Confidential

UNIST

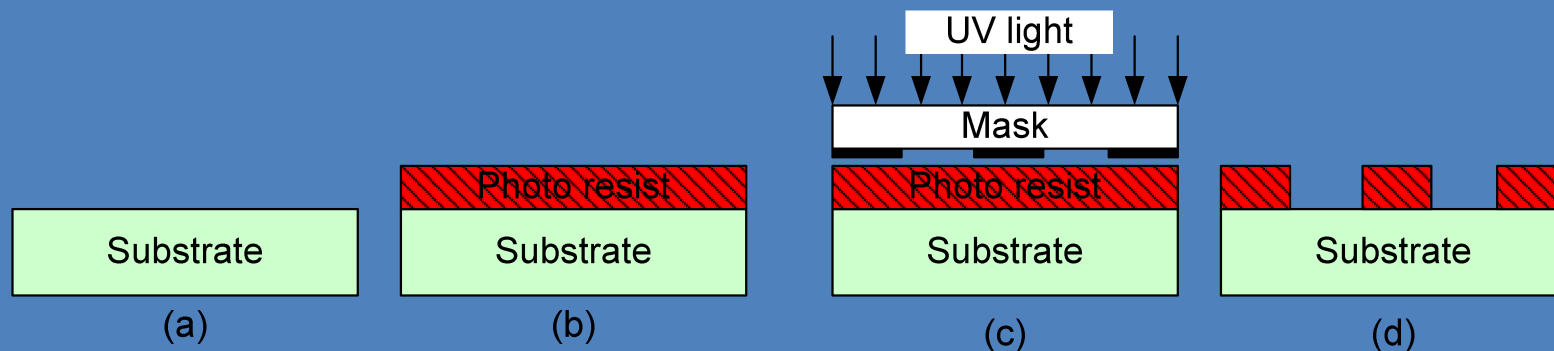
Photo Lithography process

Dong-Kyu Park
(stone419@unist.ac.kr, 내선:4165)

UNIST Central Research Facilities (UCRF)

1. Photo lithography

1. Summary : Photo lithography process is designed pattern on the mask onto the wafer as a photosensitive film that Photo resist film is coated on the substrate exposed through the mask to transfer the mask pattern on the substrate. And the MEMS device fabrication process, the general photolithography, thin film deposition, and etching processes are repeatedly performed, which makes the accuracy of the photolithography process is determined by the consequence of the final element so that the process should be to minimize error range.



<The schematic of photo lithography process>

2.Purpose : Make a pattern and protect for substrate etch.

1. Photo lithography

3. Photo Resist

: Photoresist properties will change after received UV energy. In the developer, photo resist will remove receive UV energy area or NOT

Request of Resist

- High Resolution
- High Selectivity
- Good Adhesion
- Good & fast Removal

Control of resist resolution

- Speed of development (Non-exposed)
  : Slower is better
- Speed of development (Exposed)
  : Higher is better
- Effective of protect surface

1. Photo lithography

Resist composition

▶ Polymer : Material of repeated atomic arrangement with a certain molecular substacnce. Protect layer at dry and wet etch process

▶ Solvent : separate polymer molecular in photo resist. and control the viscosity for good coating

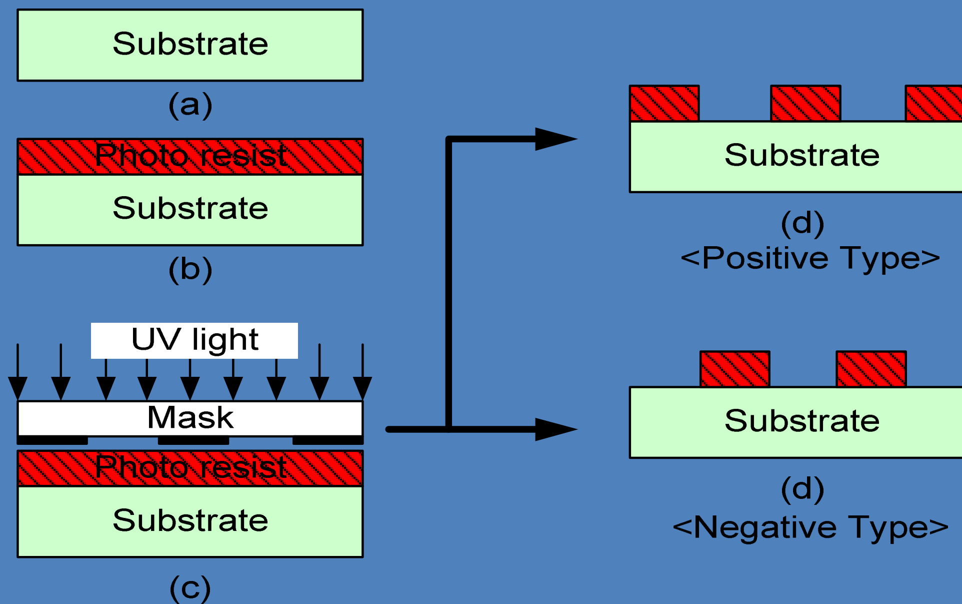
▶ Photoactive agent : The material of Exposed at UV energy(Photochemistry), After exposed area will change of structure of polymer

※ HMDS(Hexamethyldisilane) : HMDS can use before resist coating for adhesion, Photo resist with Si wafer. After use, Surface will change Hydrophilic to Hydrophobic

1. Photo lithography

Resist tone

Photo resist divide Positive and Negative. The Positive is develop at exposed area. The Negative is develop at Non-exposed area.



- Positive

- AZ5214E : 1~3 ㎛
- AZ4330 : 3~5 ㎛
- AZ9260 : 5~15 ㎛

- Negative

- AZ nLOF2035 : 3~5 ㎛
- SU-8 2050 : 50~170 ㎛
- KMPR1050 : 25~120 ㎛

2. Spin coating

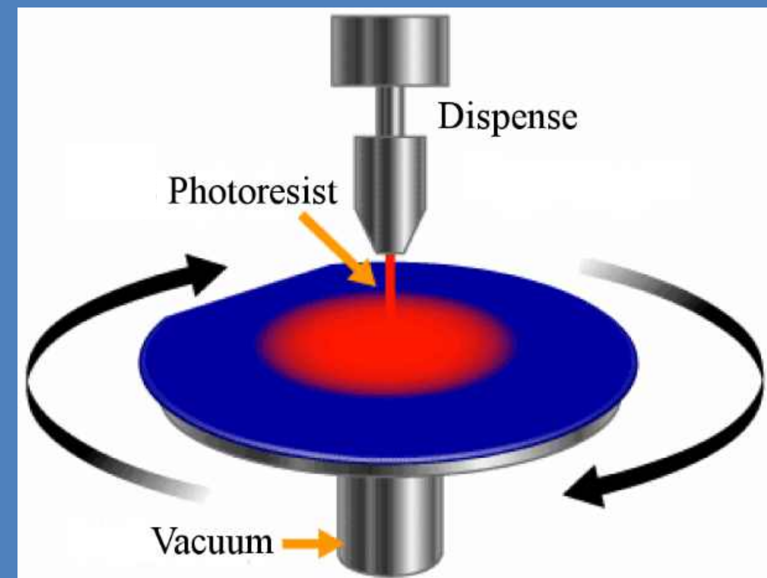
1. Resist coating

: Spin coating process is make a thin film used Photo resist on substrate.

The precaution is control the Adhesion, Coating Uniformity, Bubble, Particle

Coating

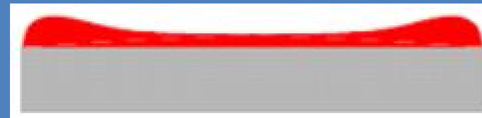
- Adhesion with substrate
- Uniform coating
- Protect Bubble & Particle

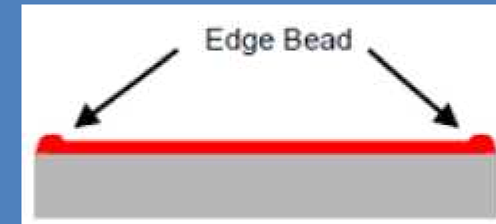


2. Spin coating

Precaution of spin coating

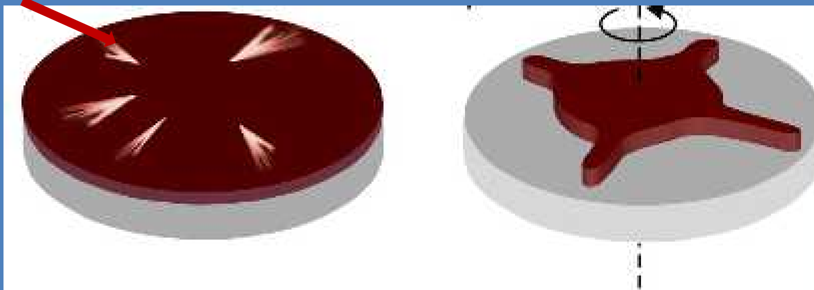
<Photo Resist Drop>


<Spinning>



<Result>

Boat effect



※ If there is some particle on Substrate, get shown Boat effect, That's effect fetch low resolution.

※ Edge Bead : Edge-Bead is present on the edge of the specimen with a perfect contact interfere with the Mask, Resist viscosity also becomes larger the higher the Bead

2. Spin coating

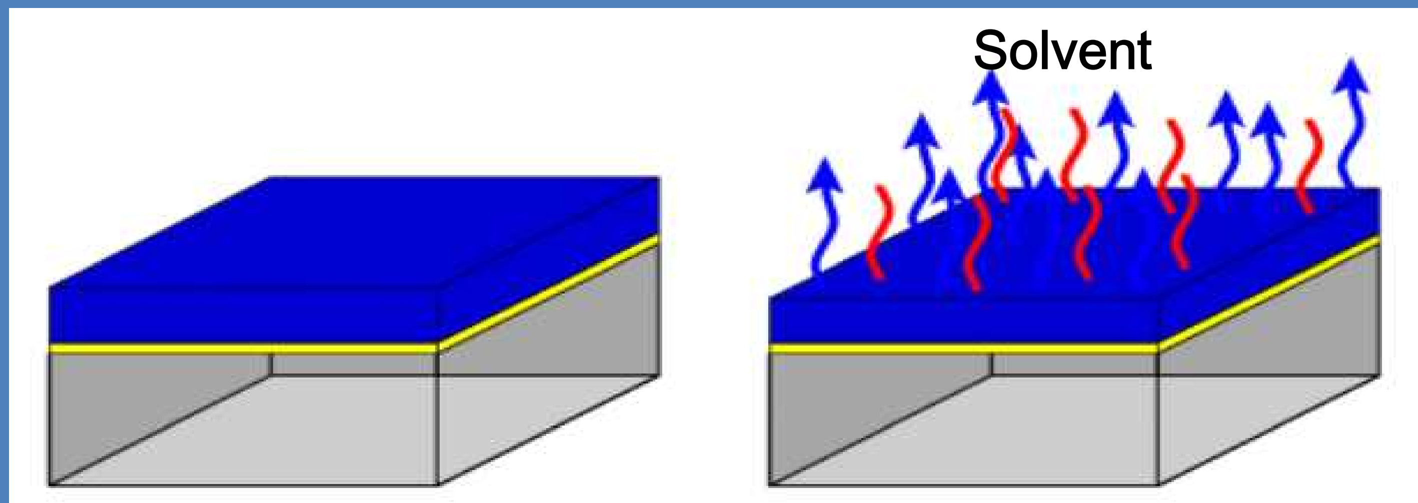
3. Manual of Spin coater

1. Turn on the Power
2. Load the sample chuck at spin coater
3. Select one of recipe
4. Change parameter of RPM and time
5. Loading the wafer on to chuck and turn on the vac. Pump
6. Select recipe and push the “열기”(korean)
7. Dropping the solution(Photo Resist)
8. Close the cover(caution!)
9. Pushing “Start” button
10. Turn-off Vac. Switch
11. Unload wafer chuck
12. Cleaning machine using ACETONE
13. Turn-off main power

3. Bake(Hardning)

1. Bake process

: Bake needs curing process for use photo resist layer, because photo resist is a solution. after Bake-process solvent will vaporizing, and get the good adhesion layer. There is necessary process for mask contact mode. Add Hard bake process depends on next process.



< Spin coating>

< Bake>

3. Bake(Hardning)

2. Hot plate manual

1. Carefully check around the Hot-plate for fire hazard
2. Covered Hot-plate using Foil
3. Turn on the Power switch
4. Set-up the temperature using ‘Top’ & ‘Botto’ button
5. Put the sample on Hot-plate
6. Remove the sample after bake

   (Must use Tweezer!)
7. Turn off the Power switch
8. Cleaning hot-plate for next user

* When user leave photo litho. Room, please Turn off this equipment.(Fire hazard)

4. UV exposure system(MA6)

1. Hard Mask

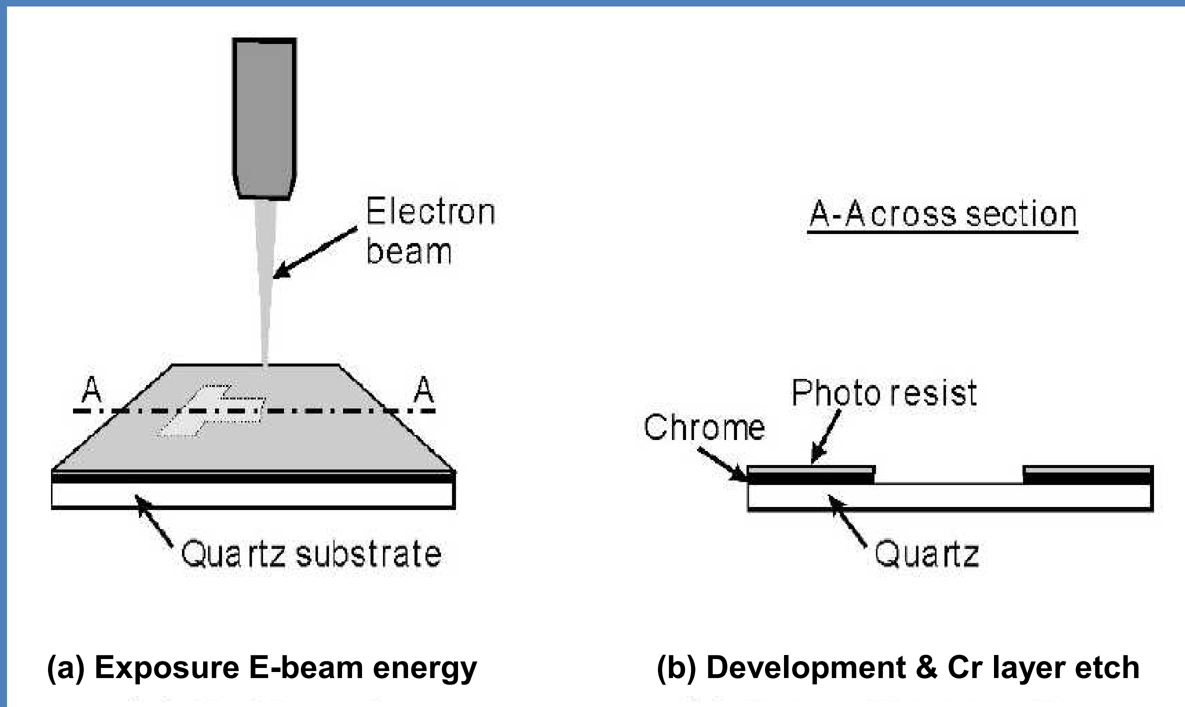
: Mask is design pattern for experiment. Can exposure to sample and copy that.

Cr Mask

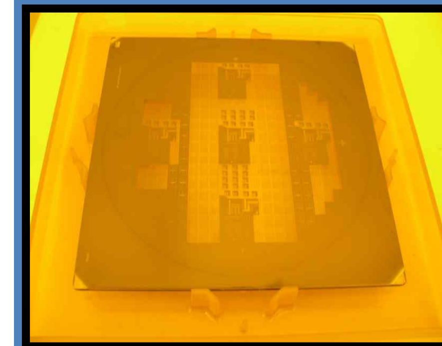
- Fabricate pattern on 1000Å Cr. Quartz substrate
- High Resolution, and have a long life time for use.
- High prices(Long working time for make, High cost quartz)
- Development 1㎛ resolution using contact mode
- Low loss energy

4. UV exposure system(MA6)

Procedure Cr-Mask



<Procedure of Cr mask fabrication>

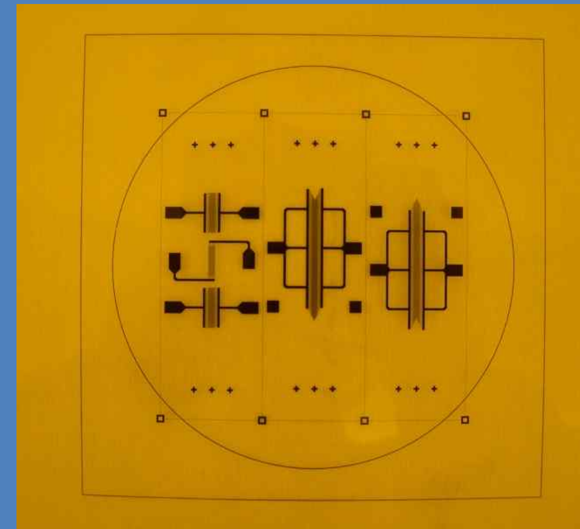


< Cr Mask >

4. UV exposure system(MA6)

Film mask

- Make the film mask using High resolution printer on film
- When use the film mask that needs attached at bare glass
- Low cost and CAD data used to create a photo-mask can be produced in real-time
- Low resolution and difficult for alignment with wafer



< Film mask >

4. UV exposure system(MA6)

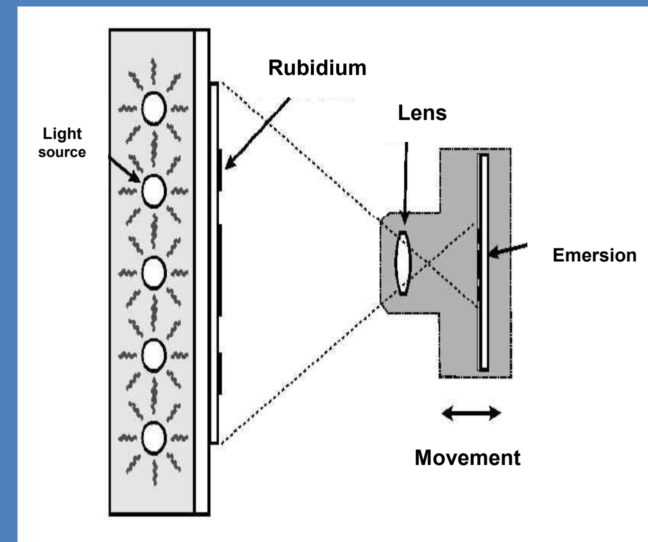
Emersion mask

• On a glass substrate coated Emulsion that exposing UV energy at layer

• Emulsion is negative resist and after exposure UV energy, emulsion will change to black.

• Low cost and simple process for fabrication

• Emulsion is easily contaminate because that layer is organic and low resolution



<Procedure of Emersion mask>

4. UV exposure system(MA6)

2. Mask Aligner

: The possible alignment and exposure equipment

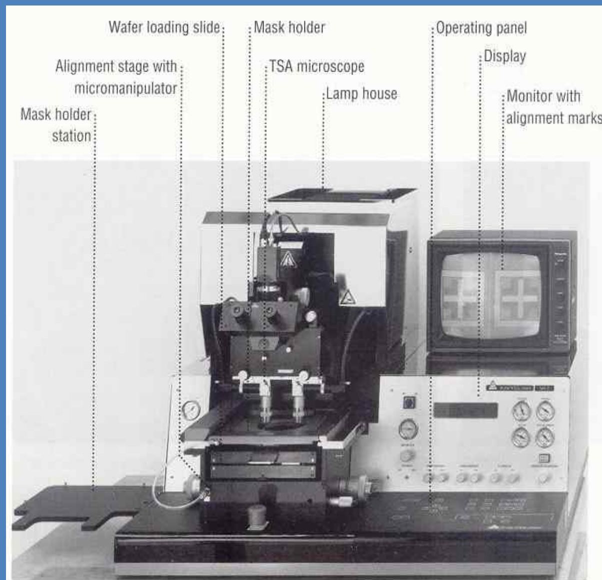
Spec.

- Light source : Mercury Lamp 1000W
- Power (intensity) : 30mW(CH1), 40mW(CH2)
- Usable wavelength : 365~405 nm broadband
- Print mode : Proximity & Contact (soft, hard, Low vac, vac.)
- Alignment mode : manual
- Microprocessor control with LCD display for top and bottom side
- Alignment accuracy : top side – 0.5 ㎛, bottom side - 1㎛
- Microscope objectives : 5X, 10X, 20X
- High resolution CCD camera

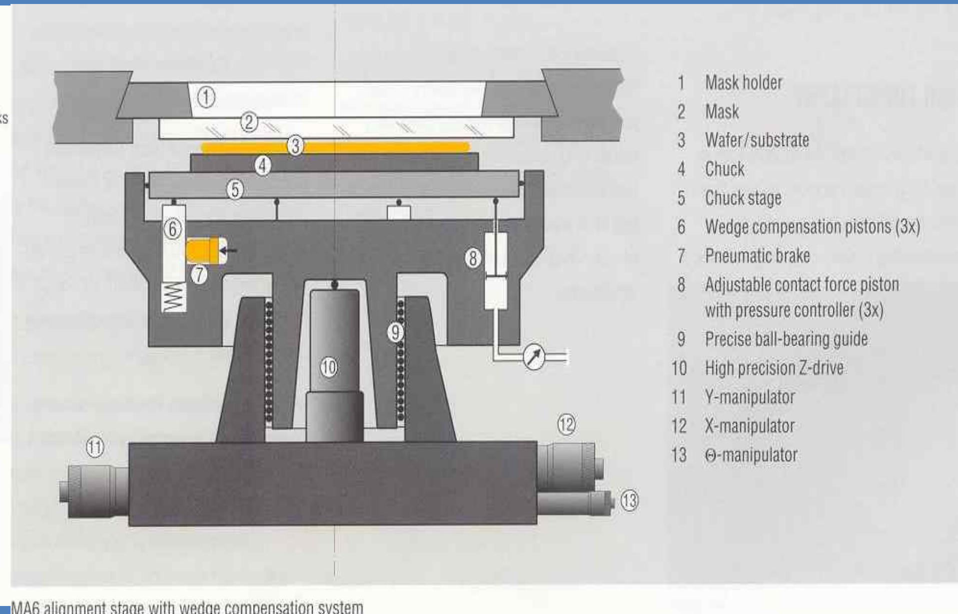
4. UV exposure system(MA6)

3. Aligner

MA6 Aligner



SUSS MA6 Mask Aligner

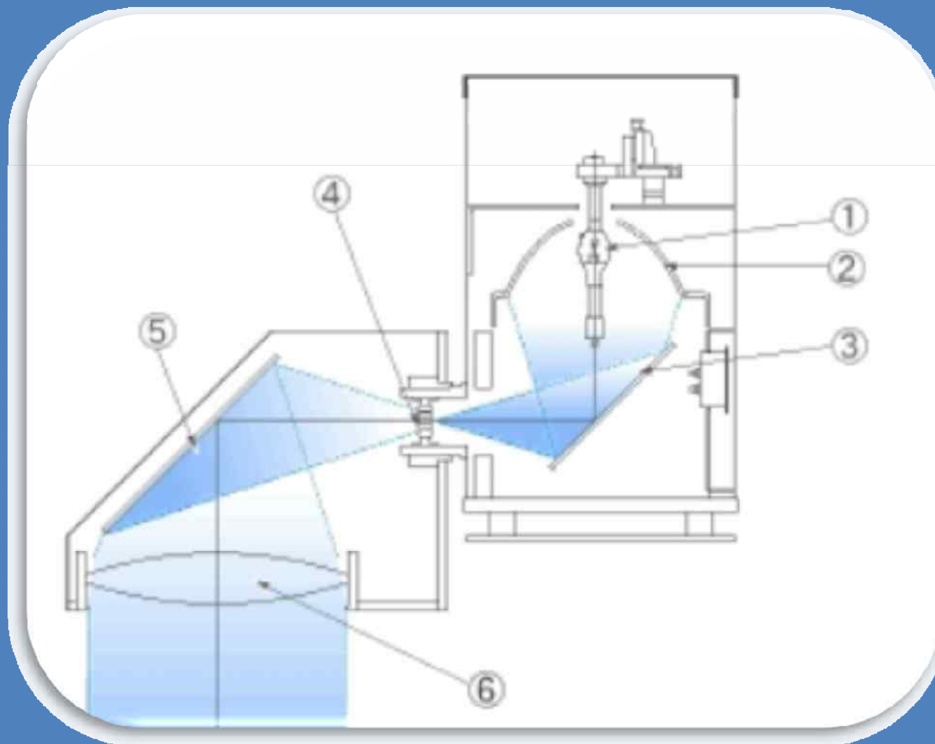


MA6 alignment stage with wedge compensation system

4. UV exposure system(MA6)

3. Aligner

Light source part



$E_{(mj/cm2)} = I_{(mw/cm2)} \times T_{(sec)}$

$E_{(mj/cm2)}$ = Energy

$I_{(mw/cm2)}$ = Intensity

$T_{(sec)}$ = Time

1. Mercury lamp
2. Ellipse collection mirror
3. Plane reflective mirror
4. Filter
5. Plane reflective mirror
6. Collimated lens

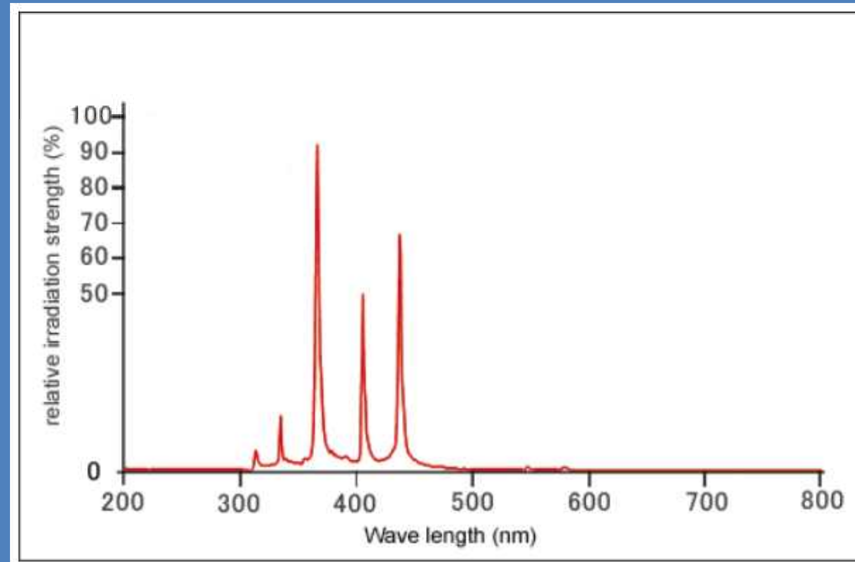
4. UV exposure system(MA6)

4. Mercury lamp and Wave length

: Mercury lamp(I-line, H-line, G-line) for exposure

Mercury Lamp

<350W Mercury lamp>



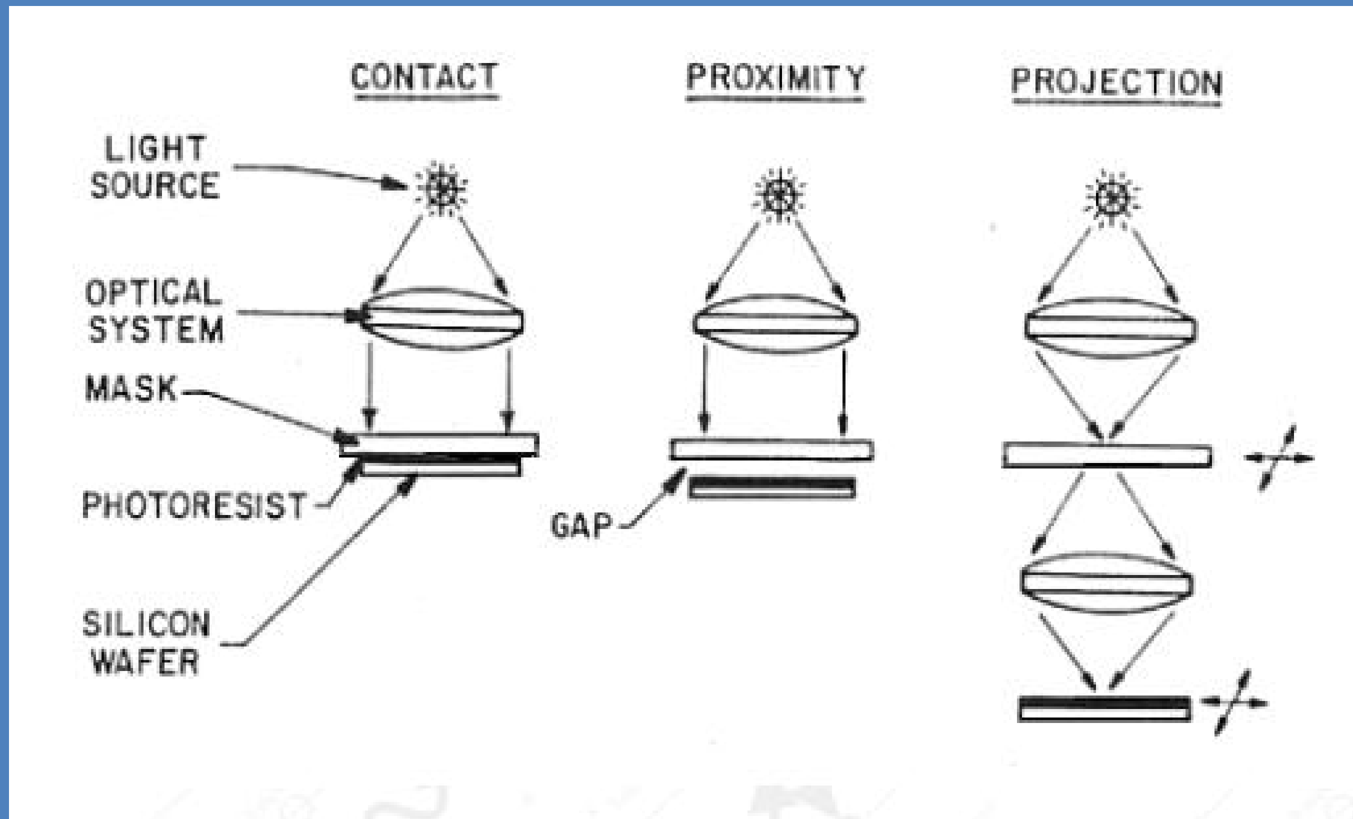
<Mercury lamp wave length>

4. UV exposure system(MA6)

6. Exposure type

: Exposure type is divided Contact, Proximity, Projection type.

UCRF exposure system practicable for use Contact, Proximity mode



4. UV exposure system(MA6)

7. Resolution

: Resolution is minimum development size in Photo lithography system

Resolution

Contact mode Resolution $= k\sqrt{\lambda(Tpr/2+gap)}$
$(k \sim 1.5)$

Projection mode Resolution

$$R = K_1 \frac{\lambda}{NA}$$

$$NA = \frac{D}{2f} \qquad D = K_2 \frac{\lambda}{NA^2}$$

R = Resolution

K1 = Proportional constant

NA = Numerical Aperture

λ = Wave length

D = Diameter of the lens

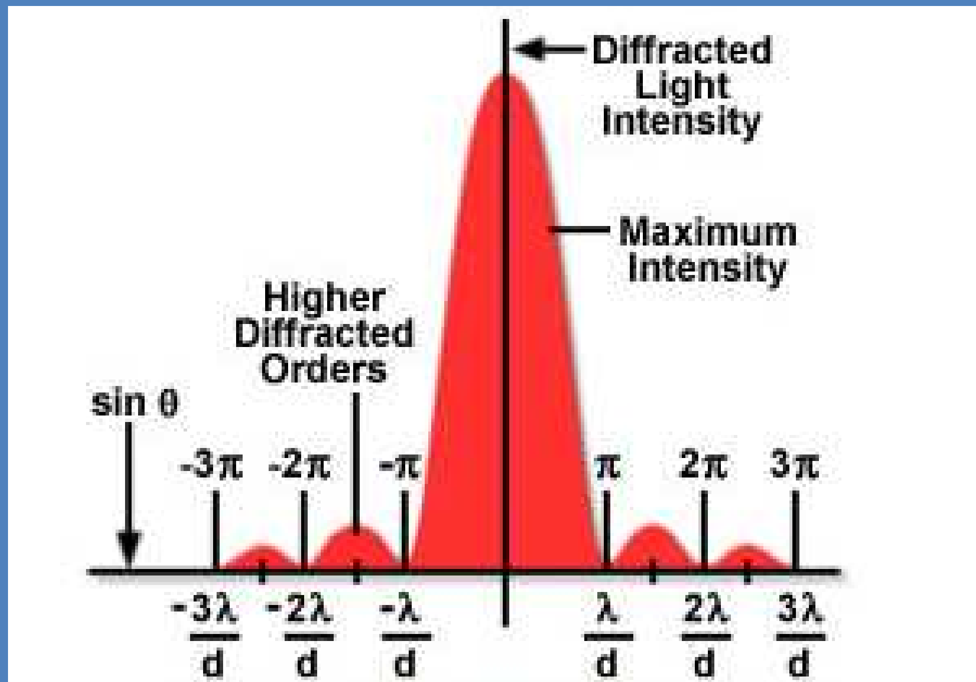
f = Focal length

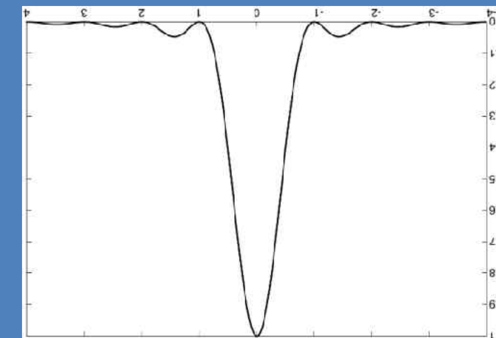
4. UV exposure system(MA6)

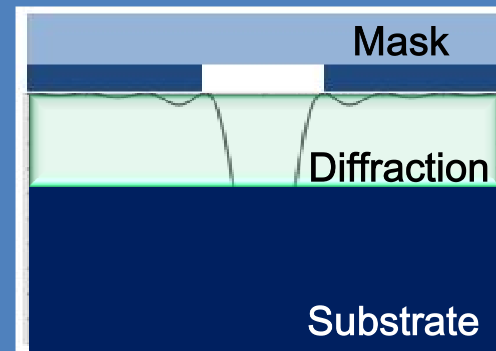
8. Diffraction

: Diffraction refers to various phenomena which occur when a wave encounters an obstacle or a slit.

Resolution







4. UV exposure system(MA6)

9. Aligner Manual

1. Push the 'CIC' Power On
2. Push Key-CP
3. Push Key-Start(Massage : Cold)
4. Massage : IDLE - available for use)
5. Main pannel switch On
6. Push the button as follows massage at display (Load-Enter)
7. Check the intensity, push lamp test button (CIC will display intensity – do not watching UV light directly)
8. Loading Mask Change-pushed change mask (Select mask holder & chuck)
9. At mask, Chrome should be top side
10. Push the Enter button and check vac. state

4. UV exposure system(MA6)

9. Aligner Manual

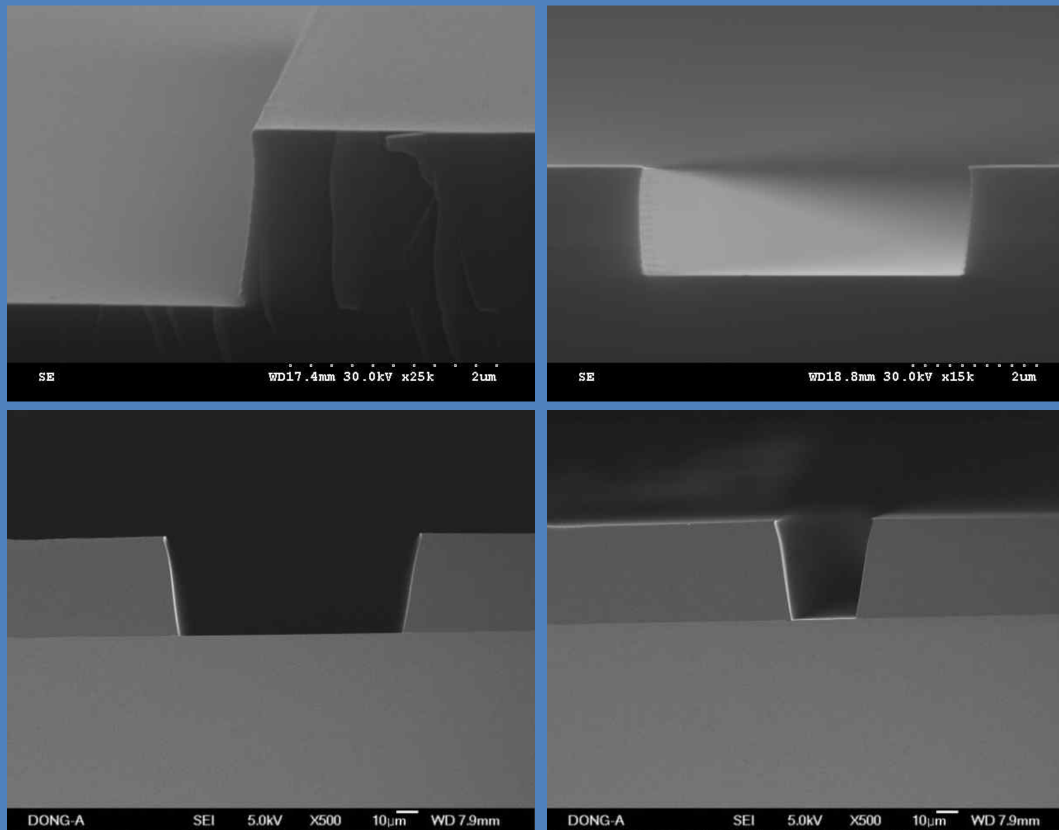
11. Loading Mask holder to equipment
12. Fix the mask holder after push Change Mask
13. Save exposure time Select Edit Parameter
14. Select Exposure type

    (soft, vac., hard, prox., flood-mode)
15. Push Load button and wafer loading
16. Push Exposure button(UV exposure to wafer)
17. Wafer unloading
18. Remove mask(Reverse sequence)
19. Main pannel switch off
20. CIC Controller – Off
21. Remove and cleaning all of tool, chemical for next user
22. Writing Log-Sheet

5. Inspection

1. Profile of resist

Inspection



▸ Inspection

- Microscope (Surface, Size)
- Surface Profiler (Resist Thickness)
- SEM (Profile, Size)