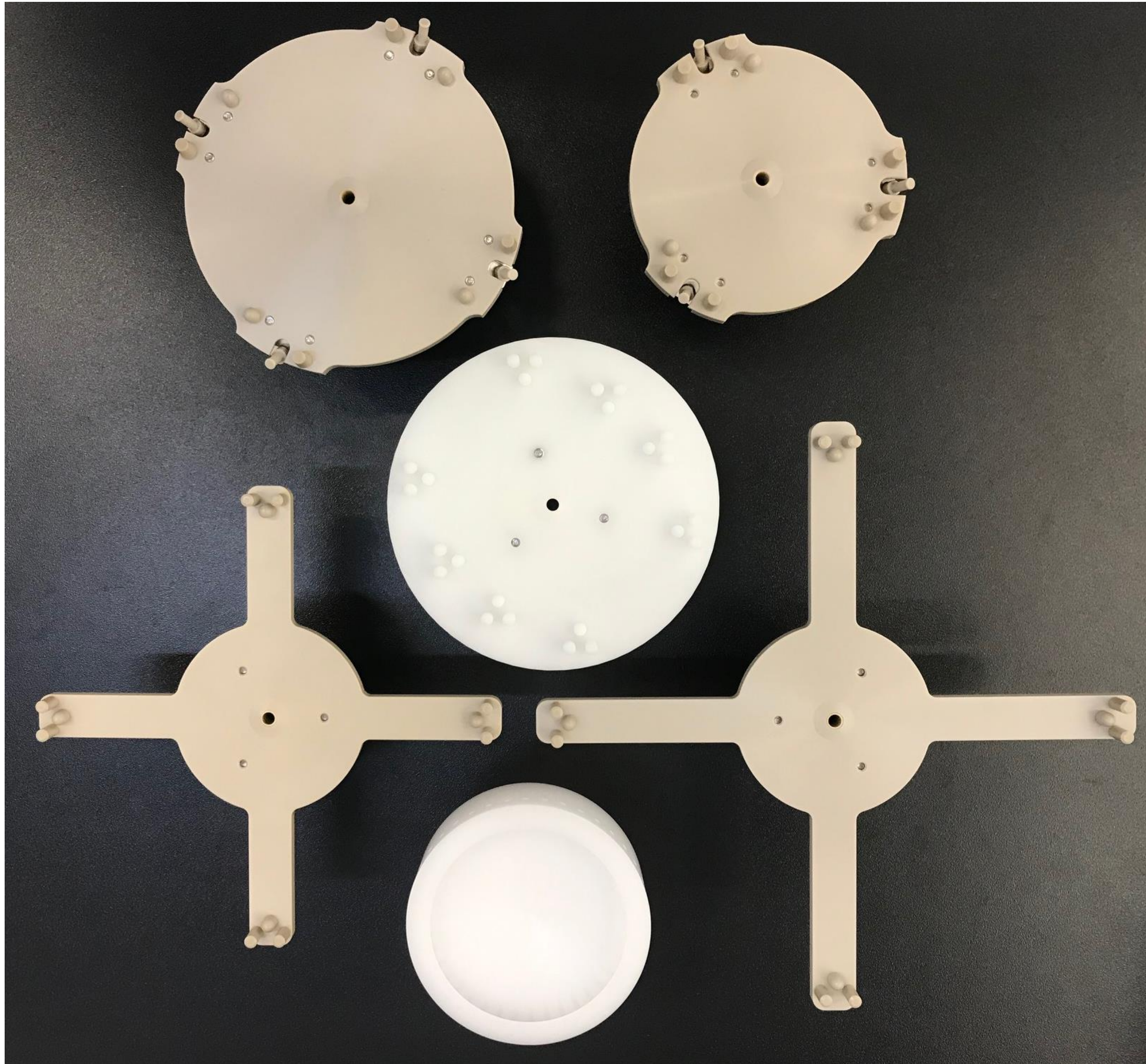
- DI Water

- Sample rinse
- Sample dry

We are actively developing new recipes, let us know if you need a particular one..

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Substrate Chucks

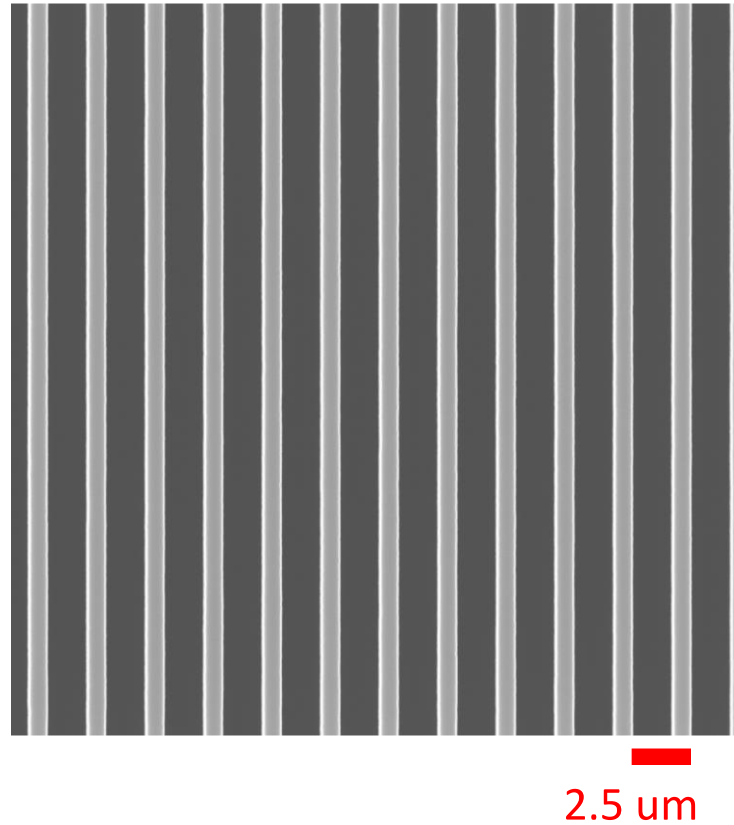


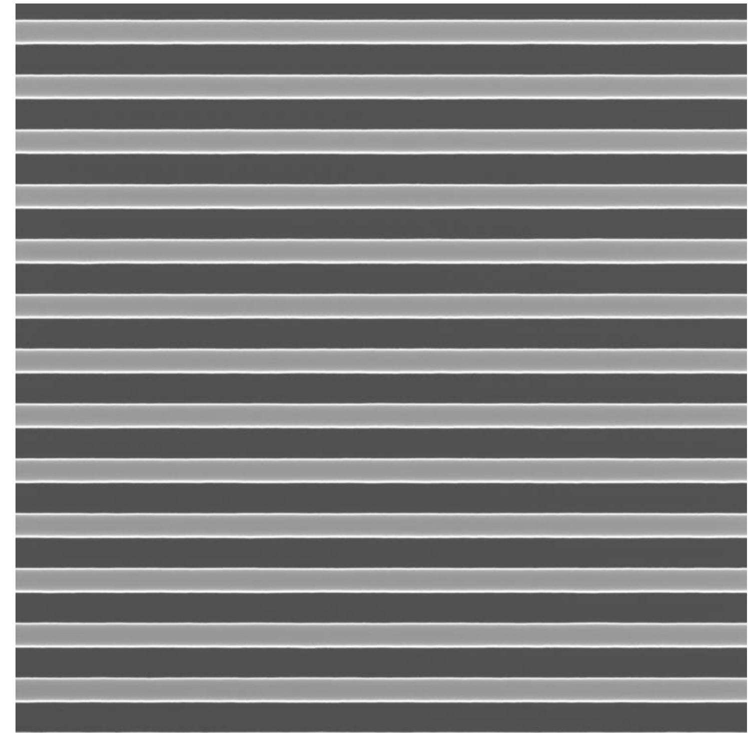
- 3 inch wafer
- 4 inch wafer
- 4 inch mask
- 5 inch mask
- 1by3 microscope slide
- 2by3 microscope slide
- Small piece basket

It is possible to get chucks for any shape substrate

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

High resolution process examples

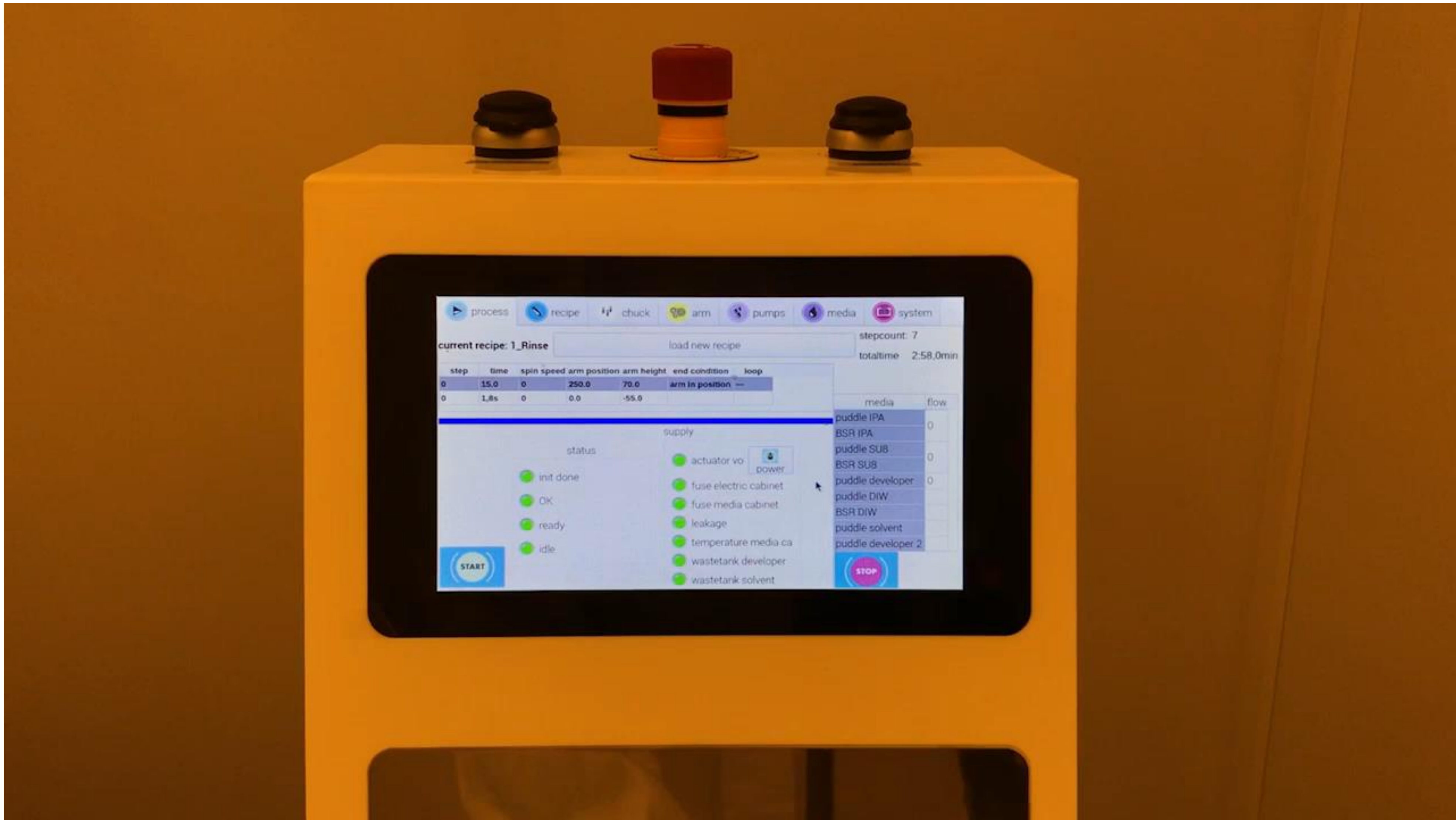




This sample is exposed in Heidelberg MLA150, **developed in Osiris Automatic Developer** and etched in STS DRIE.

Demo video

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

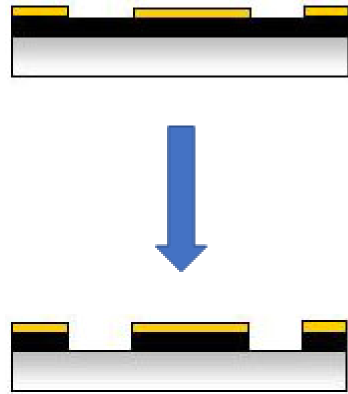


Osiris Automatic Acid Station

- Dry-in dry-out process
- Highly controlled process
- Much safer and much less cleaning work for users
- Lots of time saving for photomask and many other pattern etching
- Expandable in the future for more chemicals

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

This is how we etch a photomask manually



NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

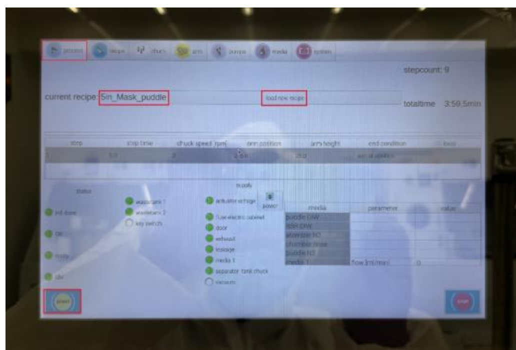
Acid that we're dealing with

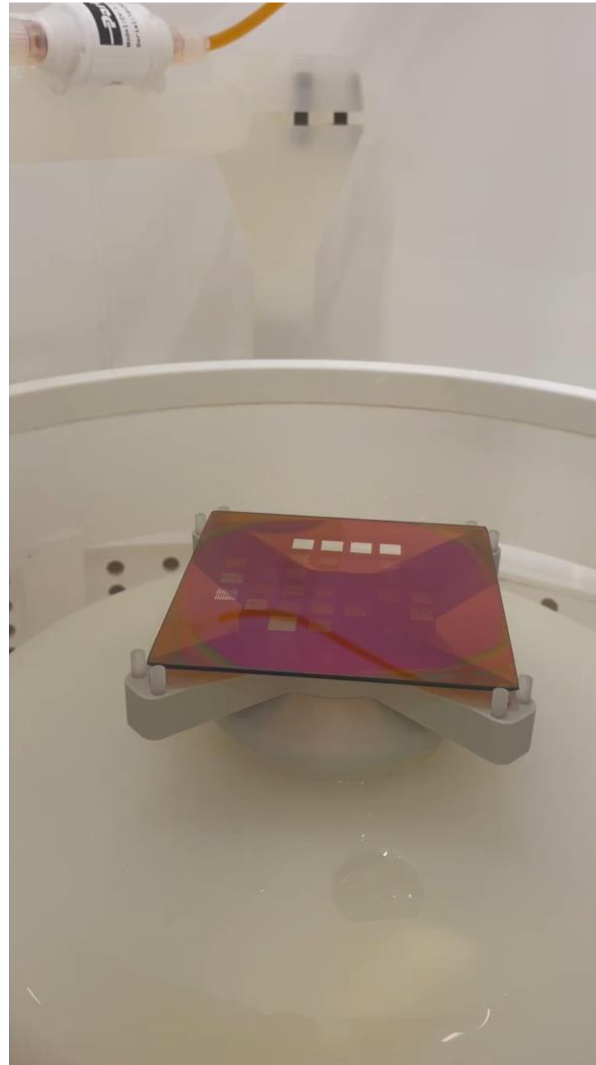
- HNO_3
- HCL
- $HCLO_4$
- H_2SO_4
- HF
- H_3PO_4

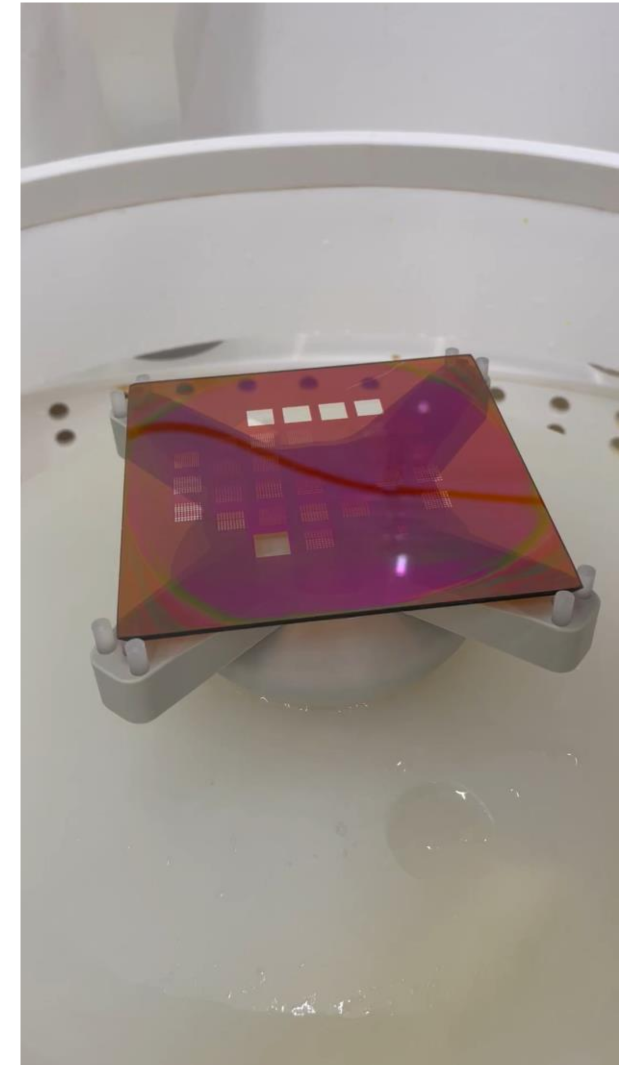
NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

With Automatic Iron Oxide Etch

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY



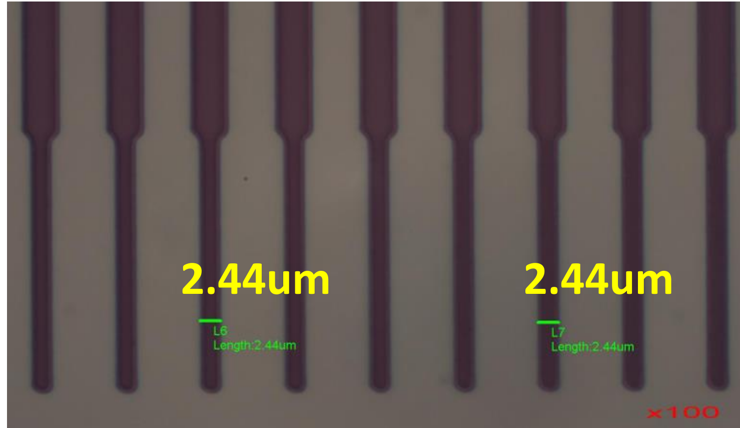




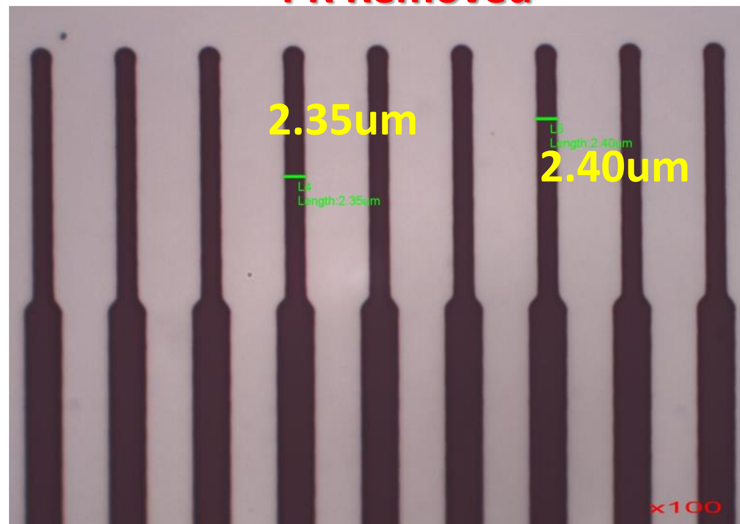
NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Etch Result

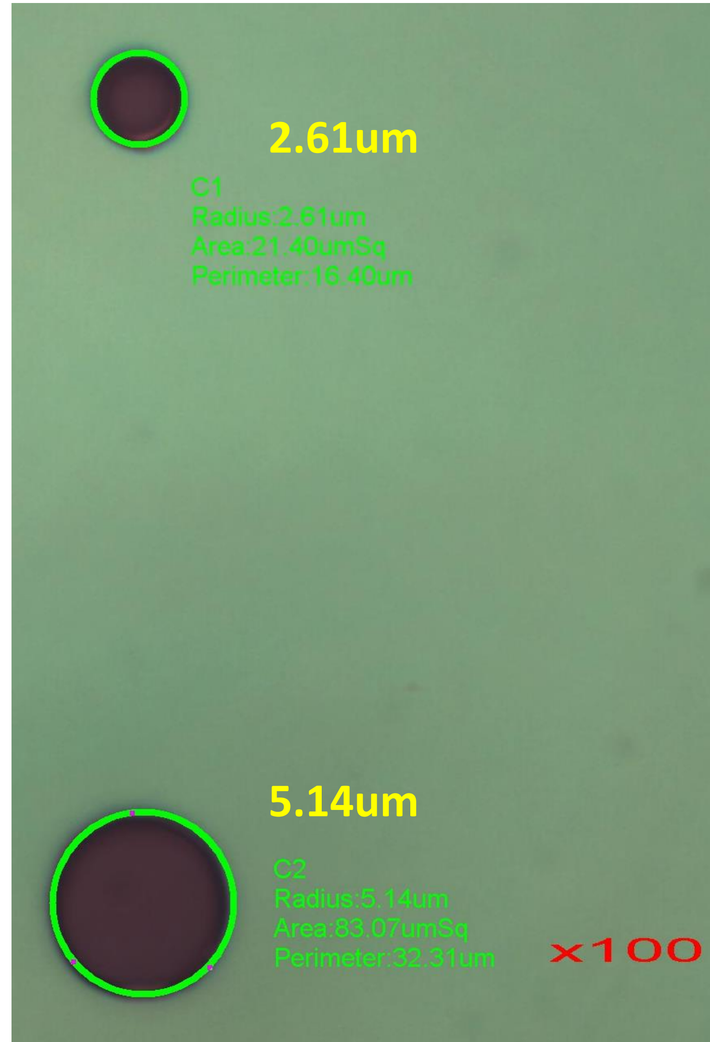
With PR



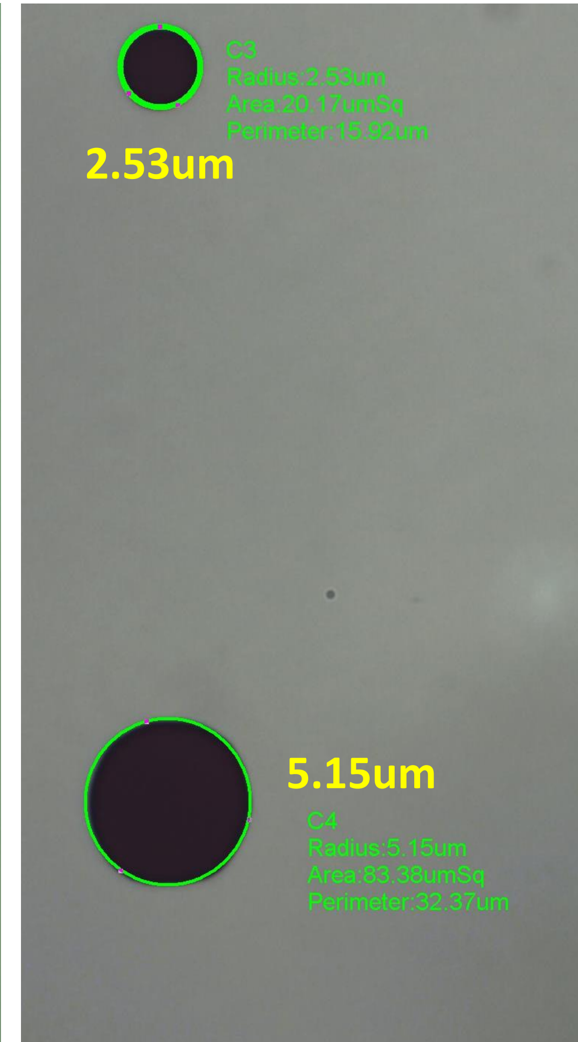
PR Removed



With PR

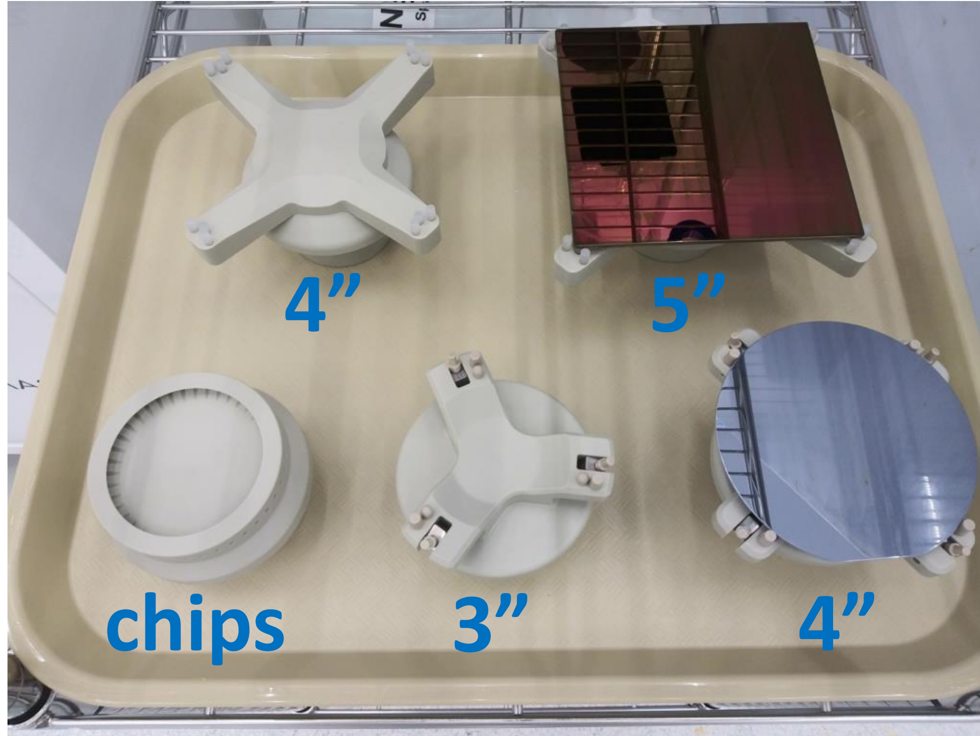


PR Removed



What is the next chemical to add?

- 5 choices of sample size
- 3 more space for chemicals



NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Recap: current wet and dry etch capabilities in NUFAB

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Wet Etch

- Cr
- FeO
- Cu
- Au
- Al
- Ni
- Ti
- SiO_2
- Pt/Mo
- PR/Other organics

Dry Etch

- Si
- SiO2
- SiN
- Polymers

Finally..

- We are working hard to serve micro/nano fabrication in research.
- Which chemicals are you (will you be) interested in using in the automatic developer/etcher systems?
- Please feel free to contact staff for your application questions or process development.

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

NUFAB
NORTHWESTERN UNIVERSITY
MICRO/NANO FABRICATION FACILITY

Thank you!

Questions?