Photolithography and the Clean Room

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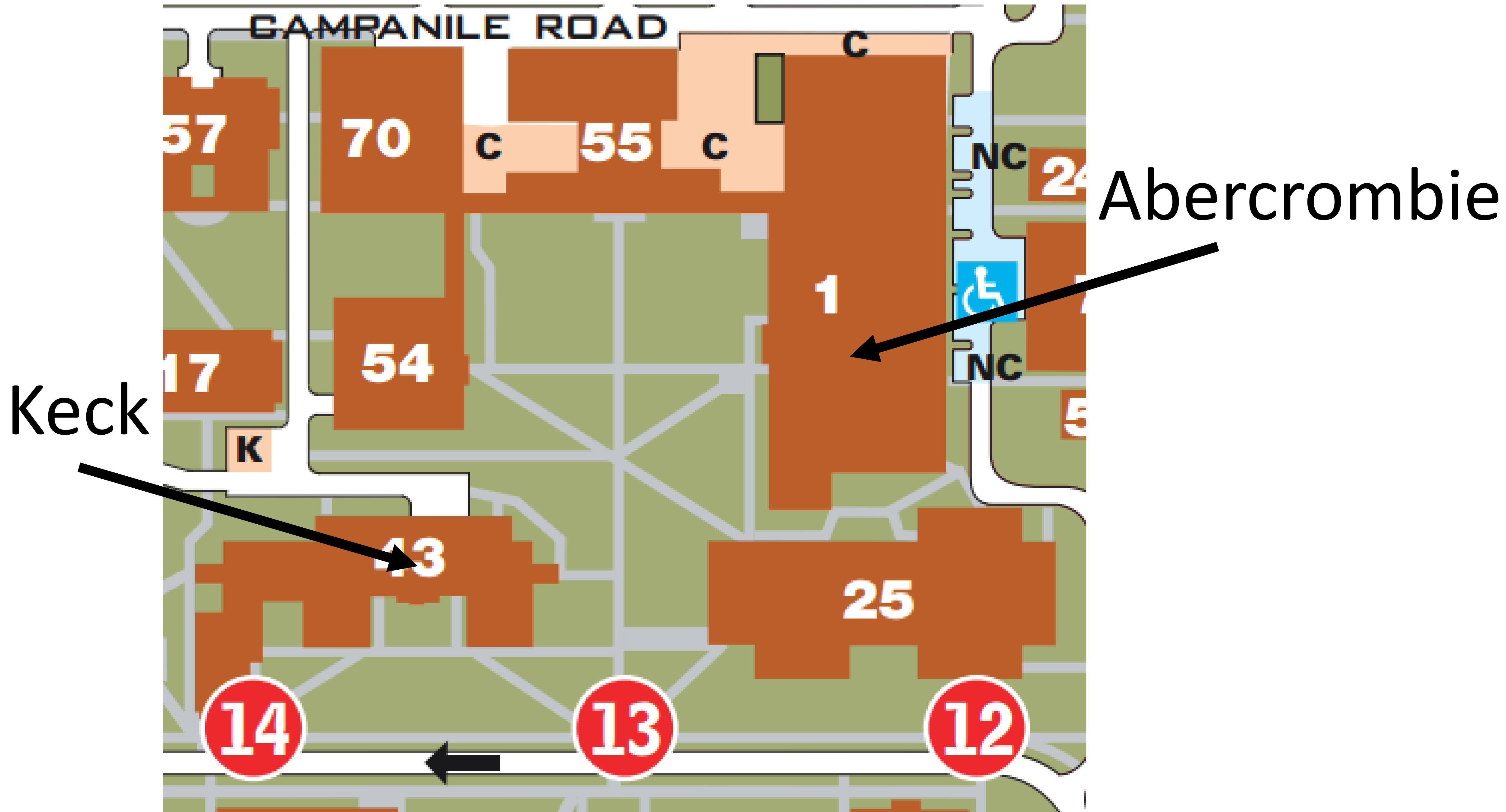
Outline

- Clean Room
- Photolithography
  - Photoresist Intro
  - Spin Coater
  - Mask Aligner
  - Positive Photoresist
  - Negative Photoresist
  - E-BEAM
  - Alignment Marks
- Scheduling

Clean Room

Clean Room

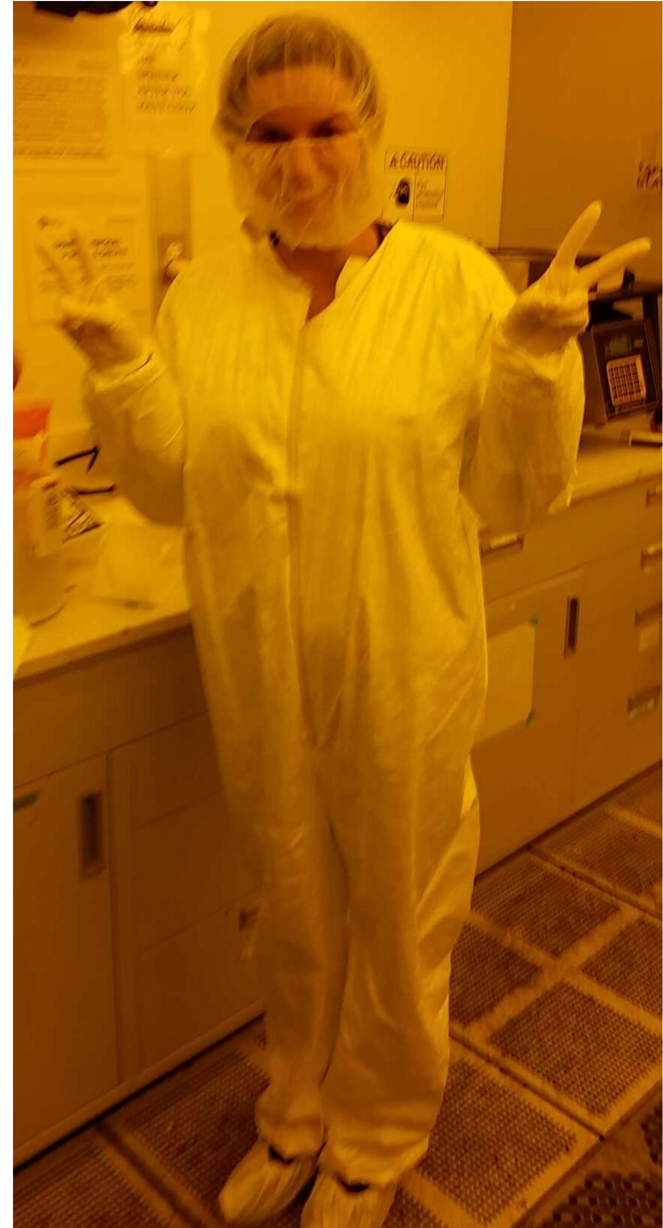
- Run by the Shared Equipment Authority (SEA)
  - SEA paperwork required for access to the clean room
  - Certification by Tim Gilheart or a certified trainer (for our lab, me) for access to instrument scheduling (on a per instrument basis)
- Card acess only 24 hours a day, 7 days a week
- Located in Abercrombie Engineering
- Need clean room suit, booties, etc. for entry



CAMPANILE ROAD
C
70
C
55
C
57
NC
24
Abercrombie
1
NC
17
54
Keck
K
43
25
14
13
12

IN USE

DANGER
CORROSIVES


CAUTION

Photolithography

Photolithography

- Litho = stone + graphy = write
  - Process using a plate or stone to imprint a pattern
- Photo = light
  - Use UV light to imprint a pattern in photoresist
- Photoresist

Photoresist

- UV reactive chemicals
  - Two classes – positive and negative
    - Positive degrades in the presence of UV
    - Negative cross-links in the presence of UV
- After exposure, unlinked resist is washed away with developer
  - Acetone will remove linked and unlinked resist
  - DON’T use acetone at any point

Spin Coating

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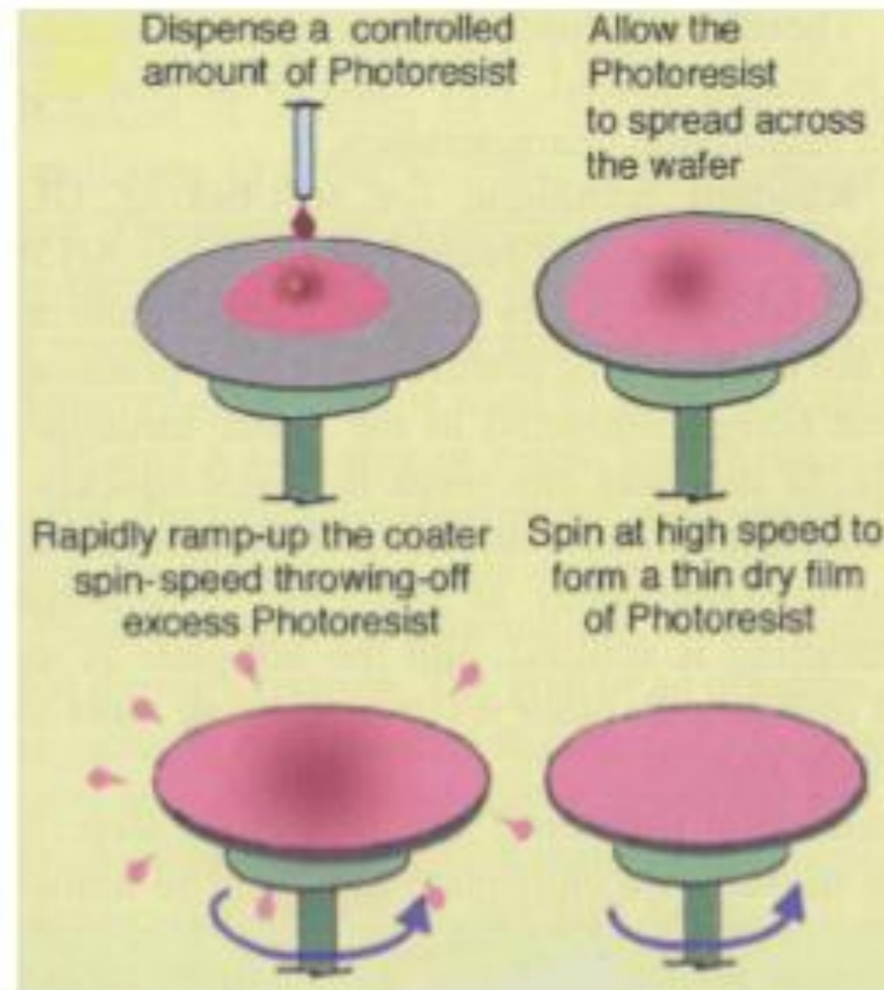
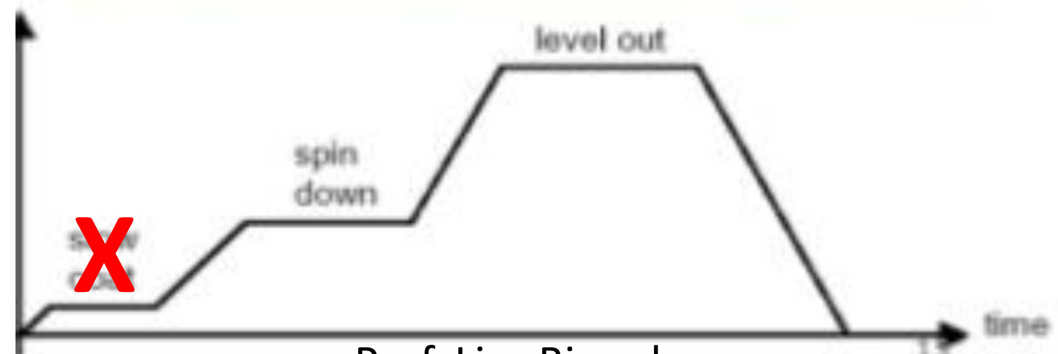
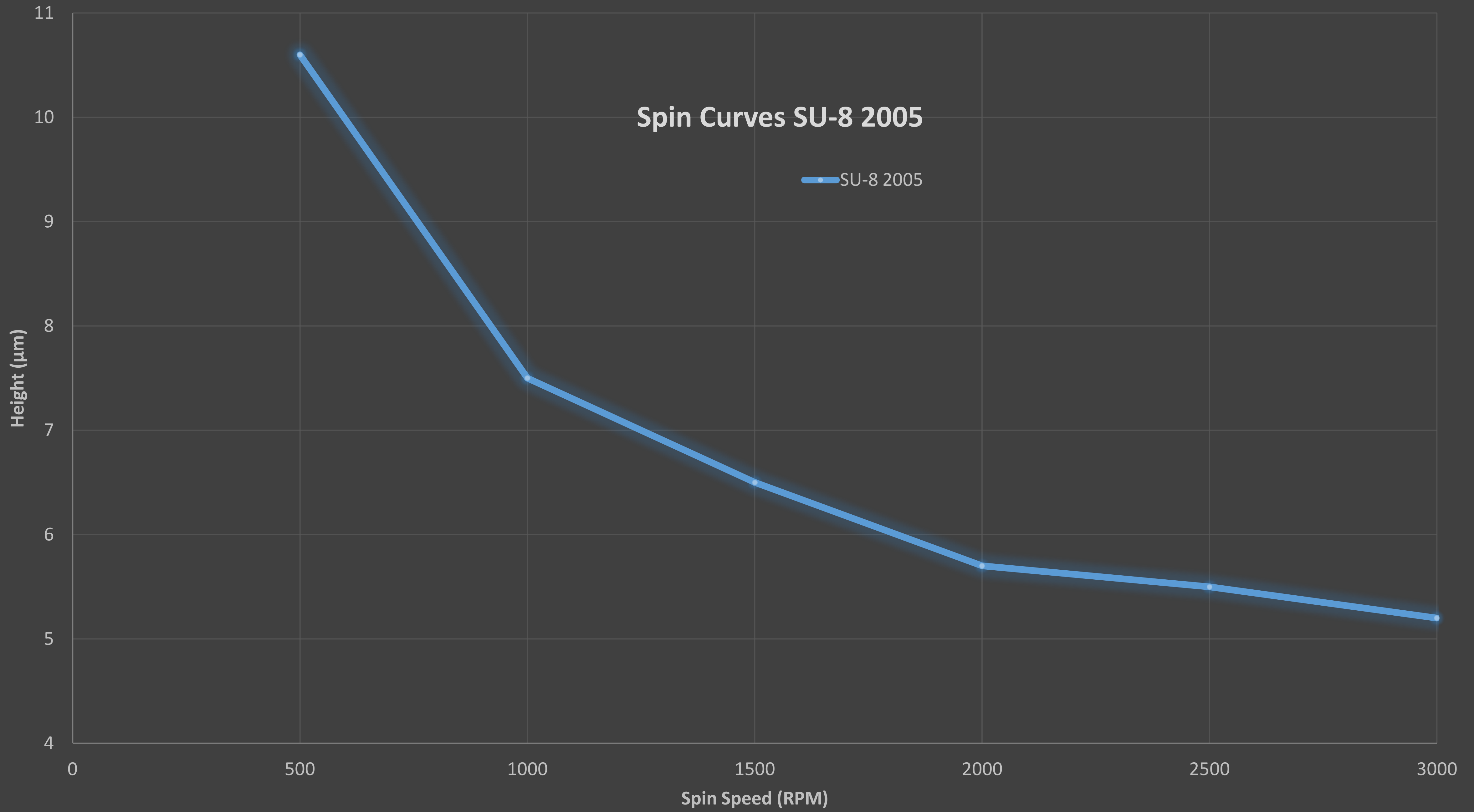
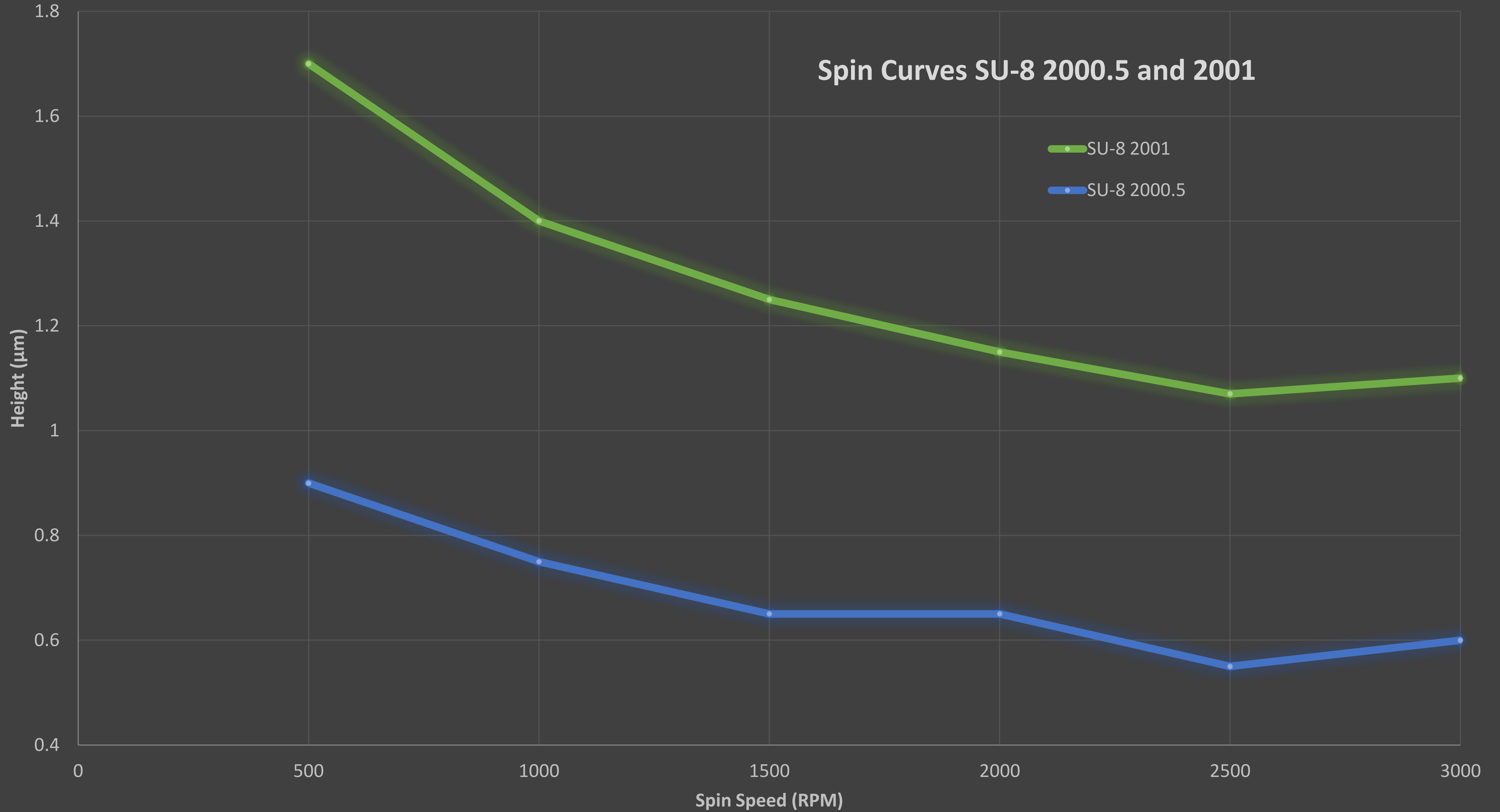


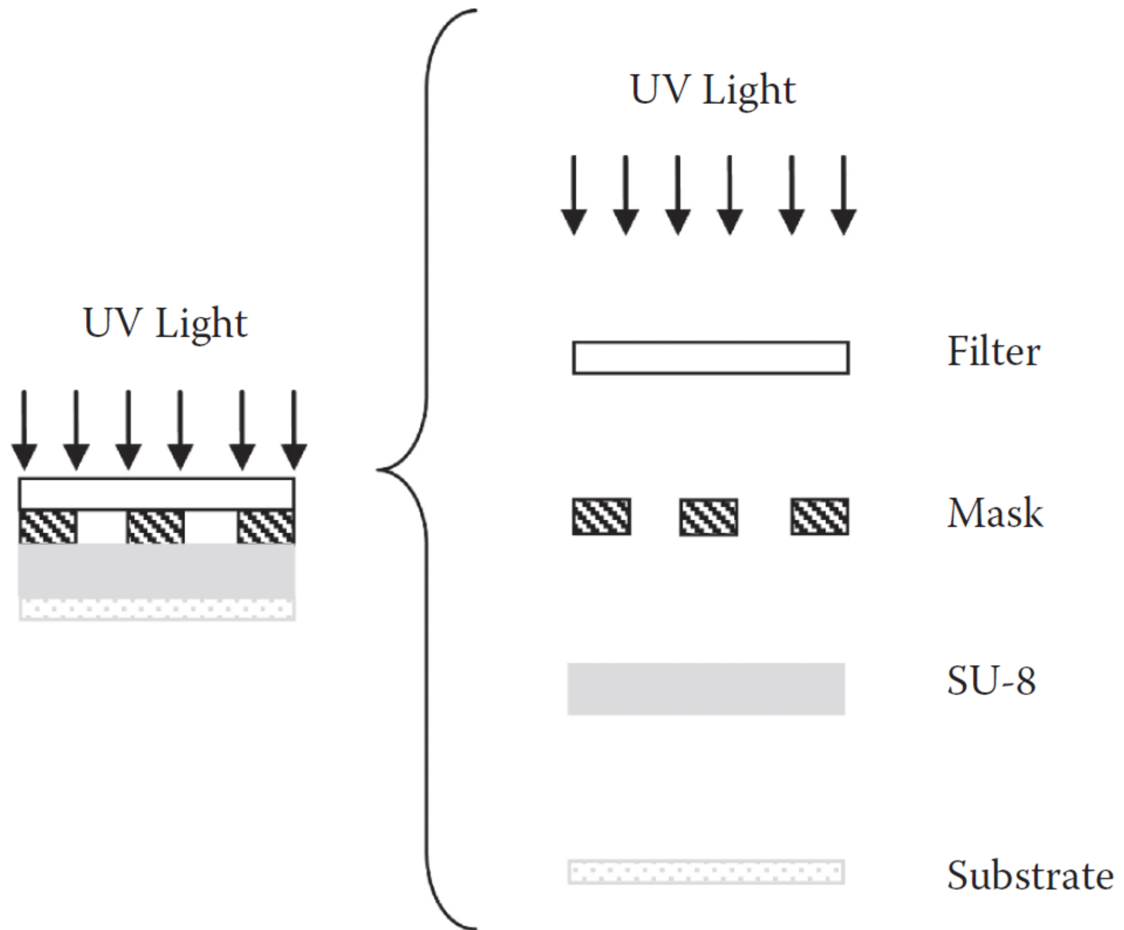



Spin Curves SU-8 2005
SU-8 2005
Height (µm)
Spin Speed (RPM)
11
10
9
8
7
6
5
4
0
500
1000
1500
2000
2500
3000


Spin Curves SU-8 2000.5 and 2001
SU-8 2001
SU-8 2000.5
Height (µm)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0
500
1000
1500
2000
2500
3000
Spin Speed (RPM)

Mask Aligner

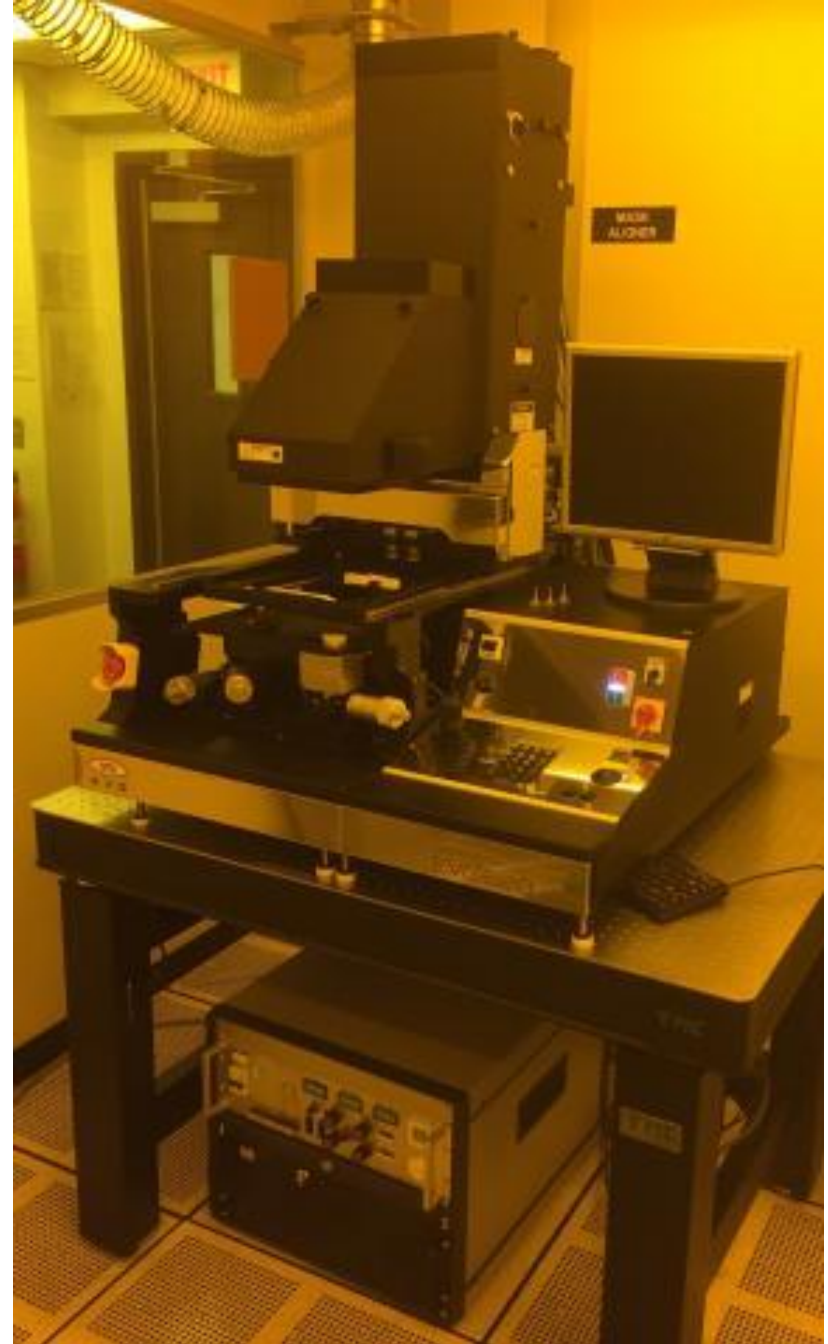
Mask Aligner Setup



Experimental Set-up

Exploded View

Martinez-Duarte and Madou, 2011



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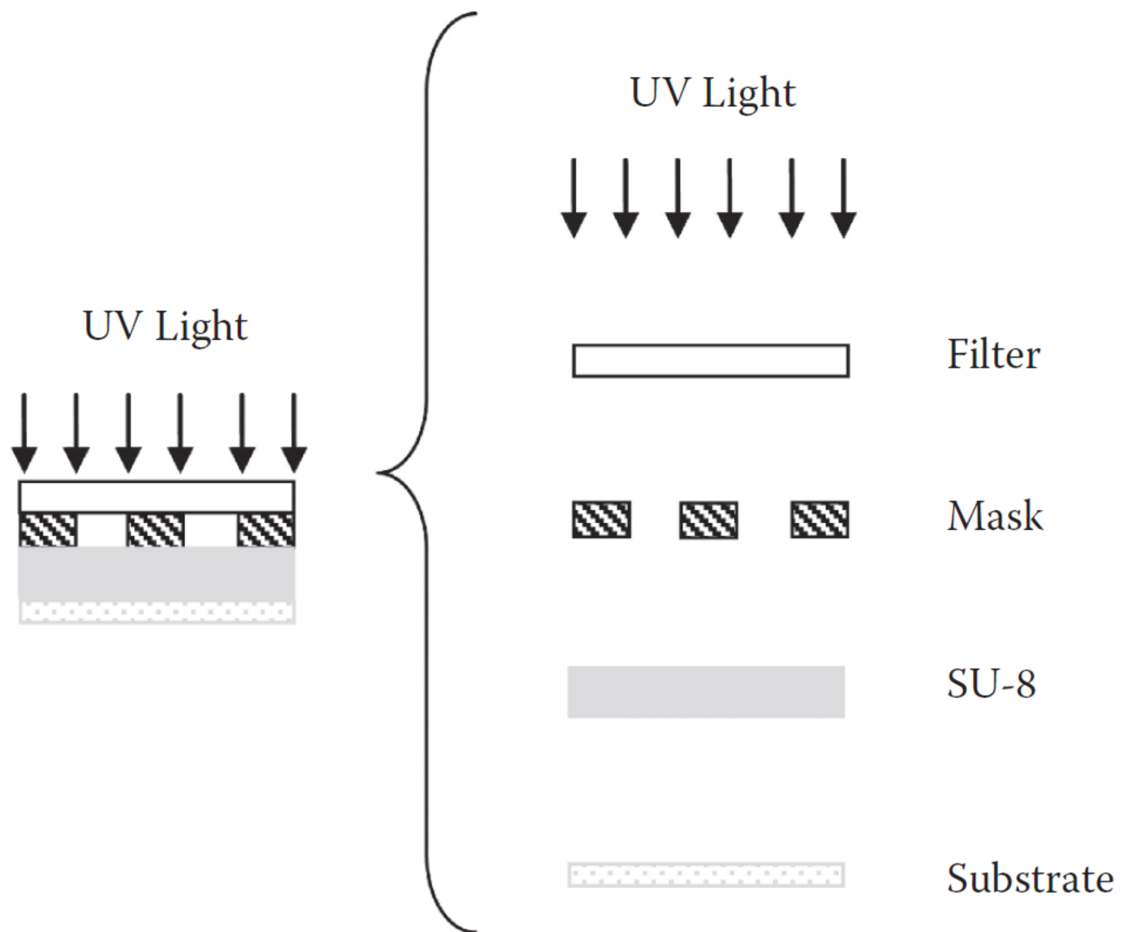
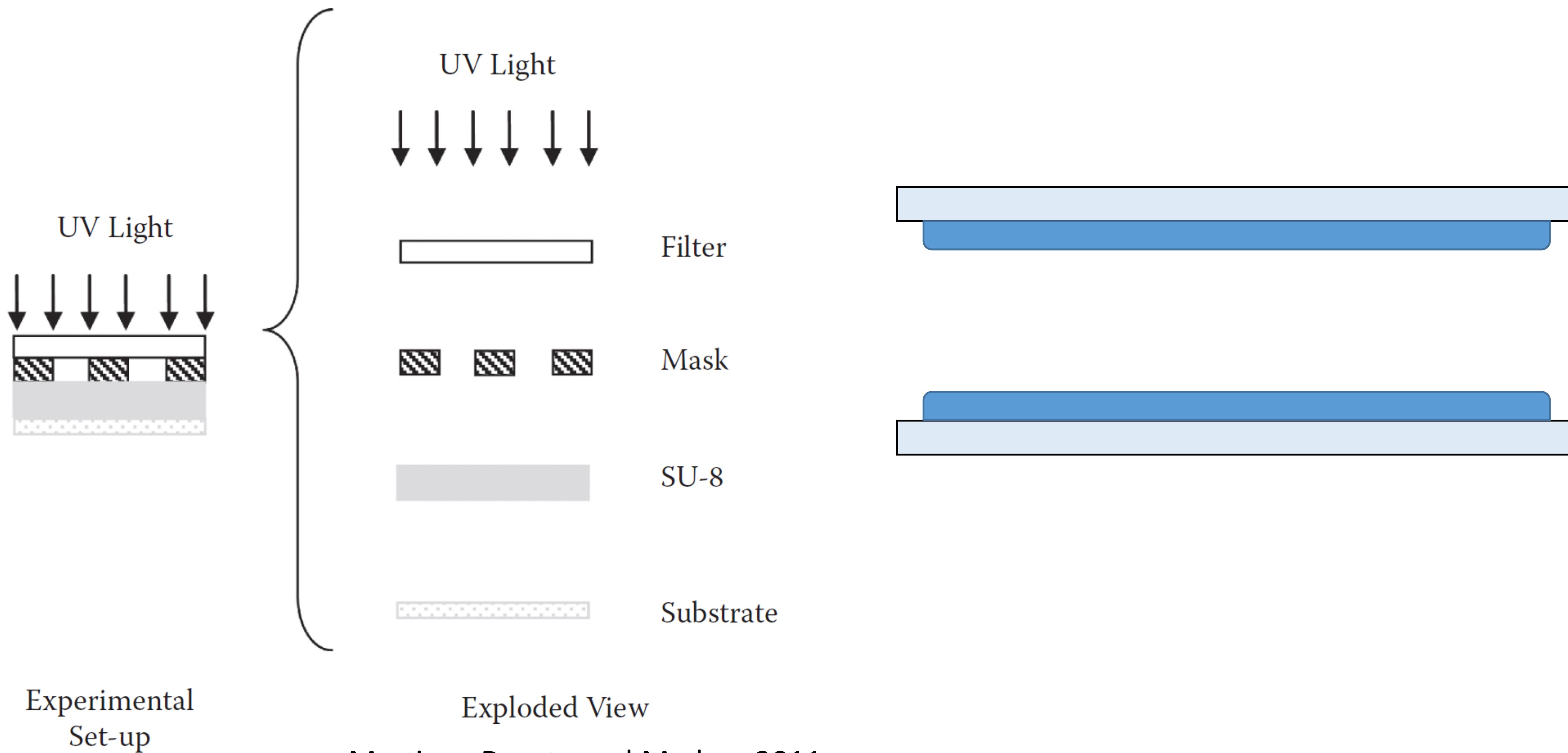
Mask Aligner Setup



Martinez-Duarte and Madou, 2011

Mask Aligner Setup



Martinez-Duarte and Madou, 2011

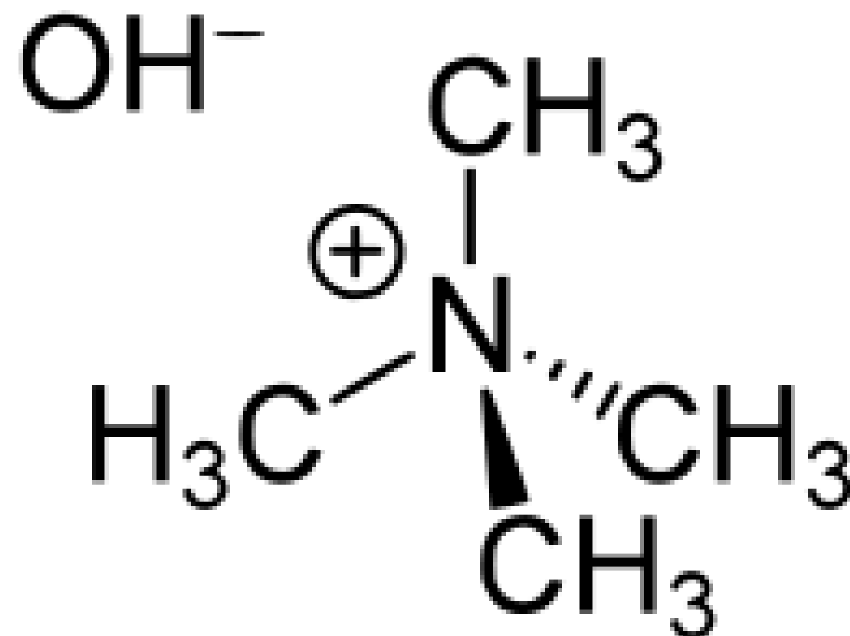
Positive Resist

Shipley 1813

Structure

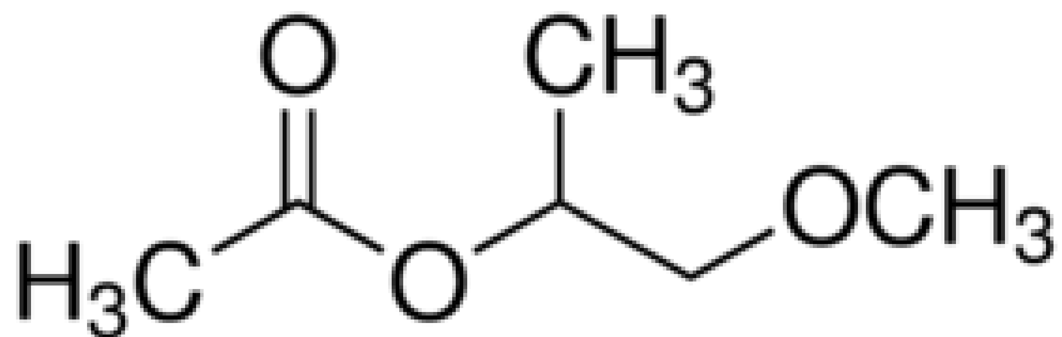
?

Developer



Tetramethylammonium hydroxide

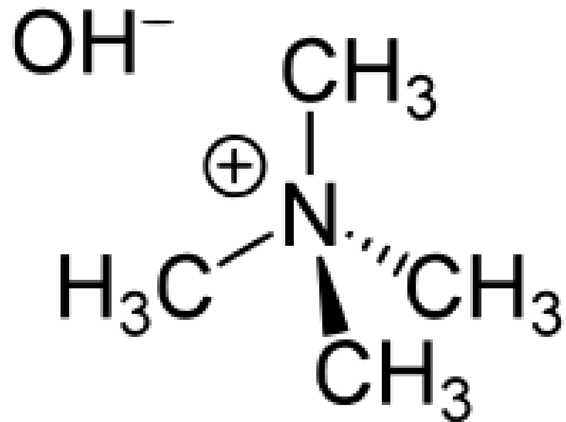
Solvent



propylene glycol methyl ether acetate

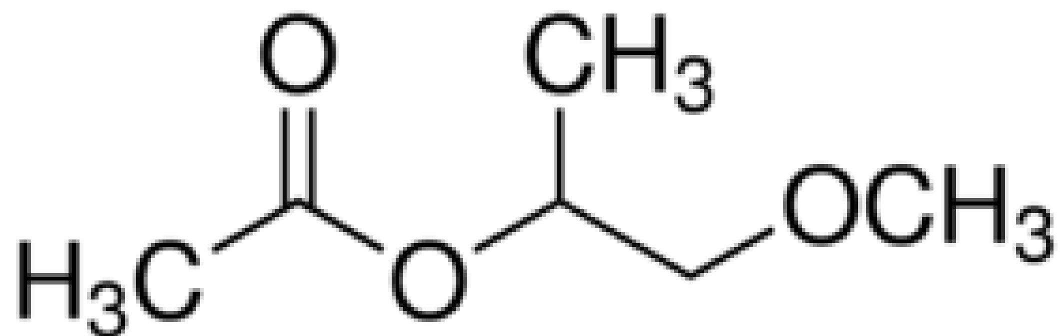
Shipley 1813

Developer



Tetramethylammonium hydroxide

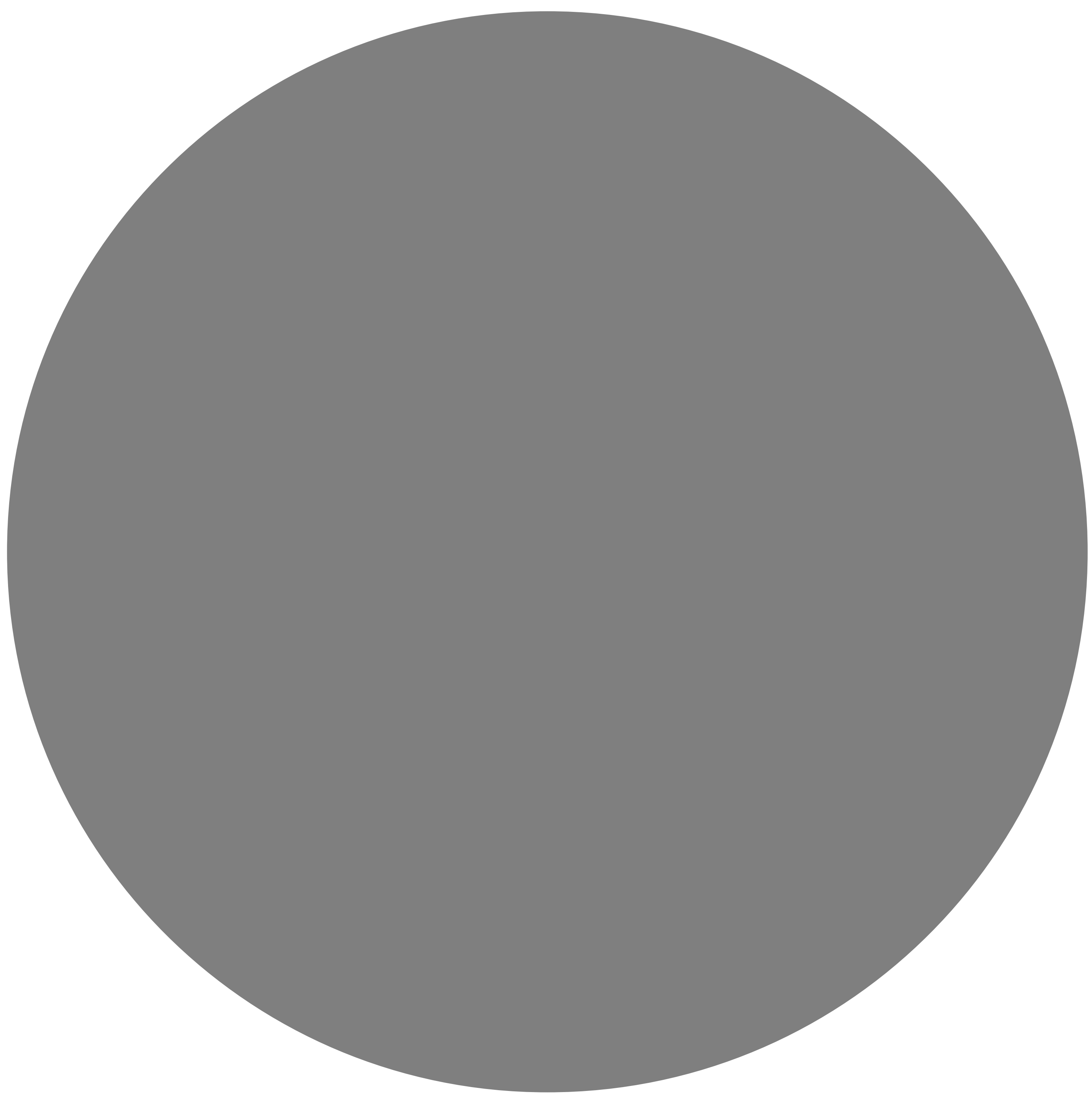
Solvent

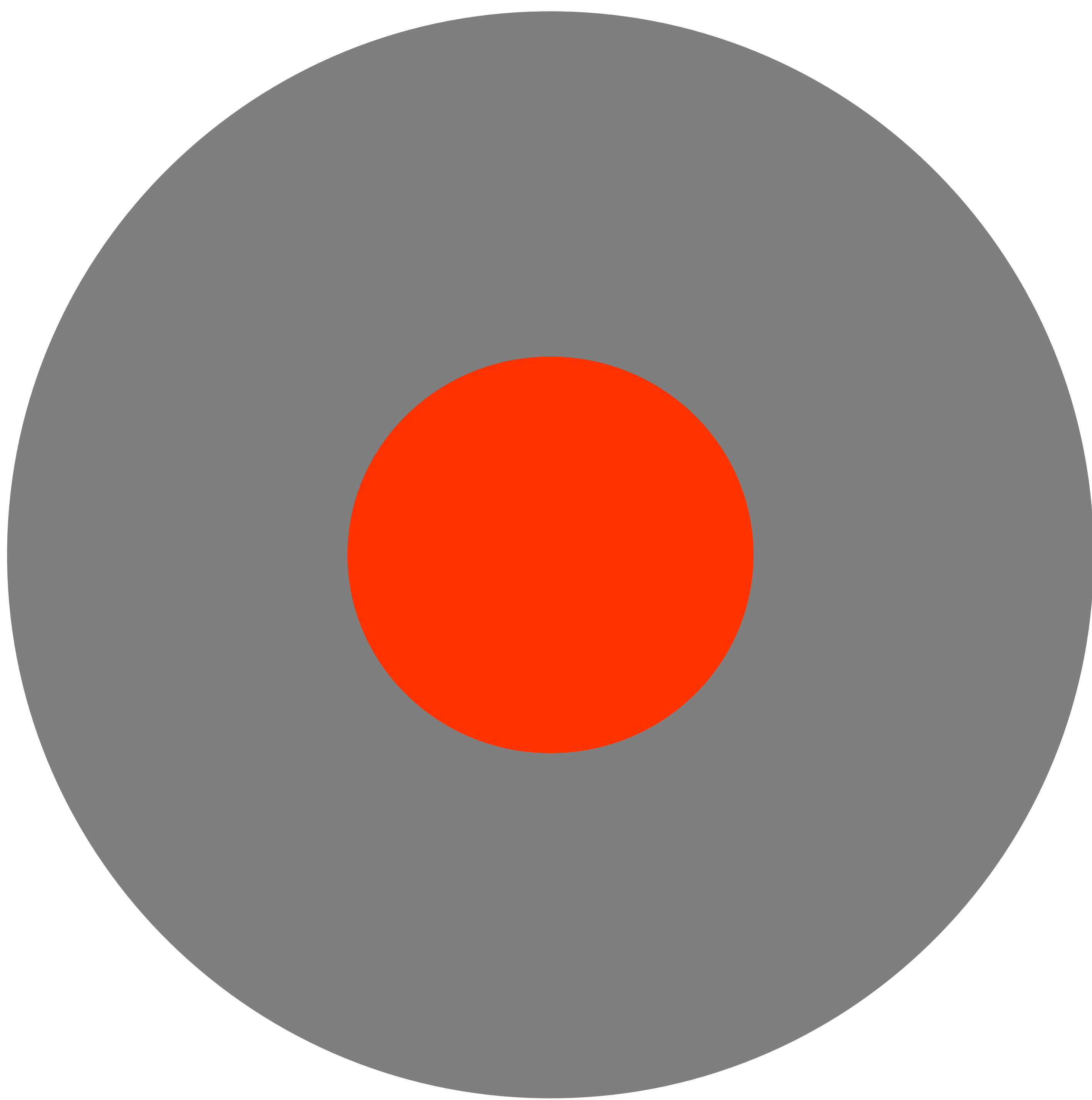


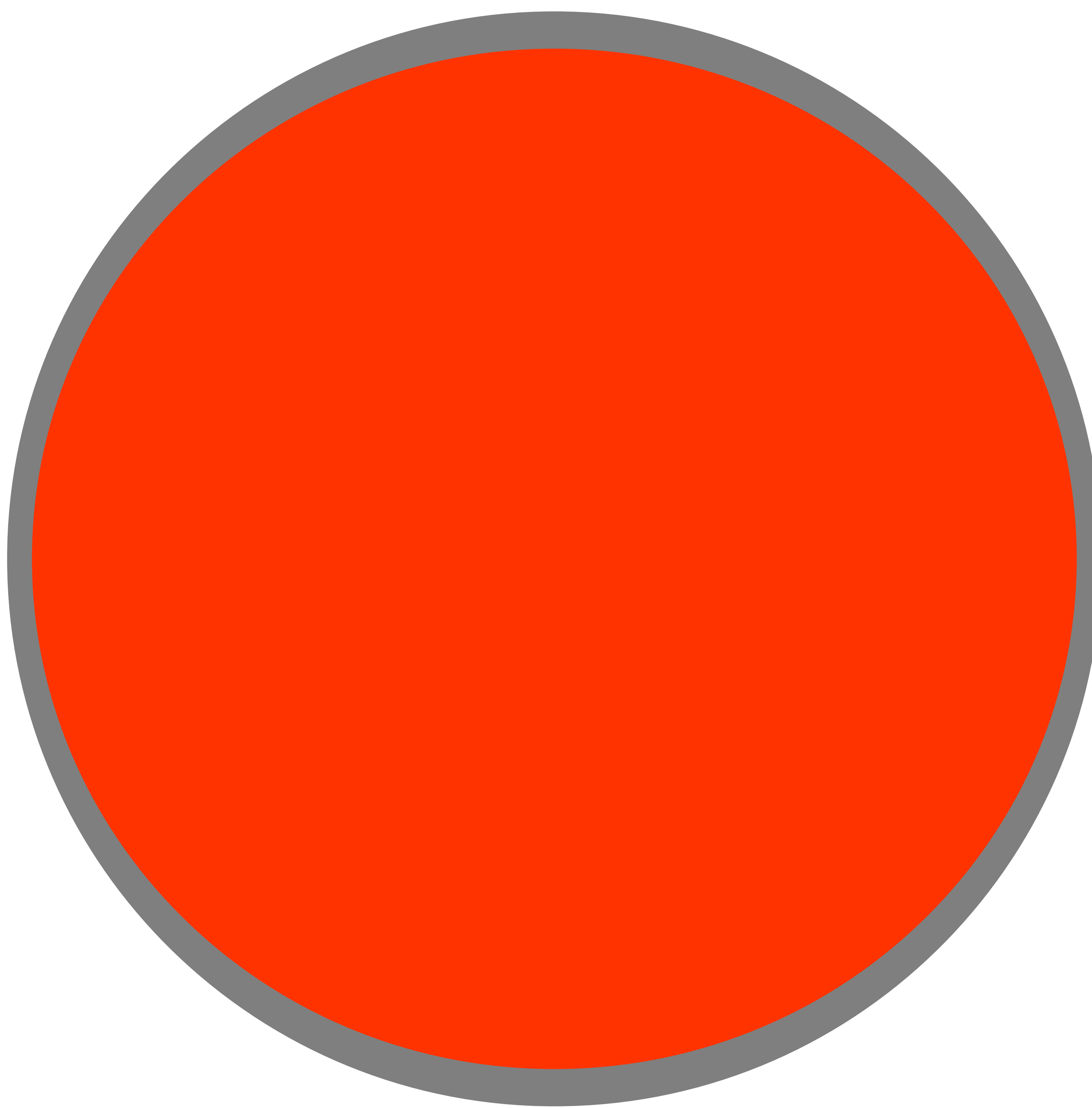
propylene glycol methyl ether acetate

Basic Developer

- Use only water to rinse residual developer from the wafer
- Do not use isopropanol or other organic solvents







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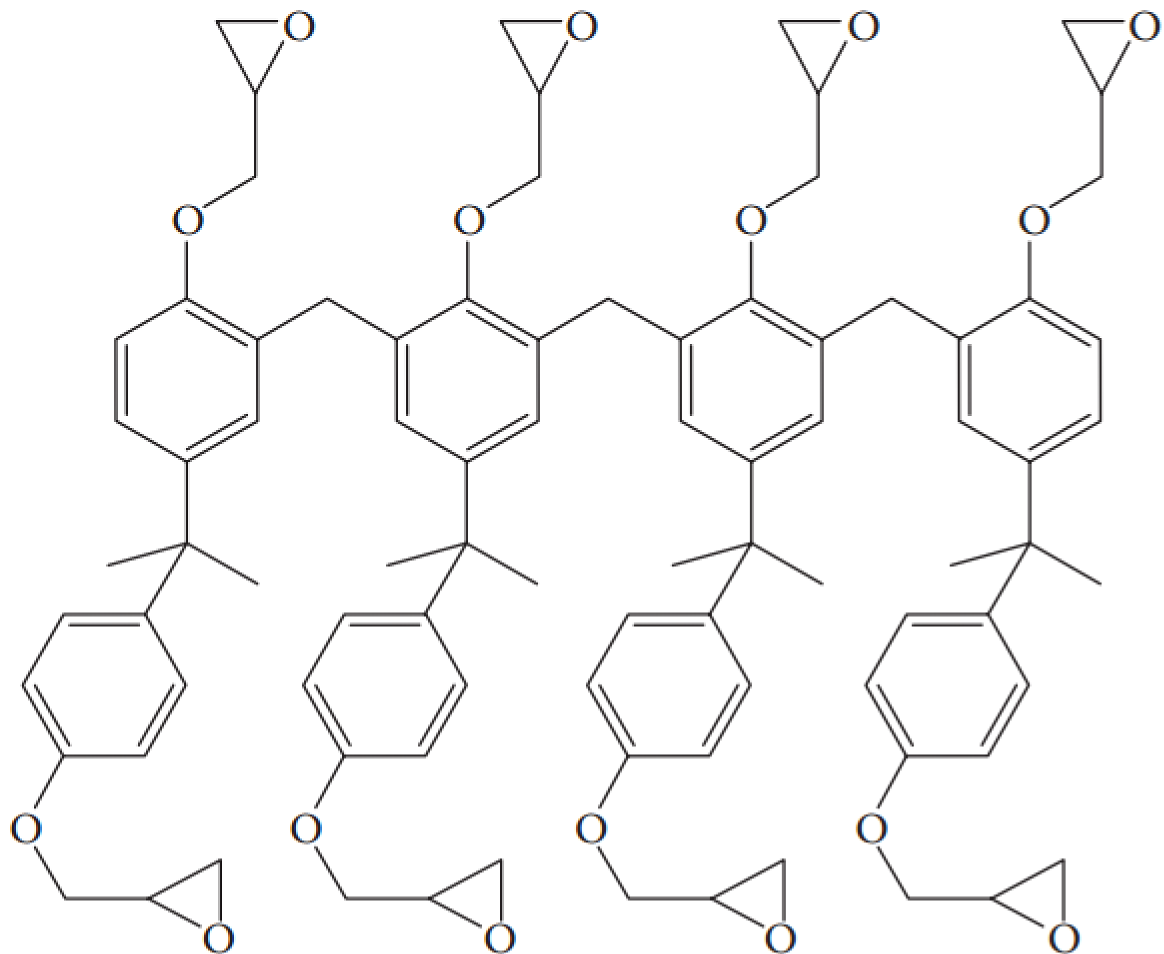
Negative Photoresist

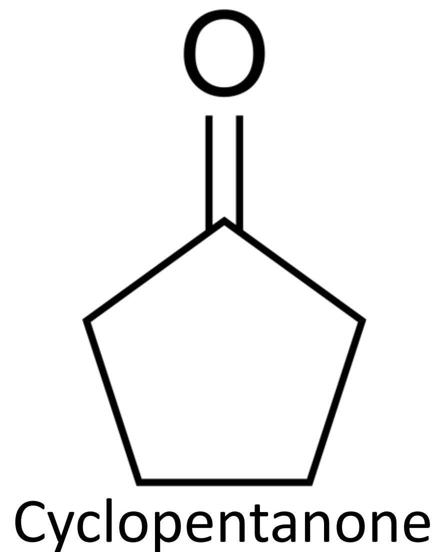
SU-8 2000 Series

Structure

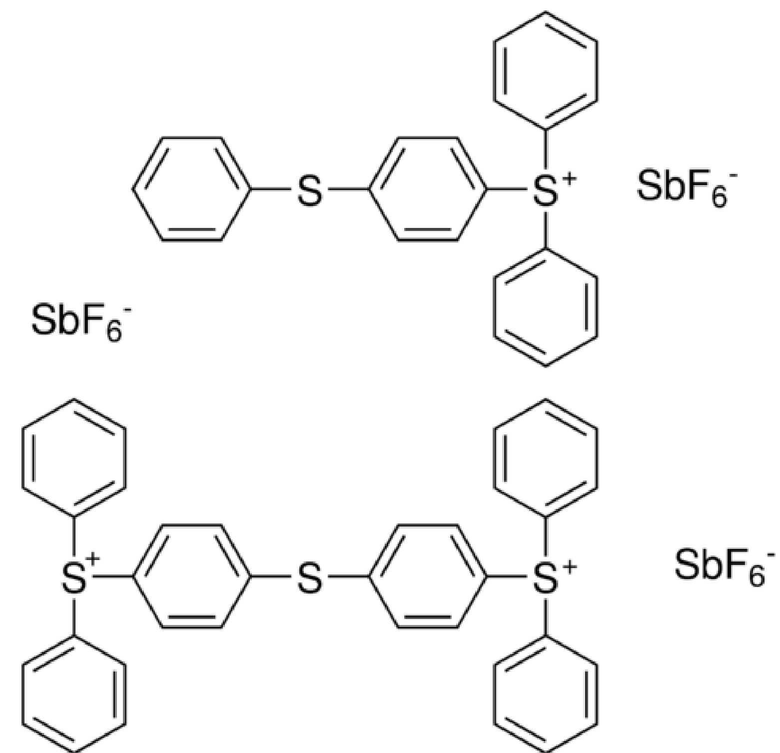


Martinez-Duarte and Madou, 2011

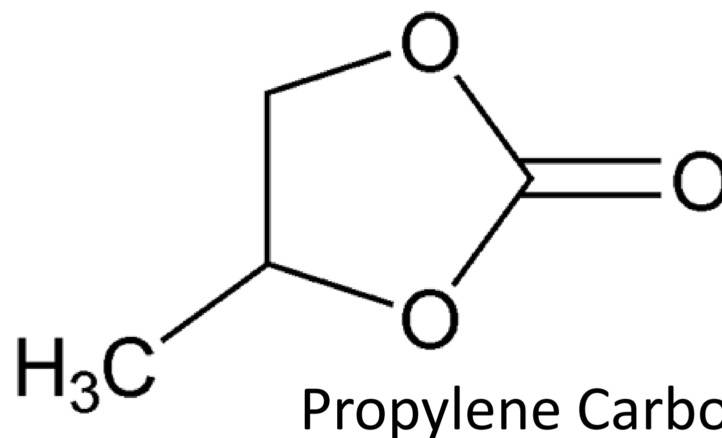
Solvent



Cyclopentanone



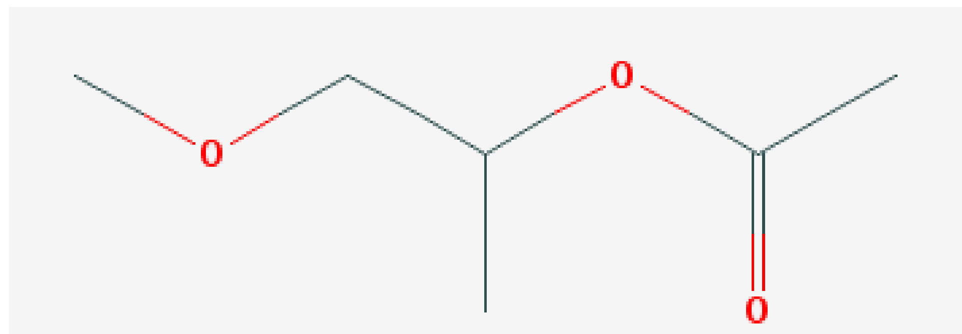
Triarylsulfonium/
Hexafluoroantimonate Salt



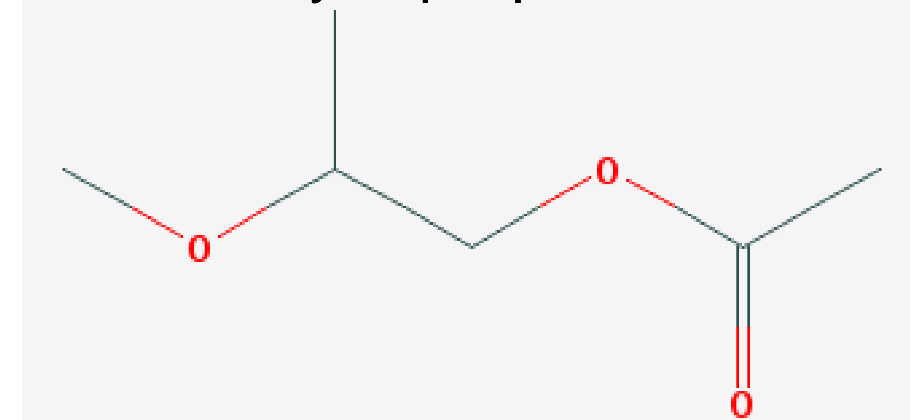
Propylene Carbonate

SU-8 2000 Series

Developer

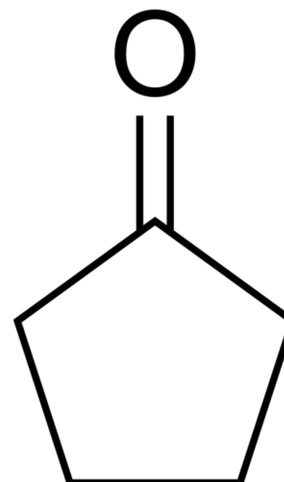


1-Methoxy-2-propanol acetate

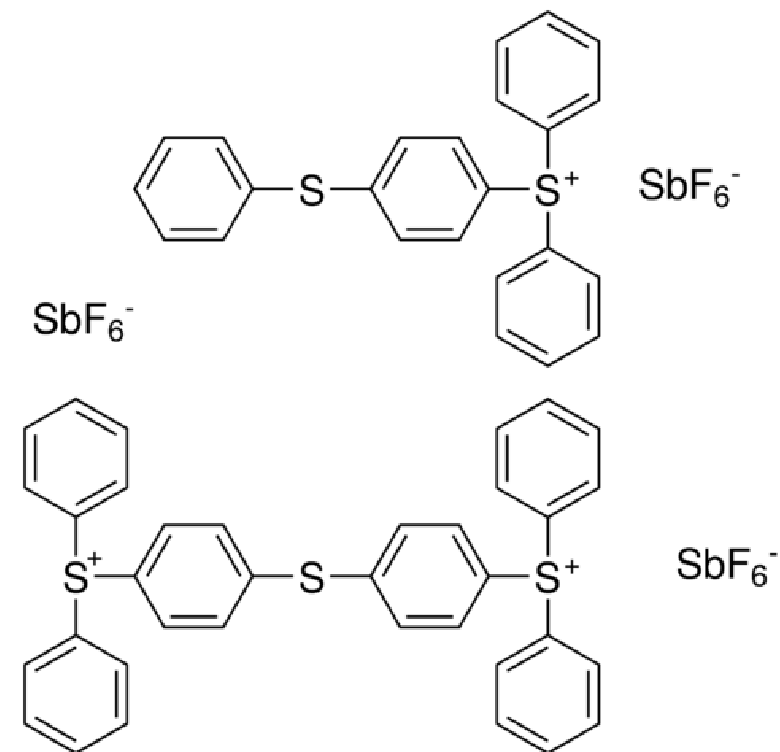


2-Methoxy-1-propanol acetate

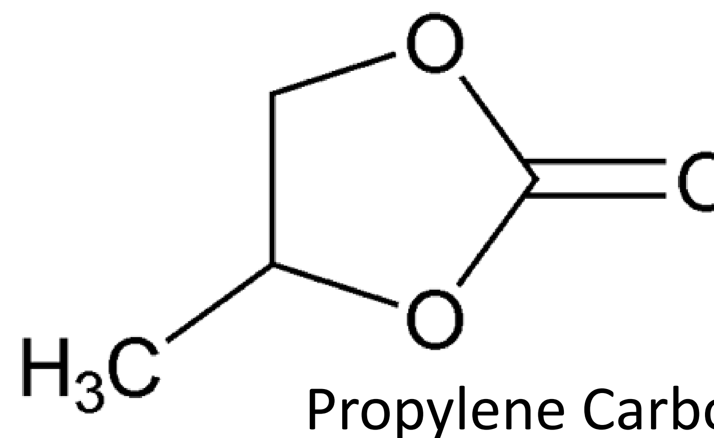
Solvent



Cyclopentanone



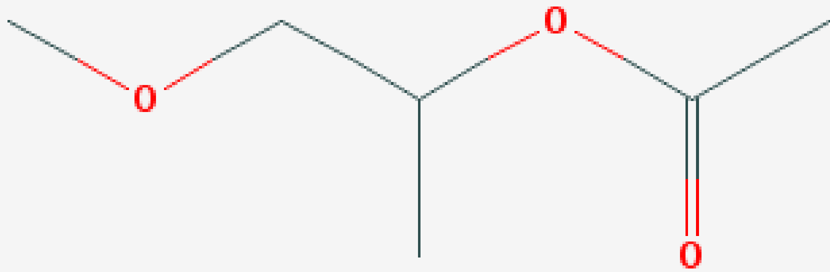
Triarylsulfonium/
Hexafluoroantimonate Salt



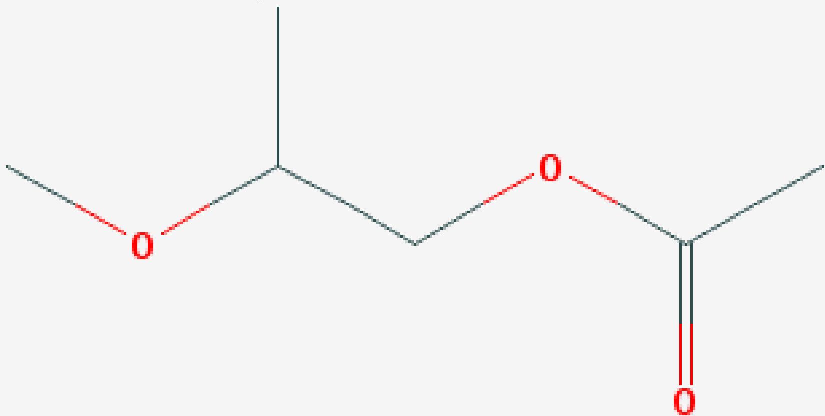
Propylene Carbonate

SU-8 2000 Series

Developer



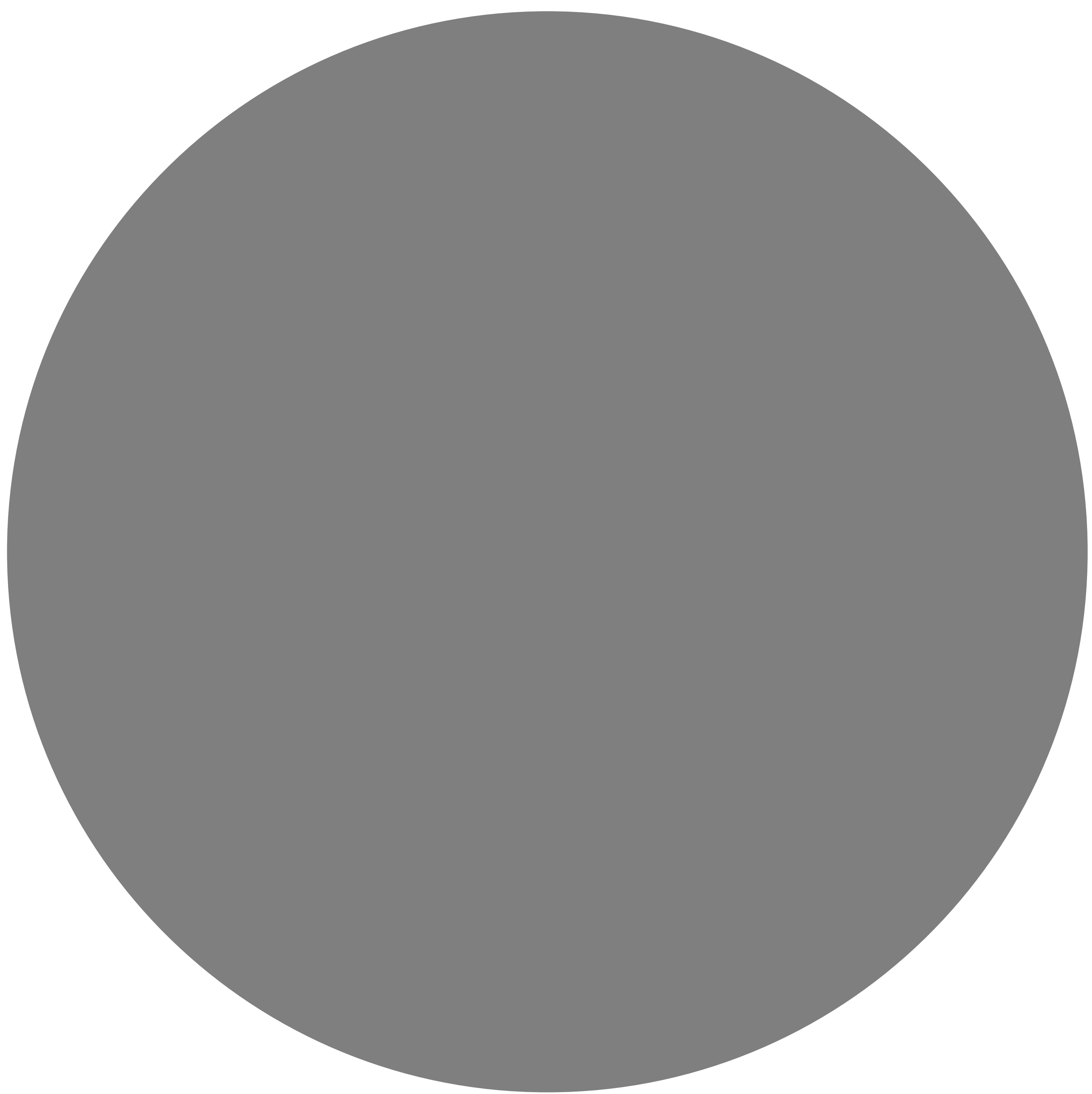
1-Methoxy-2-propanol acetate

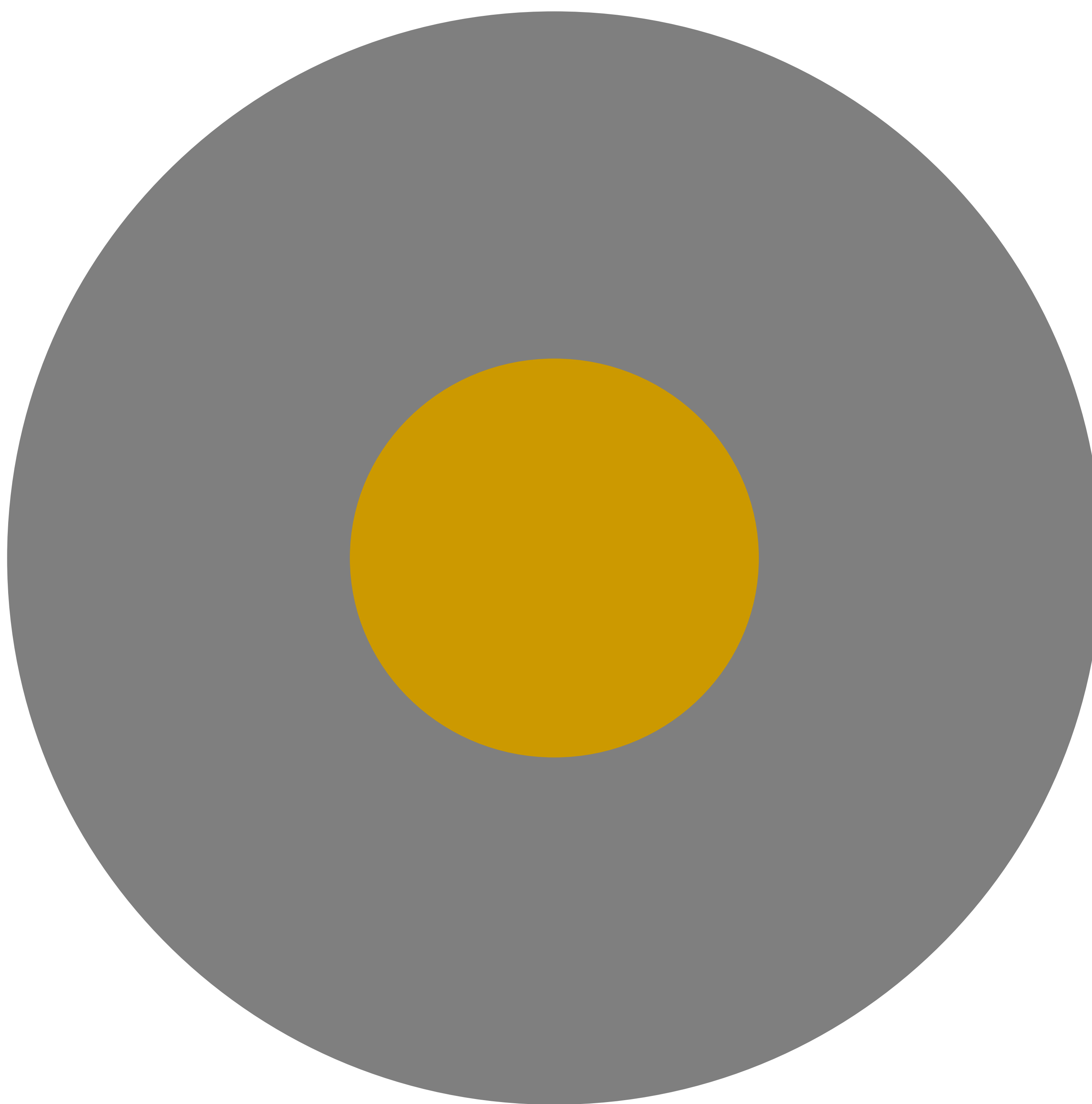


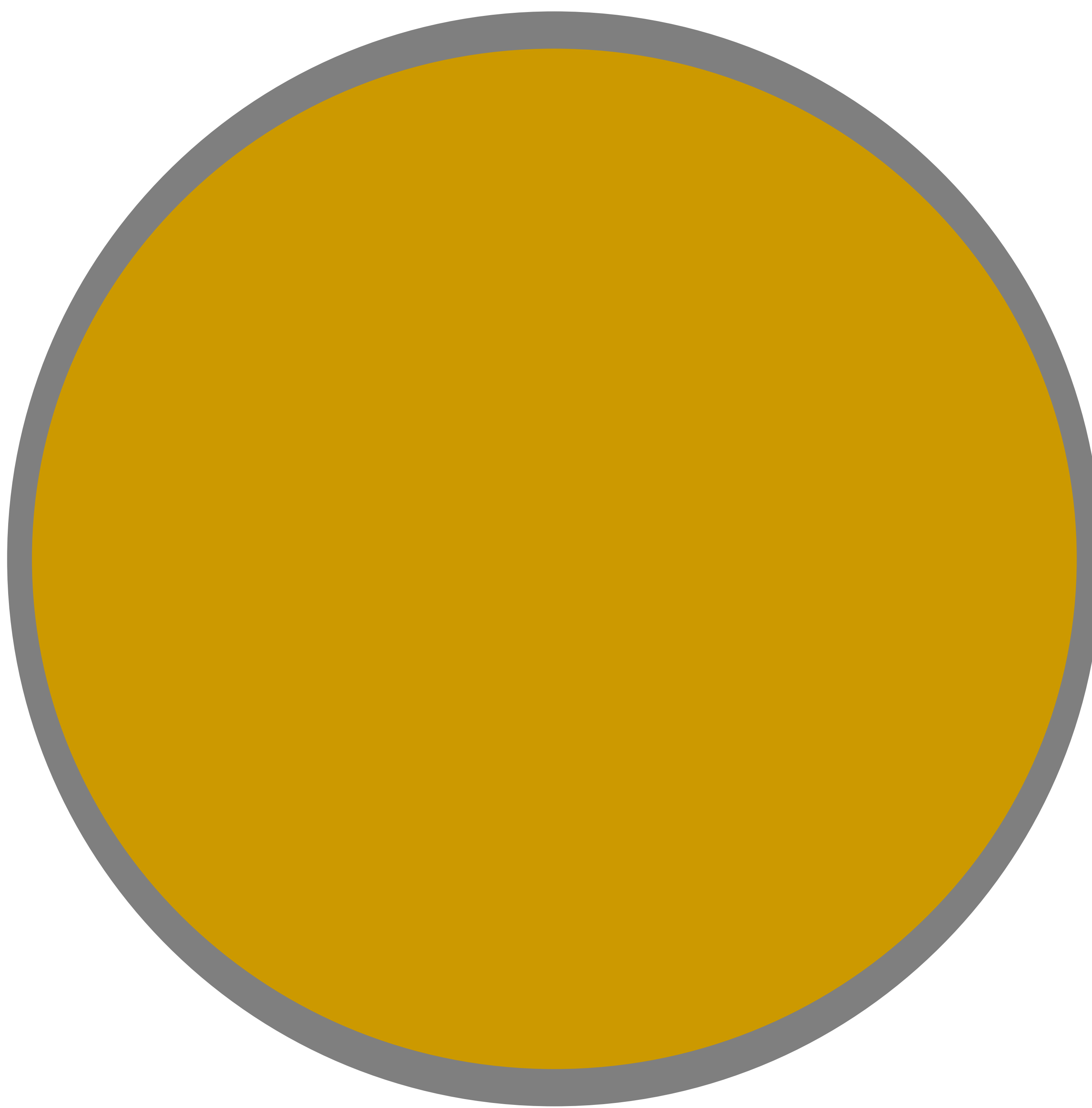
2-Methoxy-1-propanol acetate

Organic Developer

- Use only isopropanol to rinse residual developer from the wafer
- Do not use water or acetone







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SU-8 2000 Formulations

TABLE 8.2

Viscosity, Percentage of Solids, and Density of Different SU-8 Photoresist Formulations Available from MicroChem

SU-8 (Casting Solvent: Gamma-Butyrolactone)				SU-8 2000 (Casting Solvent: Cyclopentanone)				SU-8 3000 (Casting Solvent: Cyclopentanone)			
SU-8 XX	Viscosity (cSt)	% Solid	Density (g/ml)	SU-8 2XXX.X	Viscosity (cSt)	% Solid	Density (g/ml)	SU-8 30XX	Viscosity (cSt)	% Solid	Density (g/ml)
				2000.5	2.49	14.3	1.070				
2	45	39.5	1.123	2002	7.5	29	1.123				
5	290	52	1.164	2005	45	45	1.164	3005	65	50	1.075
				2007	140	52.5	1.175				
10	1050	59	1.187	2010	380	58	1.187	3010	340	60.4	1.106
				2015	1250	63.45	1.2				
25	2500	63	1.200	2025	4500	68.55	1.219	3025	4400	72.3	1.143
				2035	7000	69.95	1.227	3035	7400	74.4	1.147
50	12,250	69	1.219	2050	12,900	71.65	1.233	3050	12,000	75.5	1.153
				2075	22,000	73.45	1.236				
100	51,500	73.5	1.233	2100	45,000	75	1.237				
				2150	80,000	76.75	1.238				

Martinez-Duarte and Madou, 2011

E-BEAM Evaporator

E-BEAM Evaporator

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- Evenly deposits a thin layer of metal across a sample
- Can deposit many metals
- We use titanium
  - It is SHINY
  - It is EASY
  - It is FREE

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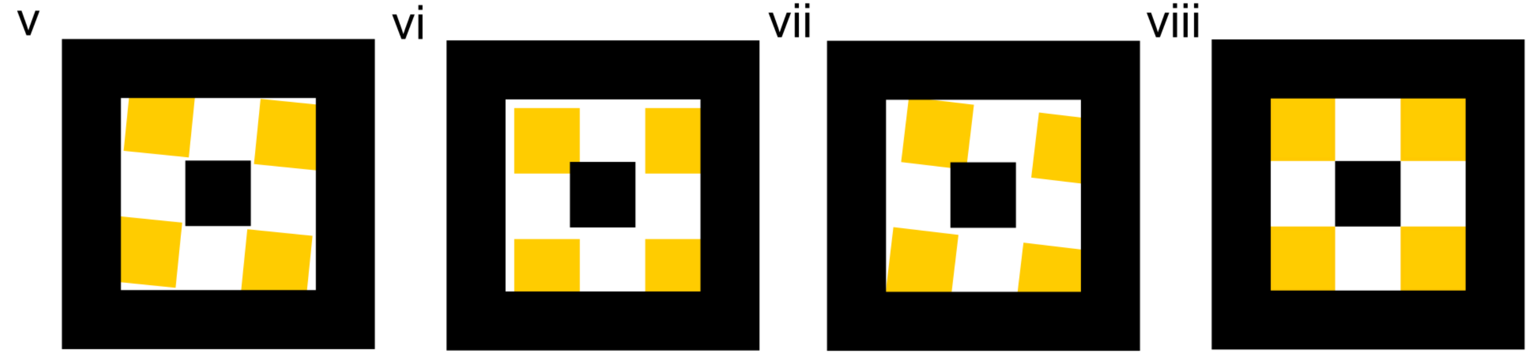
Aligning layers

- Photolithography is a 3D fabrication process
- Z-height is set by resist choice and spin speed
- X-Y patterning is set by mask design
- Therefore, a different layer is needed for each Z-height in the final pattern
- Different layers need to be aligned to each other to guarantee device function
- Alignment markers are used to align the different layers to one another

Alignment



Ferry, Razinkov, and Hasty, 2011

Alignment

- Ti markers + E-BEAM were necessary due to instrument limitations
- There are other options
  - Engraved or metal markers on stock wafers (MMG)
  - SU-8 Markers
    - 3:1 “aspect ratio” – Can only see a layer of cross-linked SU-8 of thickness X through a layer of uncross-linked SU-8 of thickness 3X
    - Can use a trick by covering markers with tape before spinning second layer – YMMV
    - Truong and I will be testing SU-8 markers on the new mask aligner

Questions?

Scheduling 1-on-1

- 3 hour block is usually enough to fab a single device with training
- Mornings are usually easier and the clean room tends to be less crowded, but afternoons/early evenings can work too
- E-mail me 3-4 options for times that work for you, and I'll try to find one that works with my schedule and the schedule on the aligner.
- Once I'm sure that you are trained, I will let Tim know and you will be able to request access to the instrument through the SEA website