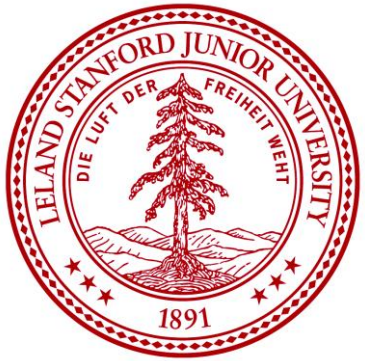
MOLECULAR VAPOR DEPOSITION AND PATTERNING OF ORGANOSILANE SELF-ASSEMBLED MONOLAYERS FOR DIRECTED GROWTH OF NEURON CELLS.

Felix Alfonso & Hsin-Ya Lou

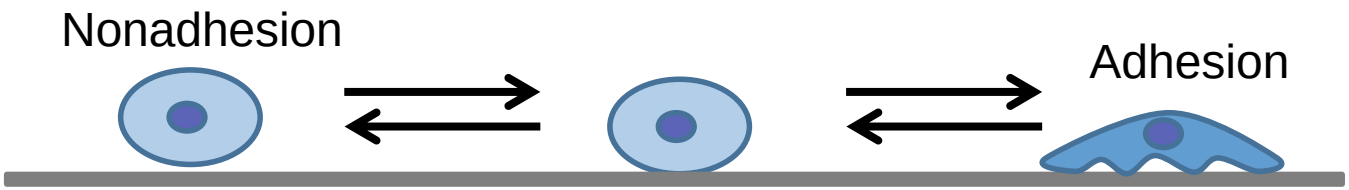
EE412 Final Presentation

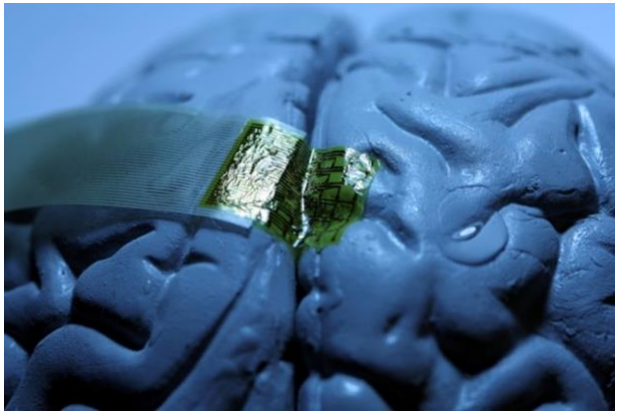
Mentor: Dr. Michelle Rincon

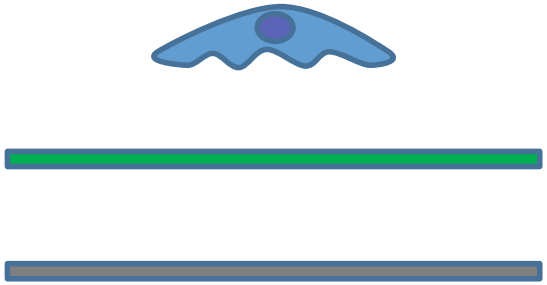
Dr. J Provine



Solid State Devices and Biotechnology







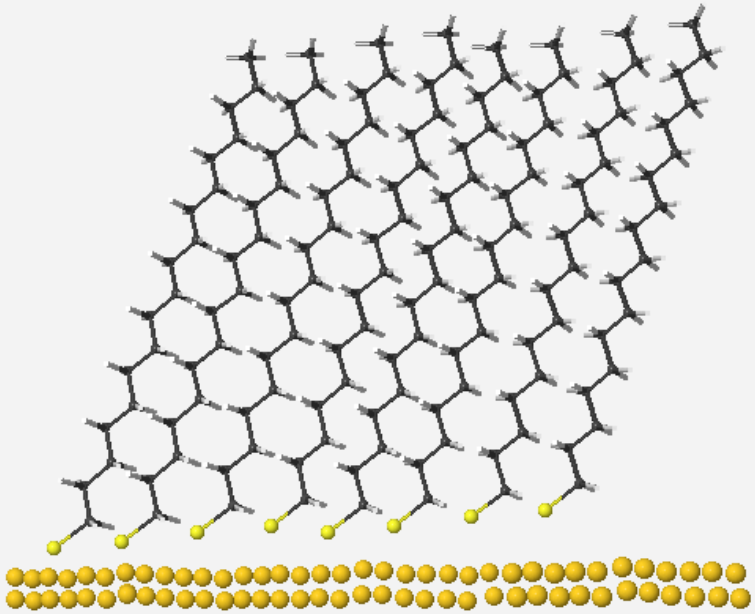
- Cell / Tissue
- Organic Thin Film
- Solid-state Device

- In order to facilitate the integration of solid state devices and biological materials extensive focus has been given to organic thin films as a mediator.

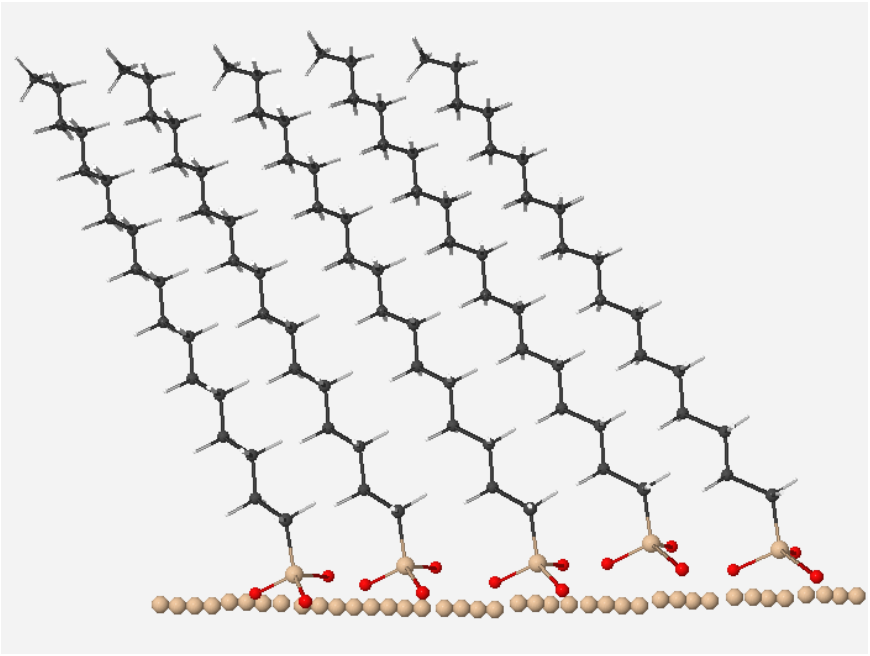
http://www.memsjournal.com/2010/07/mems-applications-for-treatment-of-nervous-system-disorders.html

Self Assemble Monolayers (SAMs)

- Alkanethiol

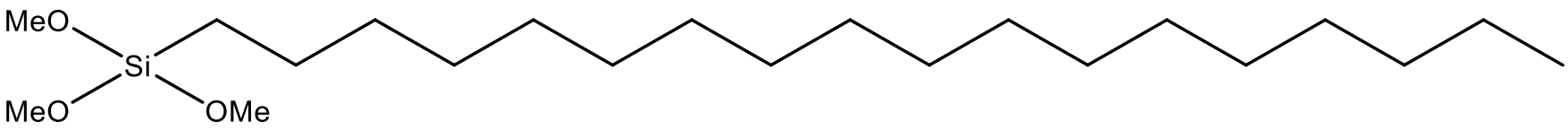


- Organosilane

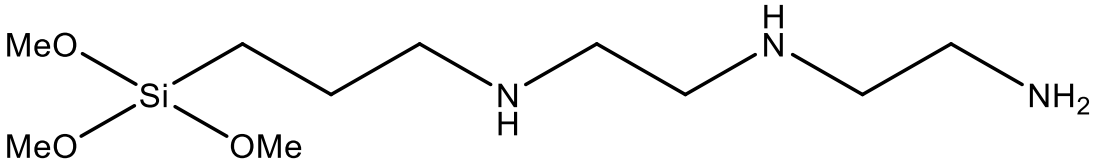


- Alkanethiol monolayers on planar Au surfaces undergo oxidation upon prolonged exposure to air.
- Organosilane mechanical and chemical stability in ambient environment once they have been anchored to a surface.

Organosilane used in this project

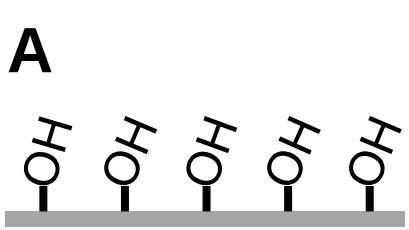


- Octadecyltrimethoxysilane (ODTS)
  - Hydrophobic, cytophobic



- Diethylenetriaminetrimethoxysilane (DETA)
  - Hydrophilic, cytophilic

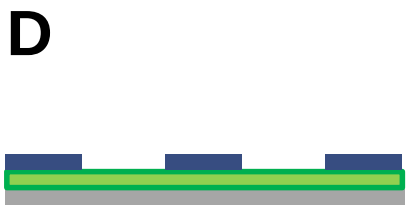
ODS-DETA deposition and Patterning



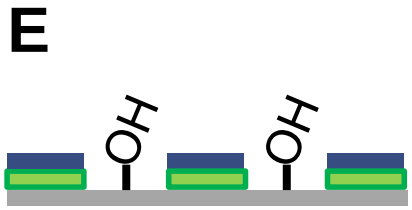
Oxygen Plasma Clean
Drytek2

Deposition of ODS
MVD

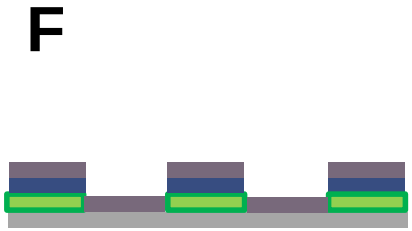
Addition of Resist
svgcoat



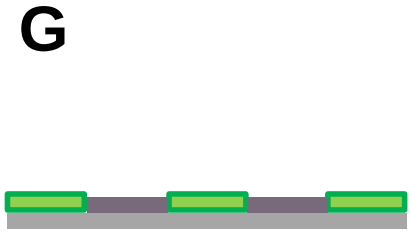
Pattern By lithography
Karlsuss



Dissolved exposed area with
Organic solvent / Oxygen Plasma



Deposition of DETA
MVD

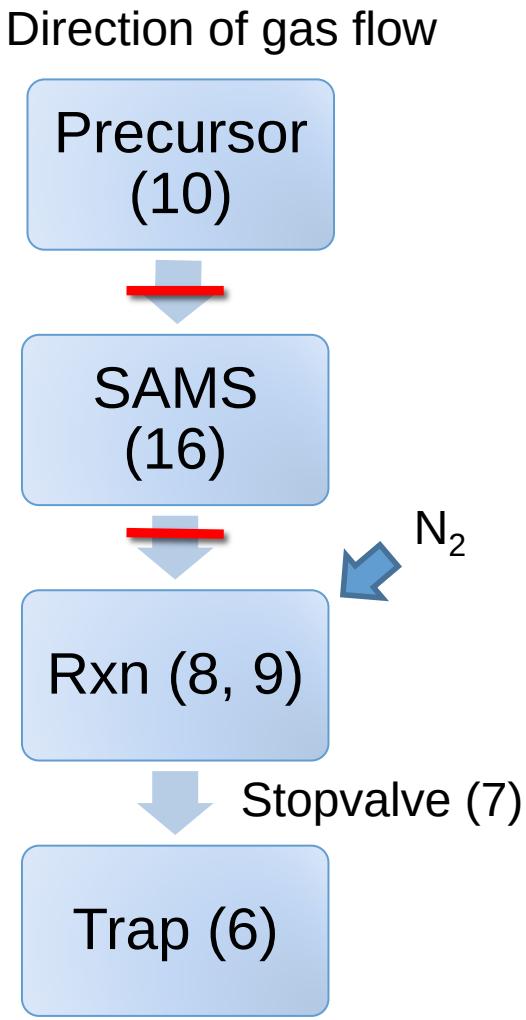


Remove Resist
Lift-off

Deposition recipe

1. Preheat:

1	Flow (N_2)		20	sccm
2	Heater	6 (Trap/Pump line)	130	Deg C
3	Heater	7 (Stopvalve)	150	Deg C
4	Heater	8 (Reaction Chamber)	150	Deg C
5	Heater	9 (Reaction Chamber)	150	Deg C
6	Heater	10 (Precursor)	120	Deg C
7	Heater	16 (SAMS Chamber)	135	Deg C
8	Stabilize	6		
9	Stabilize	7		
10	Stabilize	8		
11	Stabilize	9		
12	Stabilize	10		
13	Stabilize	16		
14	Wait		600	sec



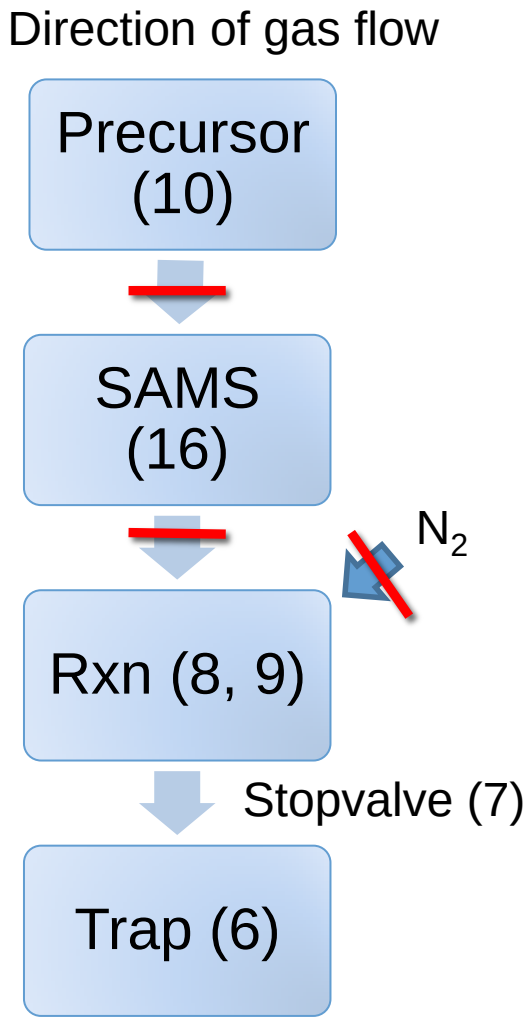
Deposition recipe

2. Chamber Purging

15	Stopvalve		0 (Close)	
16	Wait		60	sec
17	Stopvalve		1 (Open)	
18	Wait		60	sec
19	Goto	16	3	

3. Fill Precursor

20	flow		0	sccm
21	Wait		20	sec
22	SAMS Fill	0	1	torr



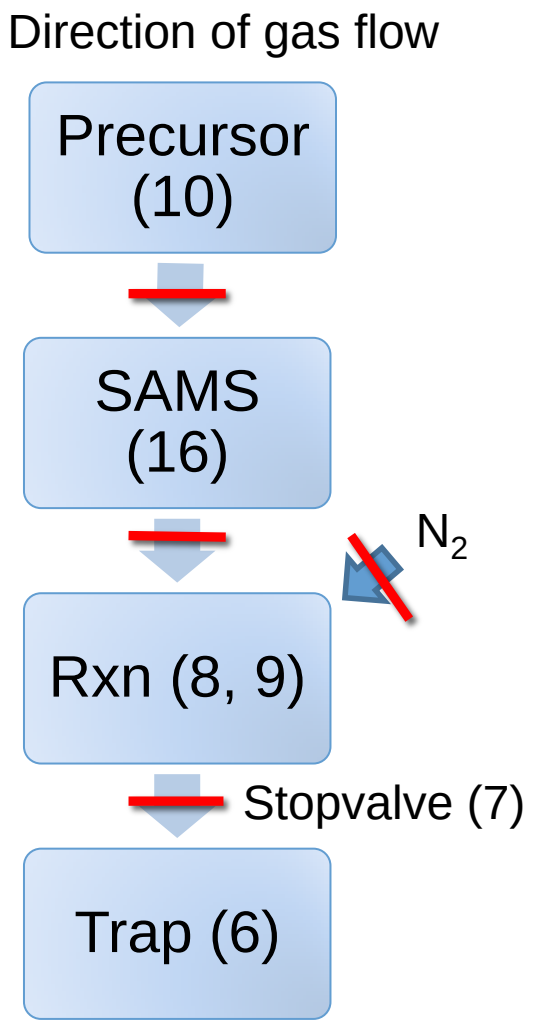
Deposition recipe

4. Reaction

22	Stopvalve		0	
23	Wait		0.5	sec
24	Pulse	0	30	sec
25	Wait		3600	sec
26	Stopvalve		1	

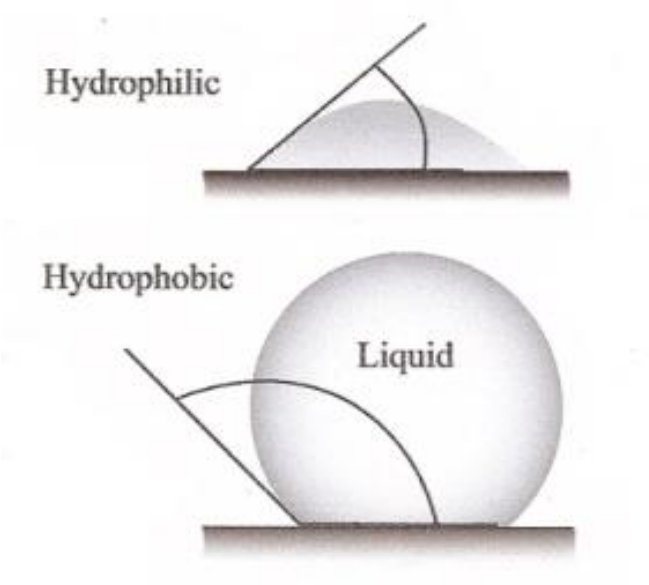
5. Remove Precursor

27	Wait	240		sec
28	flow		20	sccm



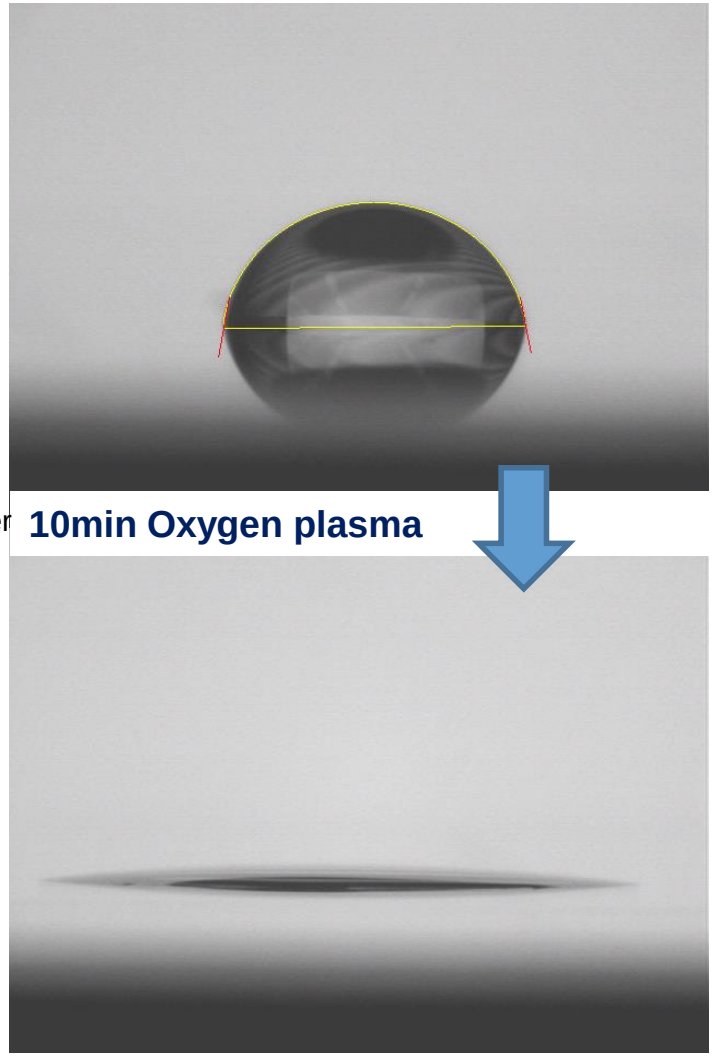
How to quantify the deposition efficiency?

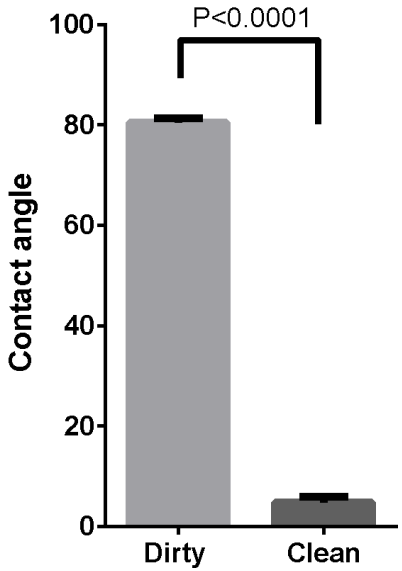
- Contact angle measurement
- Visualize the hydrophobicity of the surface
- Visualize the uniformity by multi-place measurement



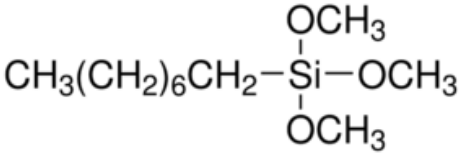
http://www.ramehart.com/

Contact angle and surface cleanness





- Wafers with cleaner (or hydrophilic) surface have smaller contact angle.



ODTS

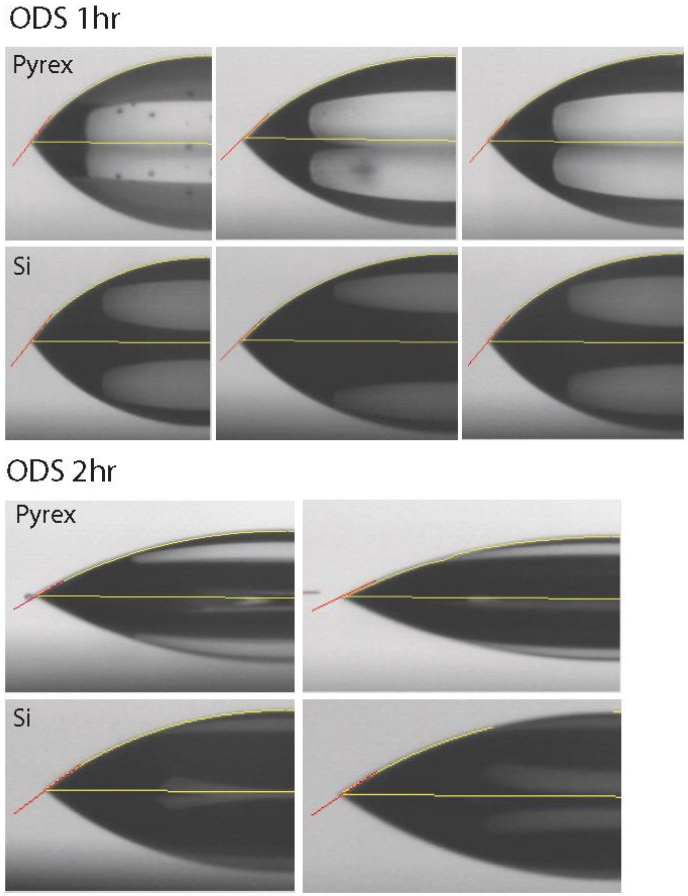
- After ODTS deposition, the surface should become hydrophobic, which results in higher contact angle.

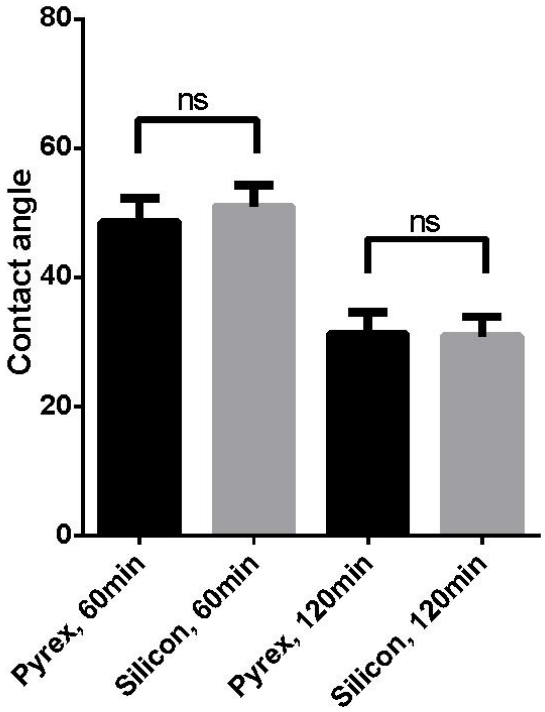
Deposition on different surface

Silicon

Pyrex®

(Contain O, Si, Na, P, B, and K)





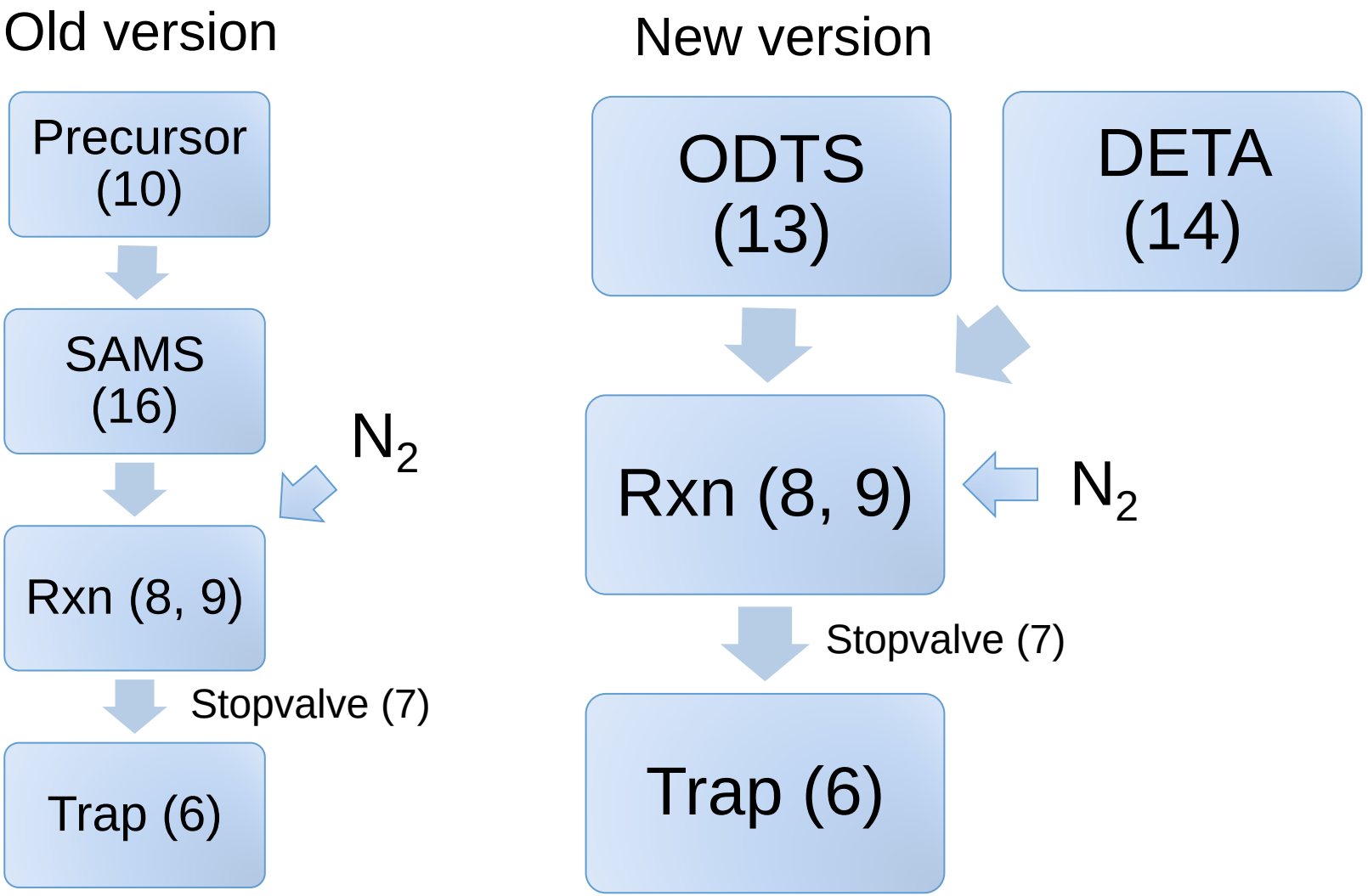
- ODS deposition characteristic for both wafers is similar.

www.amazon.com
http://www.crystal-scientific.com

Disadvantages

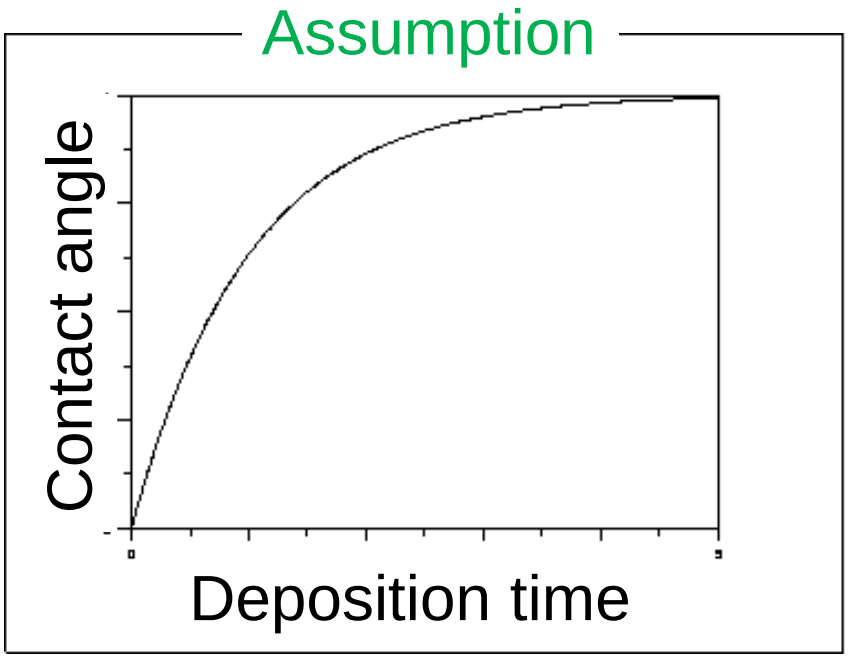
- Inefficiency of refilling precursor chamber
  - About 0.05~0.1 torr/hr, need about 6 hours to refill the SAMs chamber

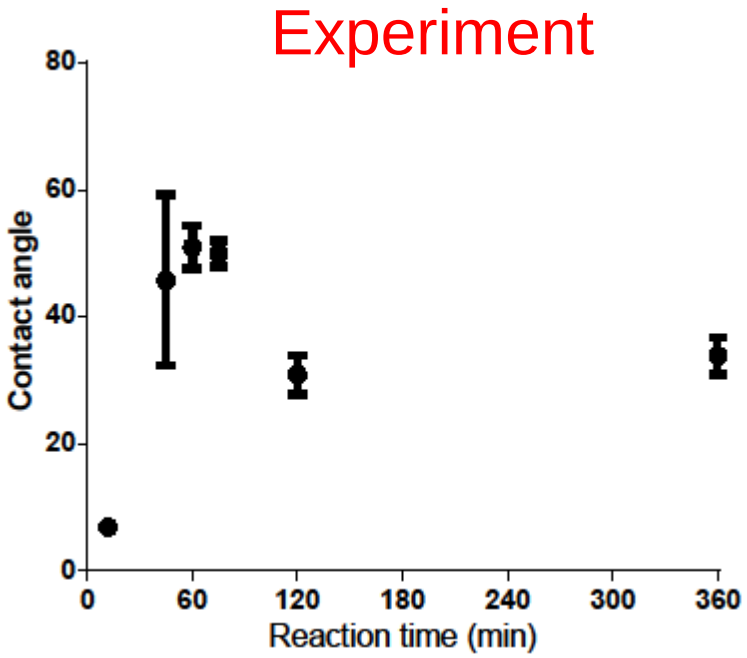
Modify the recipe



ODS deposition

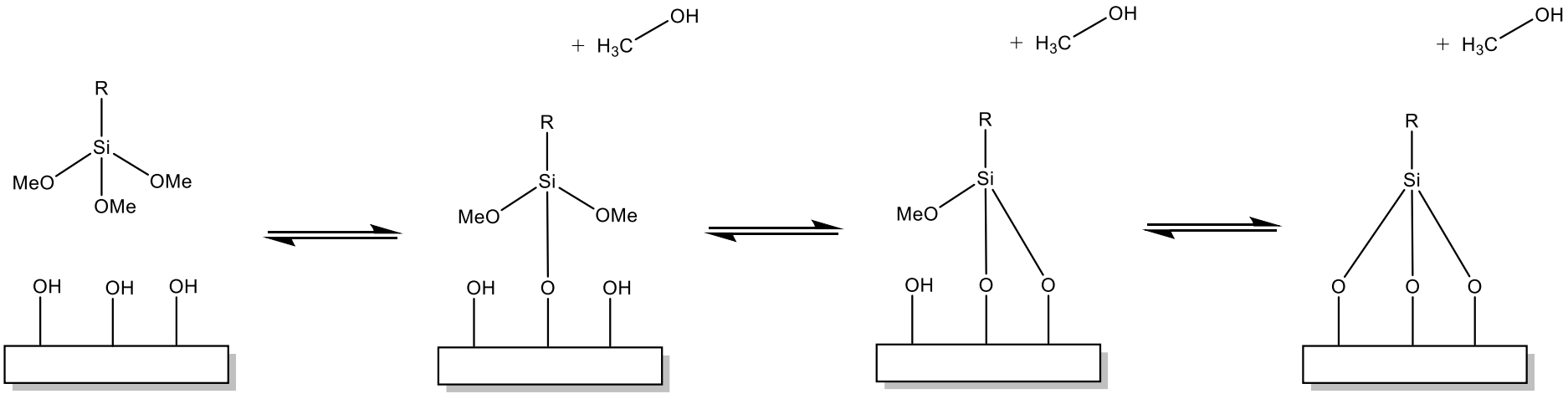
- Assumption: Longer deposition time, higher contact angle.





- Experiment: Has local maxima, and reach to equilibrium.

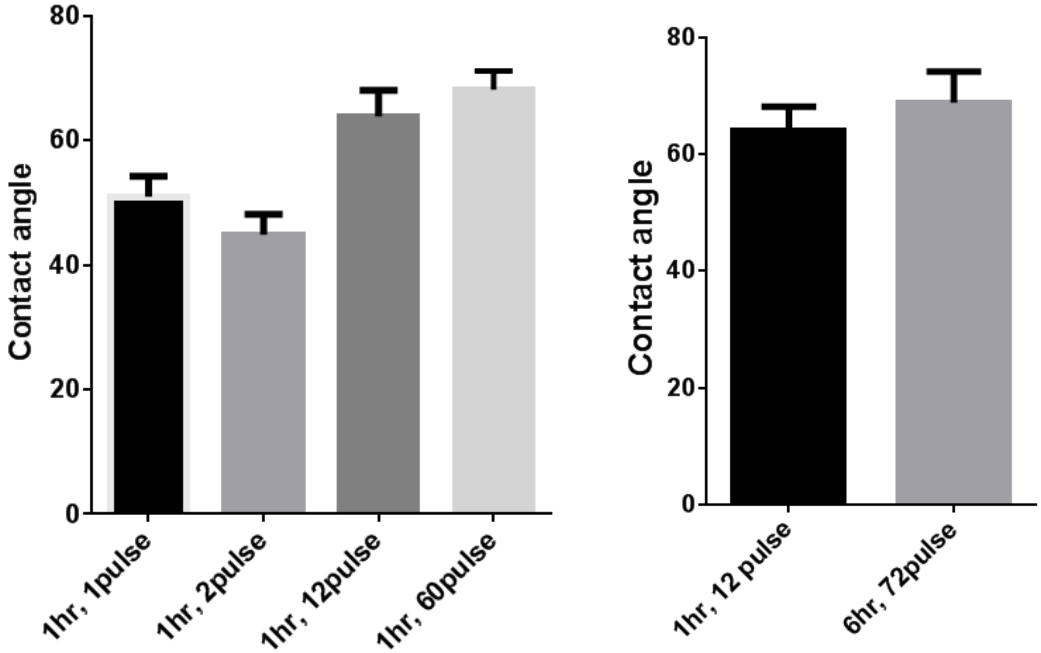
Mechanism of ODTS deposition



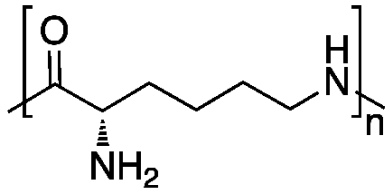
- When ODTS reacts with hydroxyl groups on the surface, methanol will appear as side product.
- Since the reaction is reversible, the more the methanol, the faster the reverse reaction.
- Once the reverse reaction is faster than forward reaction, the deposition efficiency will decrease.

Proof the mechanism

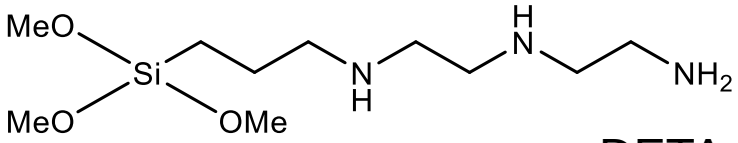
- **Multiple pulses**
- Before every pulse, methanol will be removed and new ODTS vapor will enter into the chamber.
- Results showed that increasing pulses will increase contact angle.



DETA deposition

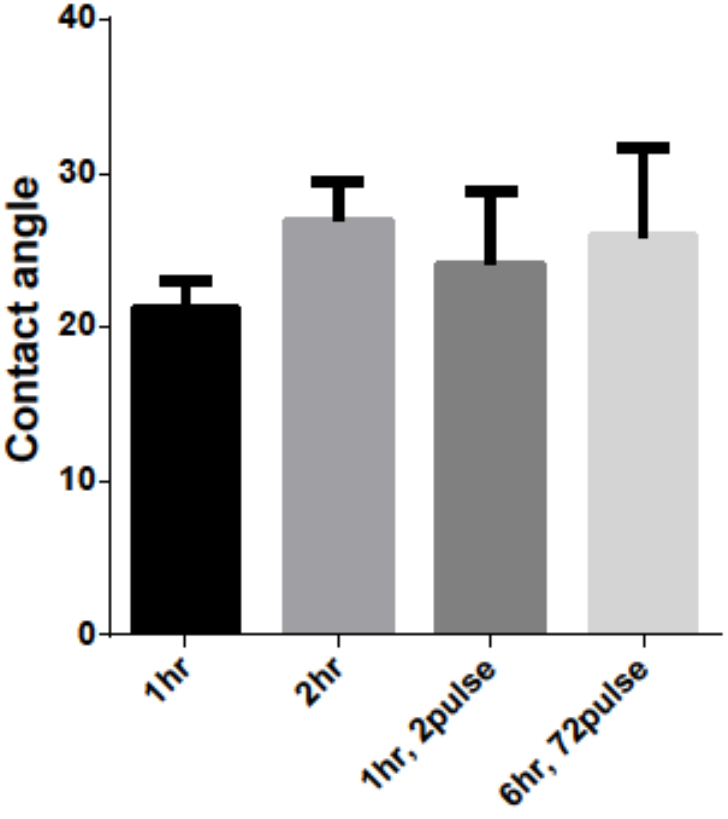


Poly-L-lysine



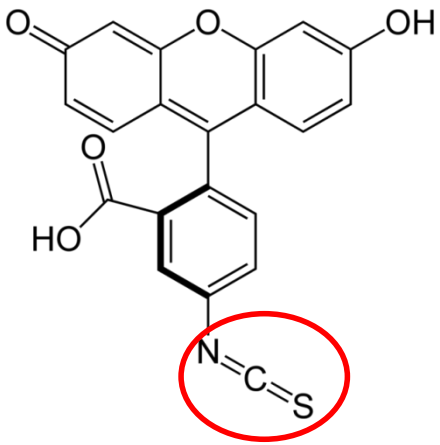
DETA

- DETA could promote cell adhesion as poly-L-lysine
- Hard to monitor the deposition efficiency by contact angle.

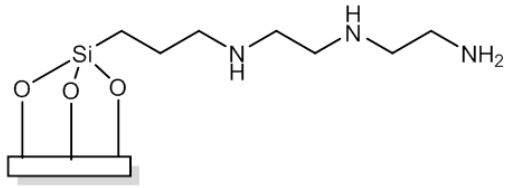


Characterization of DETA deposition

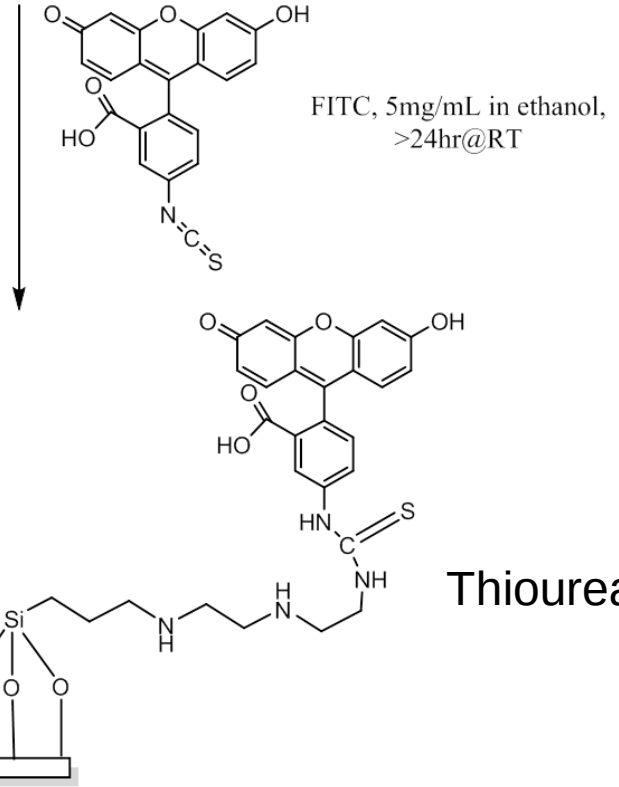
- Fluorescein isothiocyanate (FITC)



Isothiocyanate

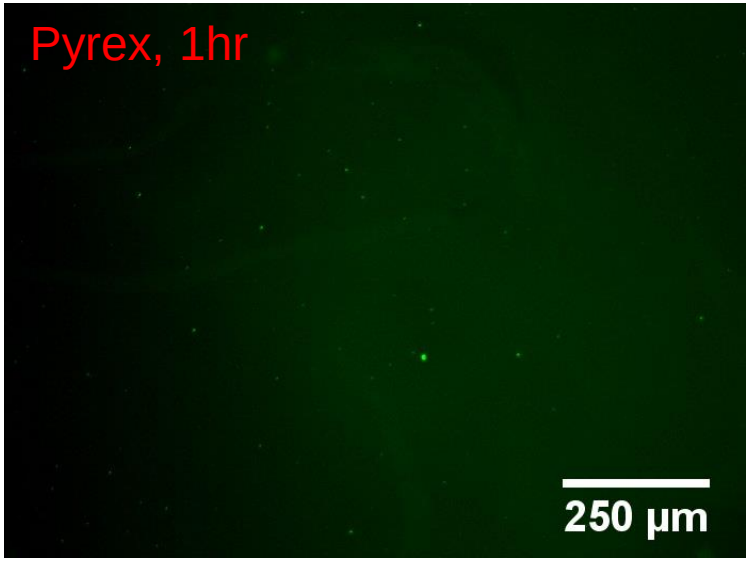


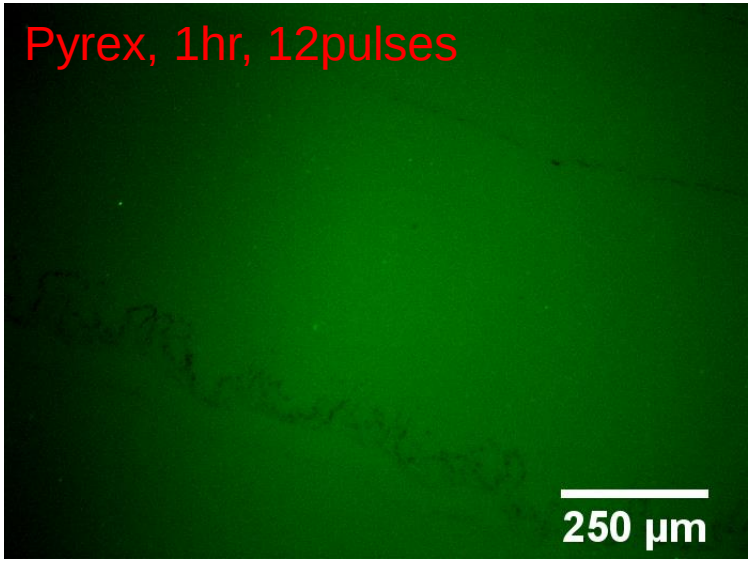
Amine

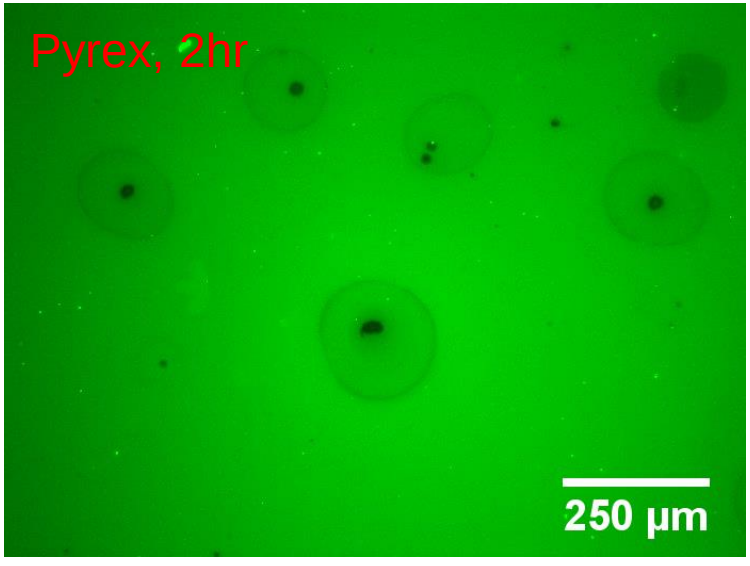


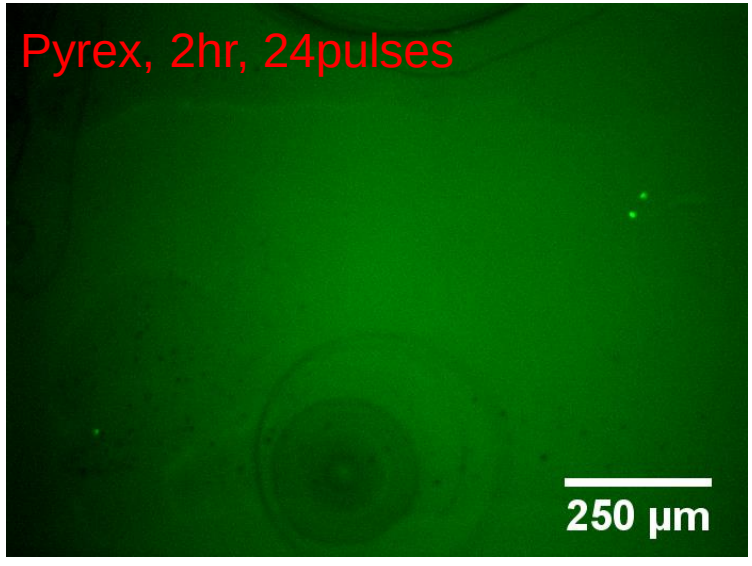
Thiourea

Characterization of DETA deposition

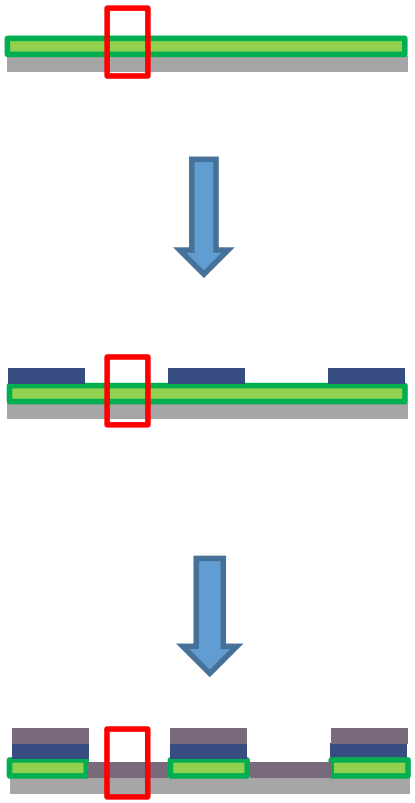








Fabrication of patterned ODS-DETA

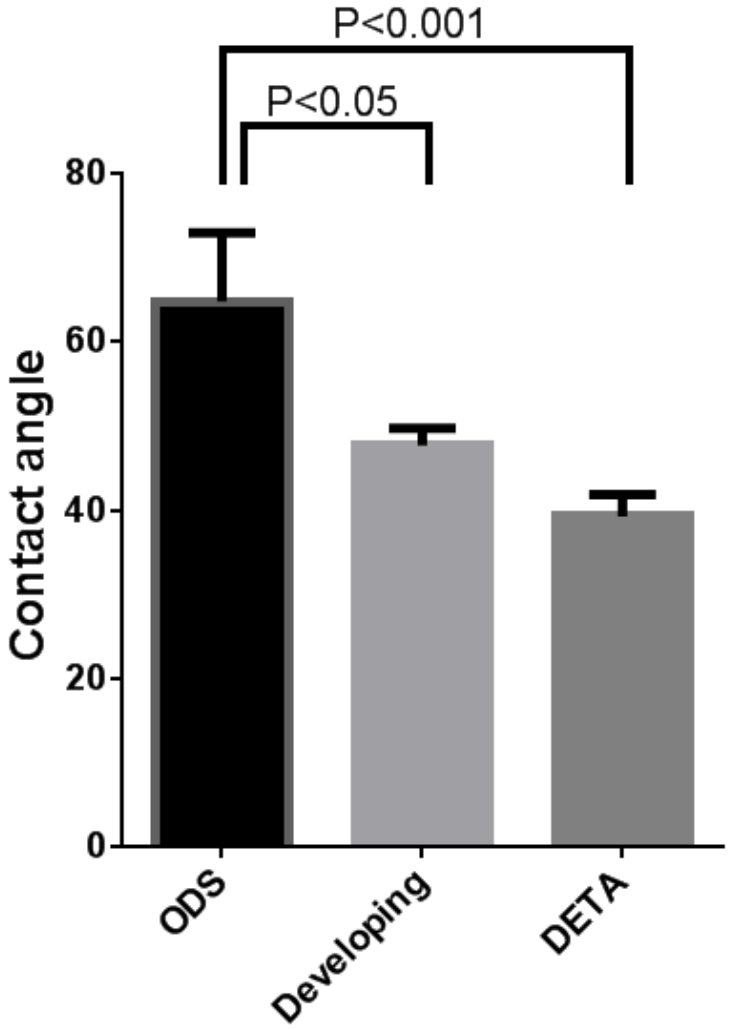


ODS deposition
(6hr, 72pulses)

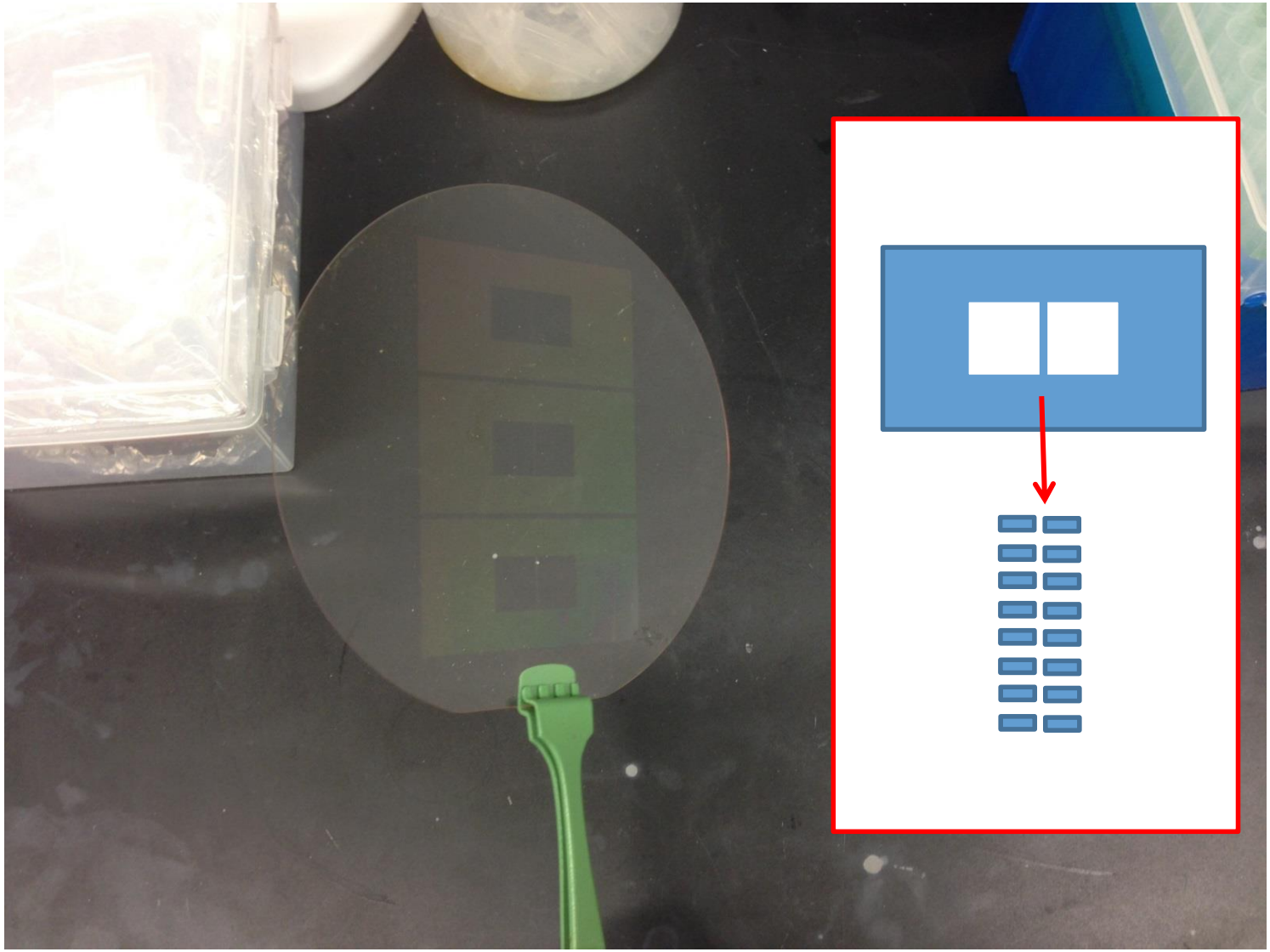
Lithography
Developing

DETA deposition
(6hr, 72pulses)

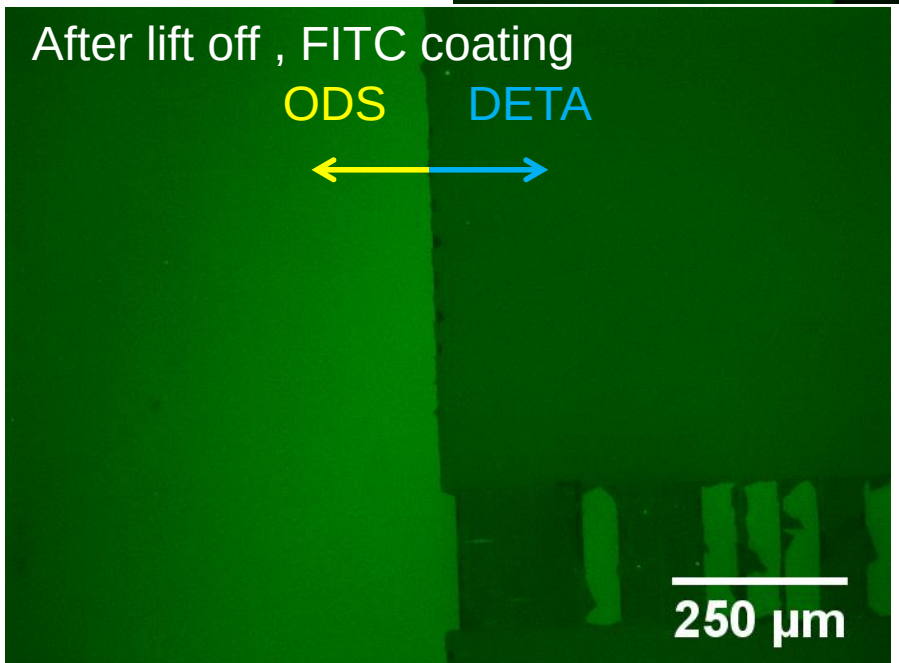
Silicon dioxide
ODTS
DETA
Photoresist

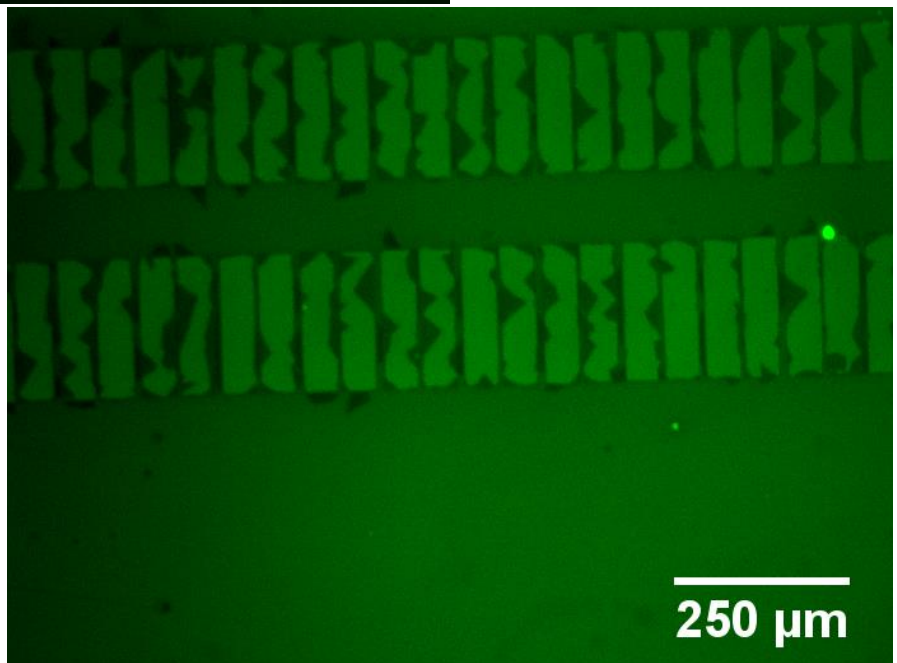


Pattern of photoresist

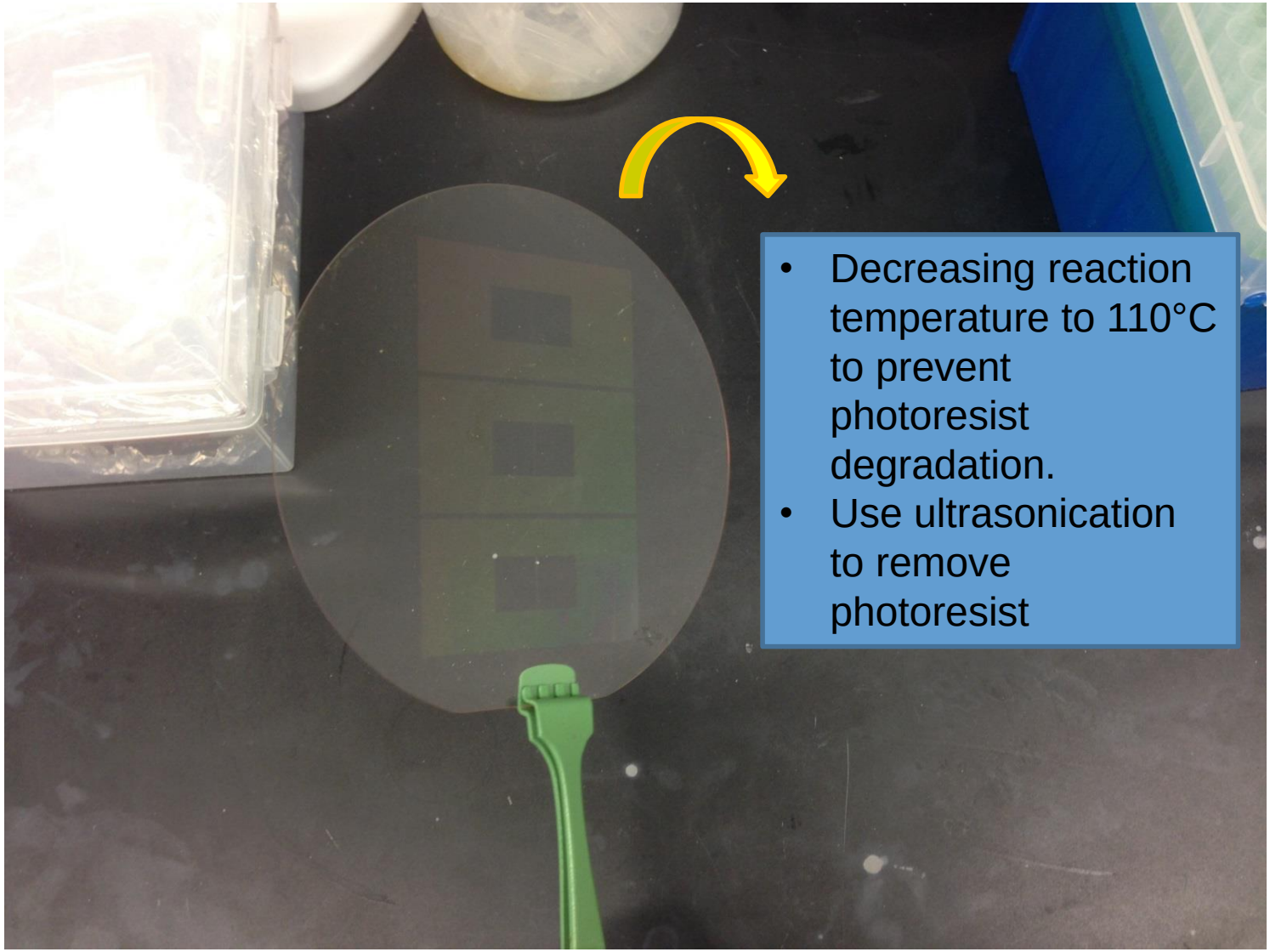



Before lift off , no FITC
Resist
DETA
250 µm

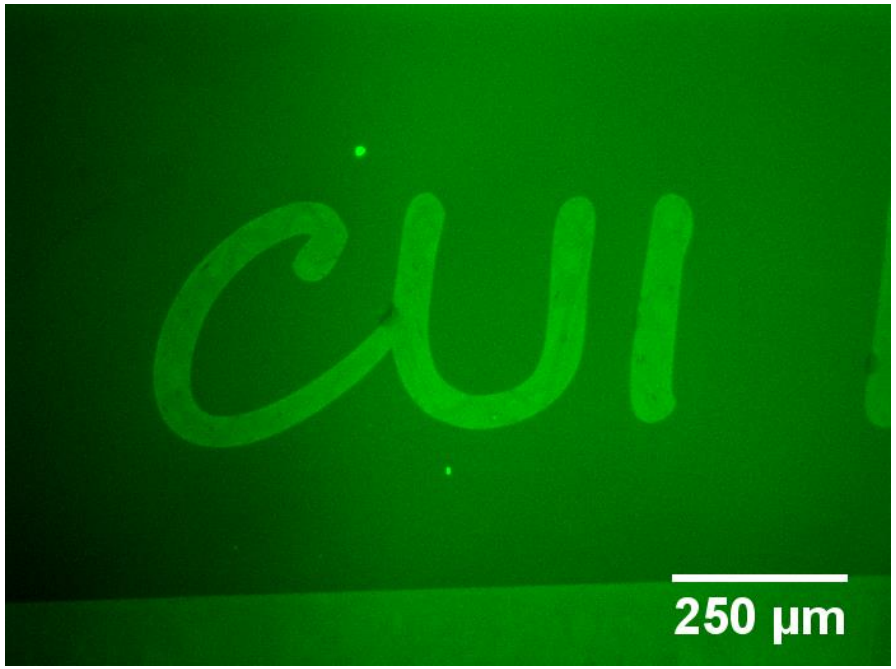

After lift off , FITC coating
ODS
DETA
250 µm

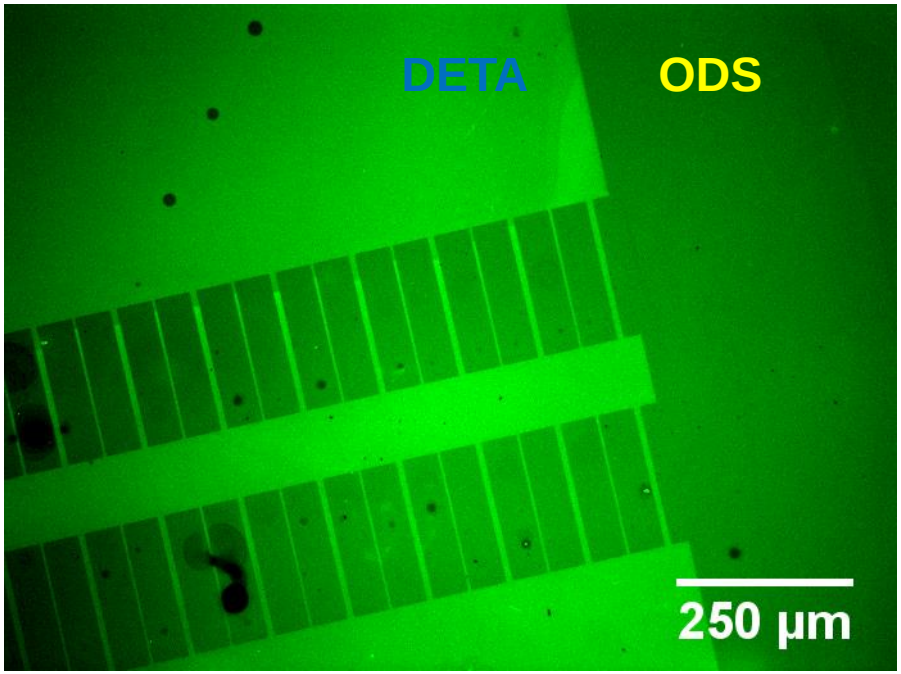

250 µm

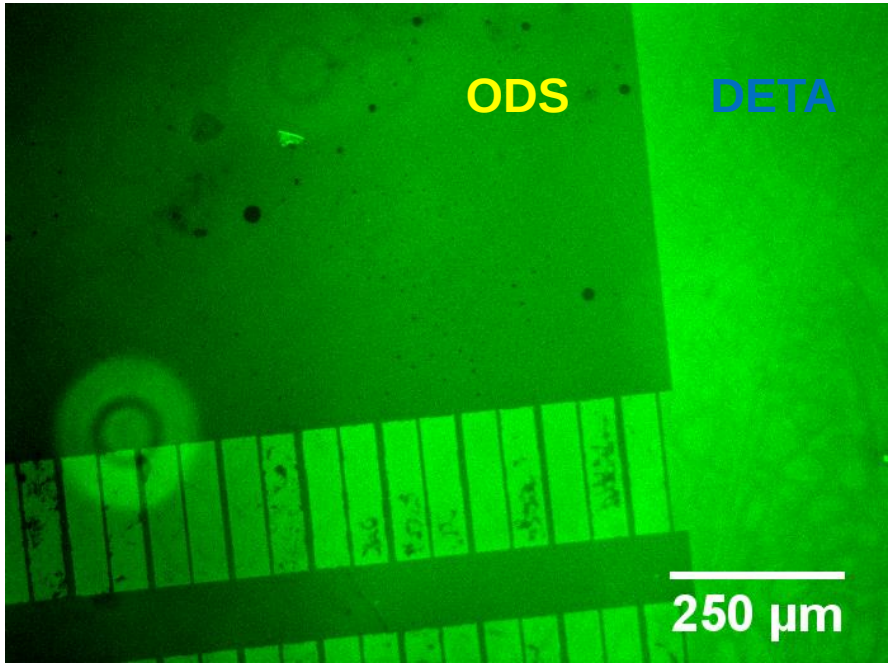
Pattern of photoresist



- Decreasing reaction temperature to 110°C to prevent photoresist degradation.
- Use ultrasonication to remove photoresist


250 µm


DETA
ODS
250 µm


ODS
DETA
250 µm

Summary

- Develop a recipe for ODS and DETA deposition.
- We used contact angle and Florescence spectroscopy to visualize the uniformity of the deposition.
- We applied photolithography to pattern a surface for neuron cells directed growth.
- Future plans is to grow neuron cells on the pattern template and apply the developed technique to modify electrodes for electrophysiology measurements.
- Optimization of ODS and DETA deposition, measuring the hydroxyl concentration on the surface. (FTIR)

Acknowledgement

- Stanford Nanofabrication Facility
  - Dr. Uli Thumser
  - Dr. Mary Tang

- Project Mentor
  - Dr. Michelle Rincon
  - Dr. J Provine

- Prof. Roger T. Howe
- Prof. Bianxiao Cui