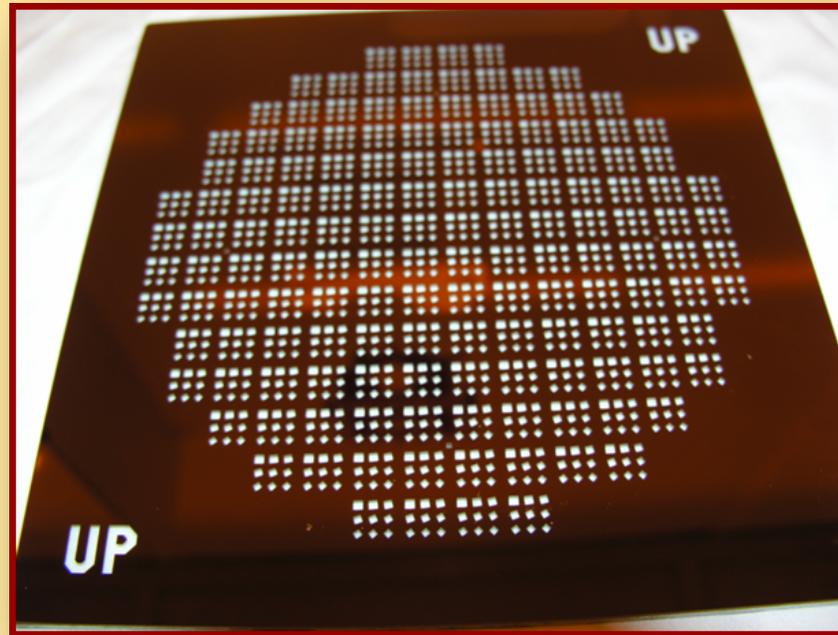


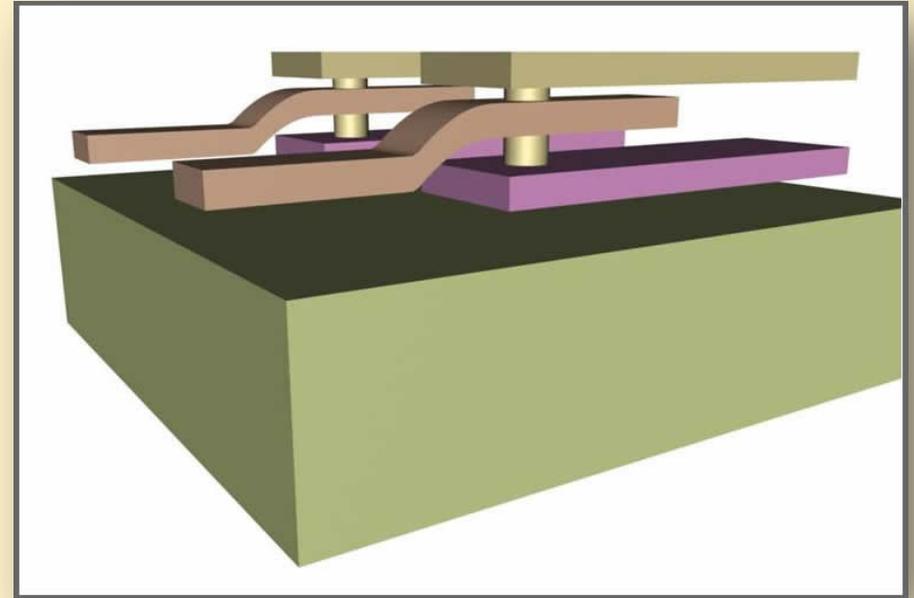
PHOTOLITHOGRAPHY OVERVIEW FOR MICROSYSTEMS



*Patterned Mask for
Photolithography
Expose*

Photolithography and MEMS

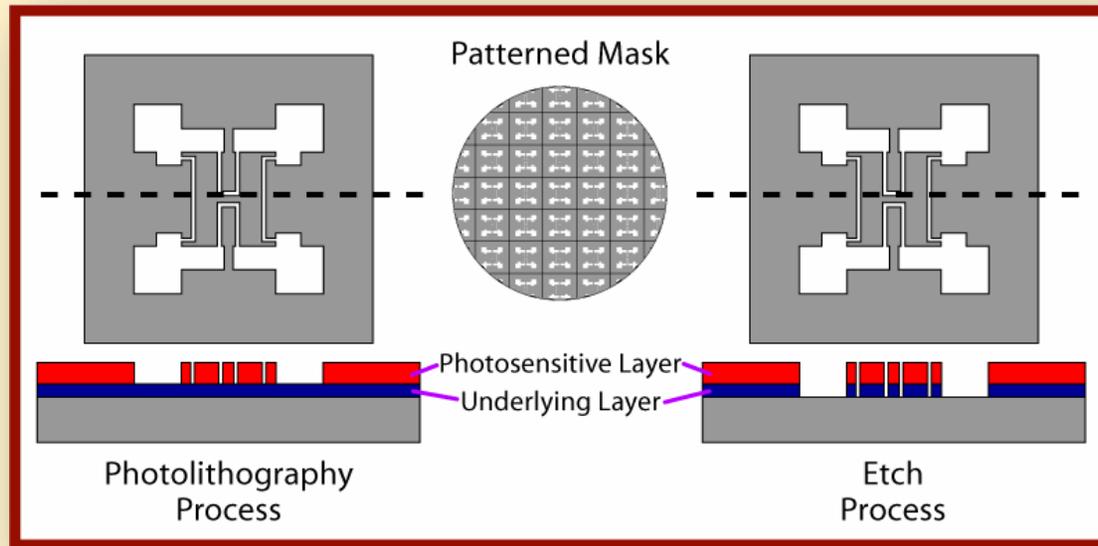
- ❖ Microsystems (MEMS) fabrication uses several layers to build devices.
- ❖ Each layer of this linkage system is a different component of the device and requires a different pattern.
- ❖ Photolithography defines and transfers a pattern to each respective layer.



MEMS Linkage Assembly

[Linkage graphic courtesy of Khalil Najafi, University of Michigan]

Photolithography



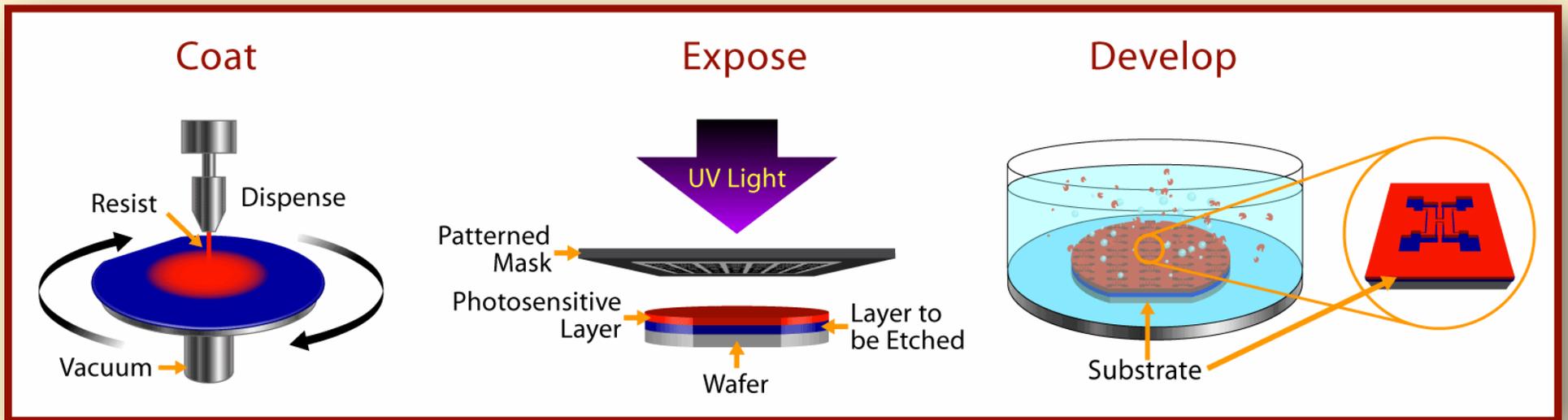
*Pattern Transfer to
Underlying Layer*

Each layer within a microsystem has a unique pattern.

- ❖ Photolithography transfers this pattern from a mask to a photosensitive layer.
- ❖ Another process step transfers the pattern from the photosensitive layer into an underlying layer.
- ❖ After the pattern transfer, the resist is stripped (removed).

Three Steps of Photolithography

- ❖ Coat
- ❖ Expose
- ❖ Develop

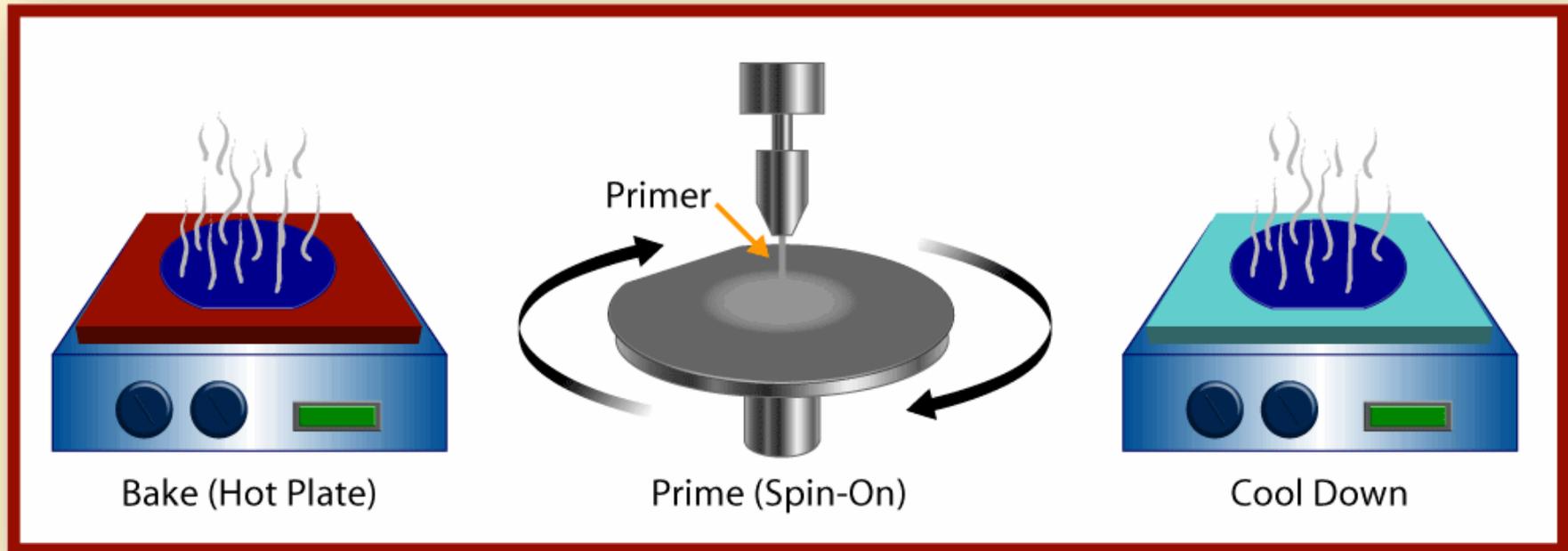


Coat Step: Surface Conditioning

In most applications, surface conditioning precedes the photoresist.

- ❖ Surface conditioning prepares the wafer to accept the photoresist by providing a clean surface.
- ❖ It coats the wafer with a chemical that boosts adhesion of the photoresist to the wafer's surface. (Usually Hexamethyldisilazane or HMDS)

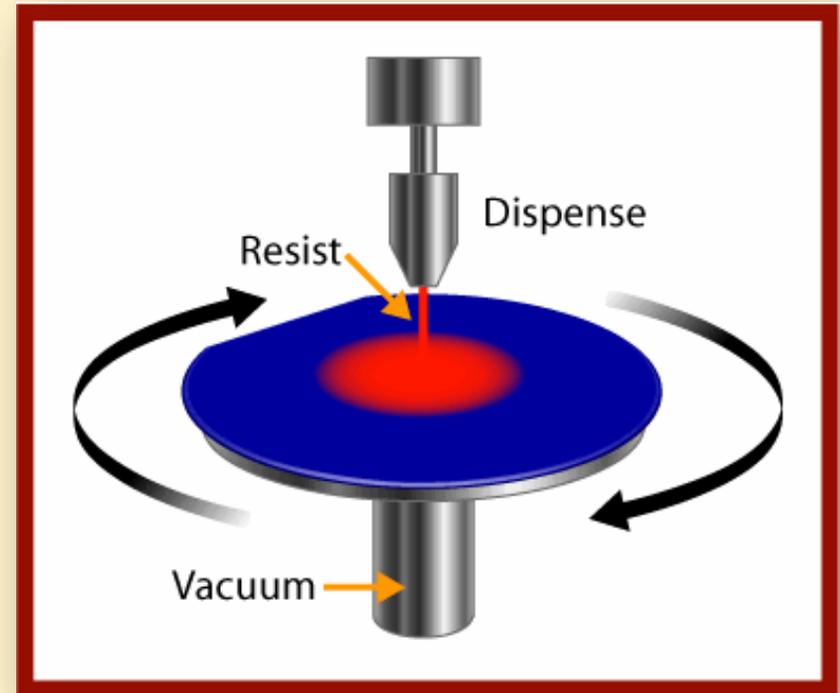
Surface Conditioning Steps



1. Wafer is baked to remove the water molecules on the wafer surface
2. HMDS is applied (prime) to create a hydrophobic surface
3. Wafer is cooled to room temperature.

Spin Coating

- ❖ Wafer is placed on a vacuum chuck
- ❖ A vacuum holds the wafer on the chuck
- ❖ Resist is applied
- ❖ Chuck accelerates for desired resist thickness
- ❖ Chuck continues to spin to dry film



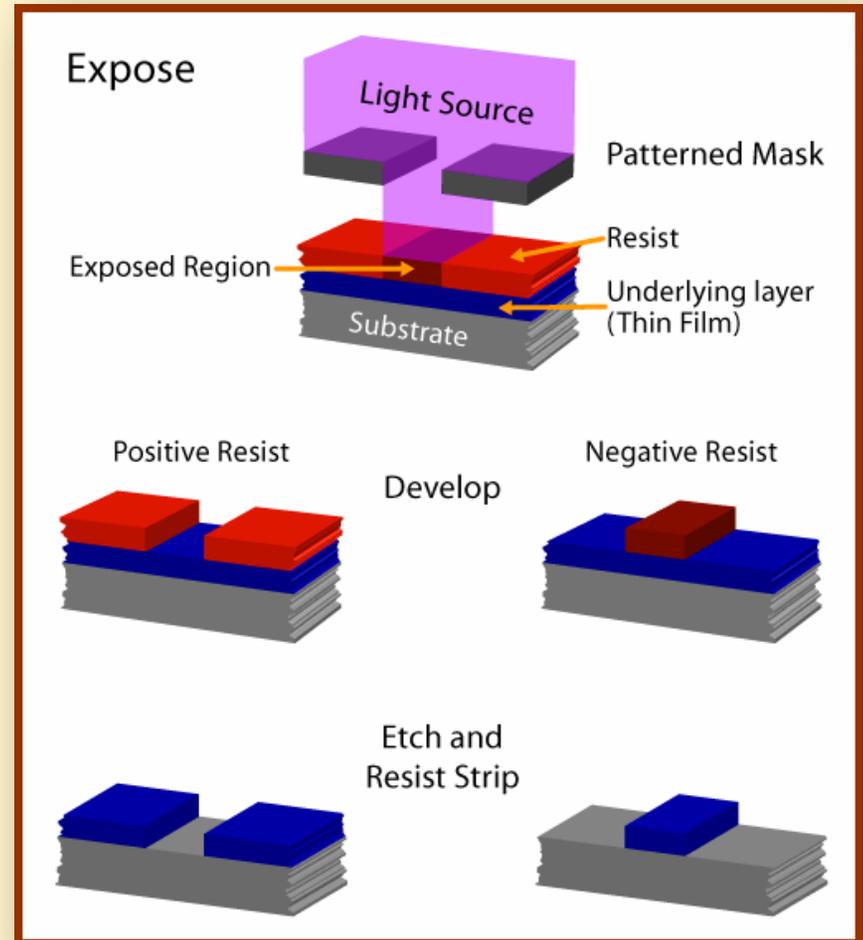
Spin Coating

Photoresist (Resist)

Photoresist is a mixture of organic compounds in a solvent solution.

Two types of resist:

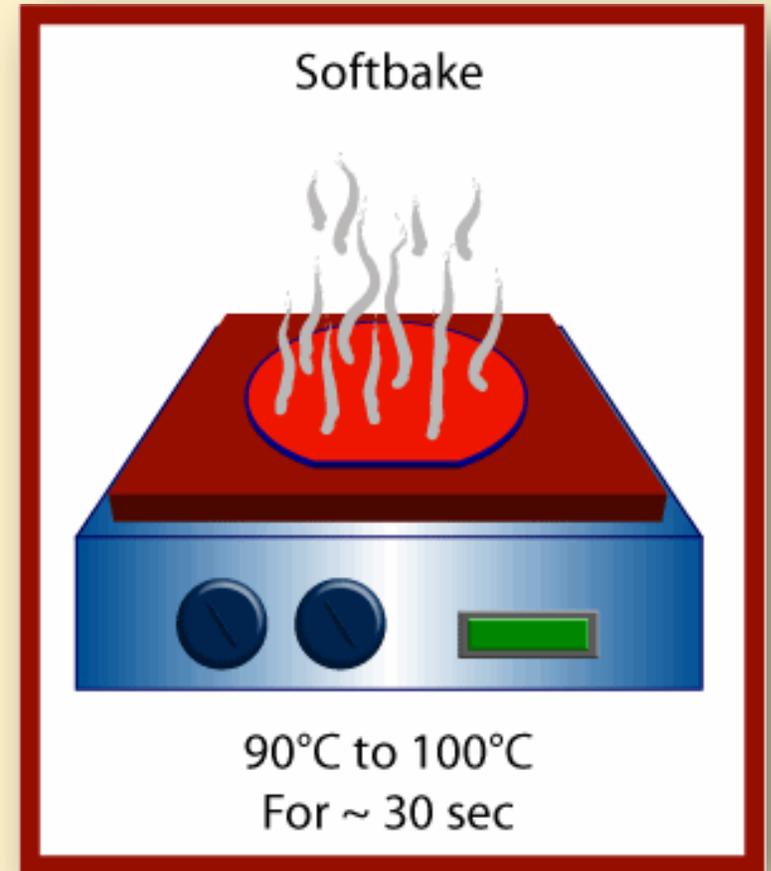
- ❖ Positive resist - Exposed regions become more soluble. A positive mask is left after develop.
- ❖ Negative resist - Exposed materials harden. A negative mask is left after develop.



Photoresist - Positive vs. Negative

Softbake

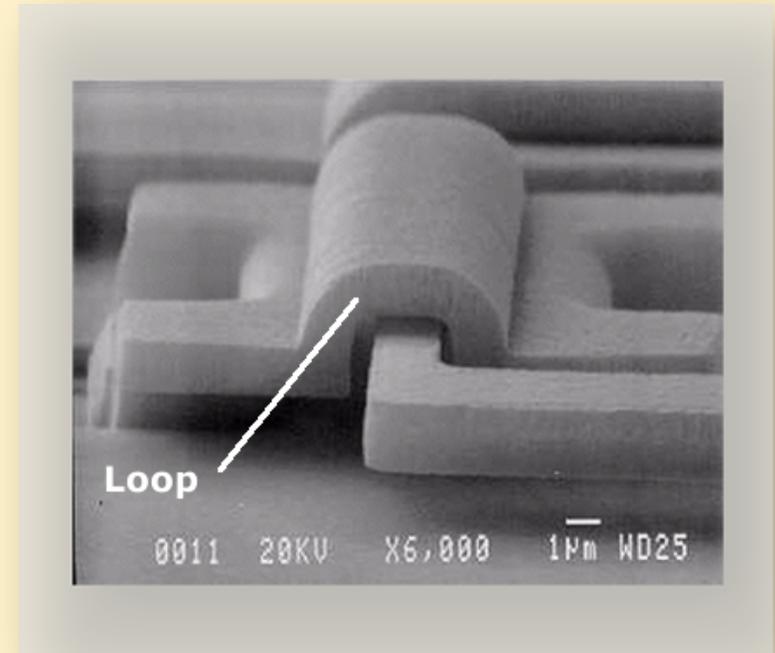
- ❖ After the photoresist is applied to the desired thickness, a *softbake* is used to remove the residual solvents of the photoresist.
- ❖ After the softbake, the wafer is cooled to room temperature.



Softbake after Applying Resist

Alignment

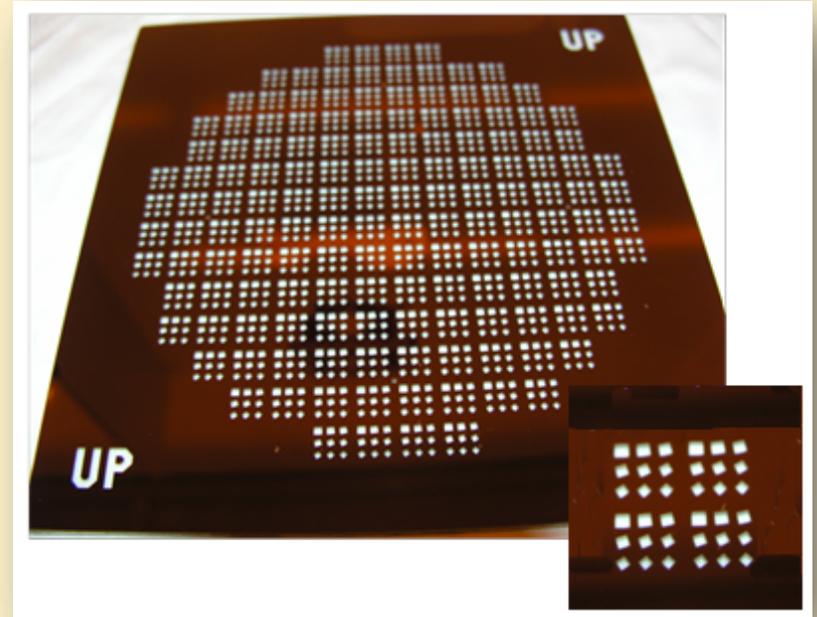
- ❖ "Align" is one of the most critical steps in the entire microsystems fabrication process.
- ❖ A misalignment of one micron or smaller can destroy the device and all the devices on the wafer.
- ❖ Each layer must be aligned properly and within specifications to the previous layers and subsequent layers.



*Microscopic Hinge
[Photo courtesy of Sandia National
Laboratories]*

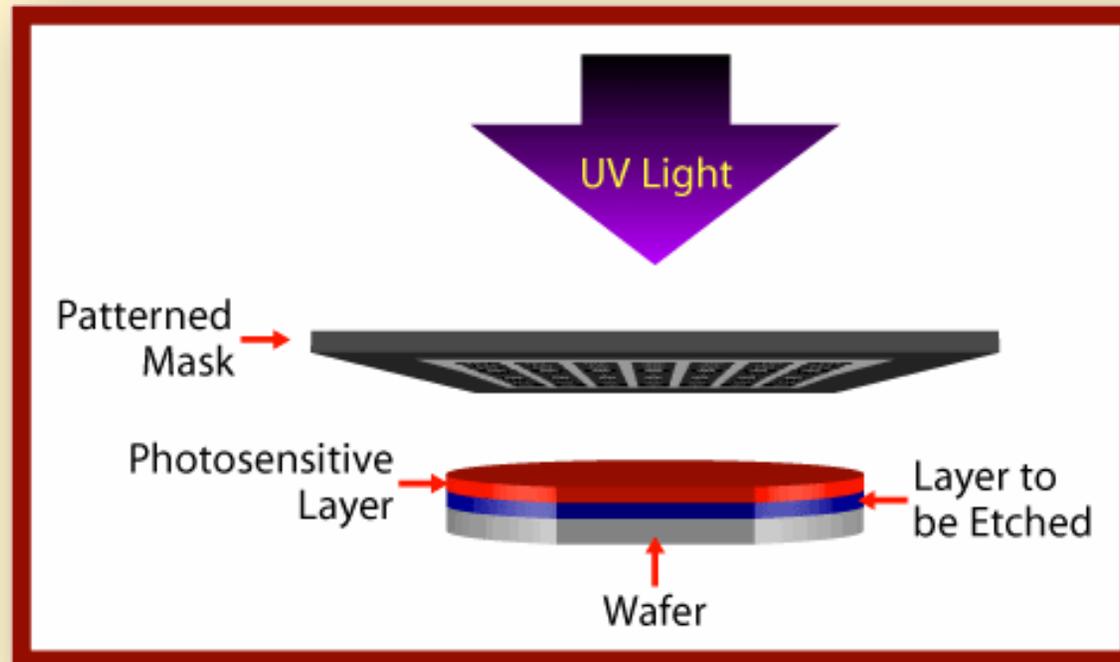
Mask vs. Reticle

- ❖ The patterned mask (or reticle) is a quartz or glass plate with the desired pattern (usually in chrome).
- ❖ Some equipment do not use a whole mask. Instead a smaller quartz plate is used with just a few die (inset). This plate is called a reticle.



Mask and Reticle (inset)

Expose

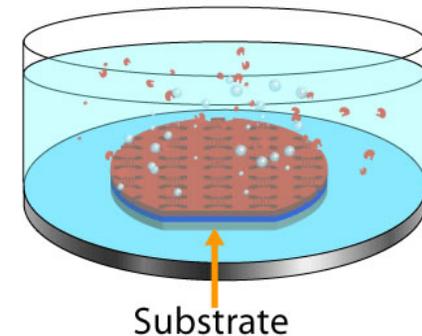


- ❖ The wafer is exposed by UV (ultraviolet) from a light source traveling through the mask to the resist.
- ❖ A chemical reaction occurs between the resist and the light.
- ❖ Only those areas not protected by the mask undergo a chemical reaction.

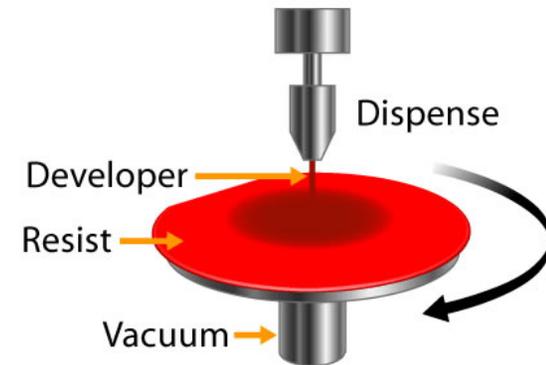
Develop

- ❖ Portions of the photoresist are dissolved by a chemical developer.
- ❖ With positive resist, the exposed resist is dissolved while the unexposed resist remains on the wafer.
- ❖ With negative resist, the unexposed resist is dissolved while the exposed resist remains.

Immersion Develop

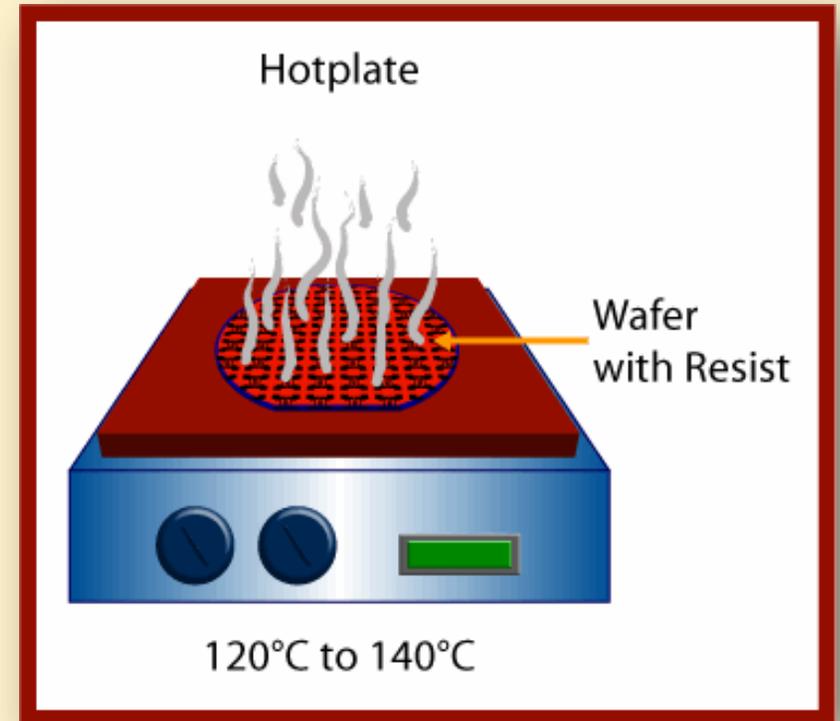


Spray-On Develop



Hardbake

- ❖ Hardens the photoresist for the next process.
- ❖ The temperature of the hardbake is higher than that of the softbake after coat.
- ❖ After the hardbake, the wafer is cooled to room temperature.

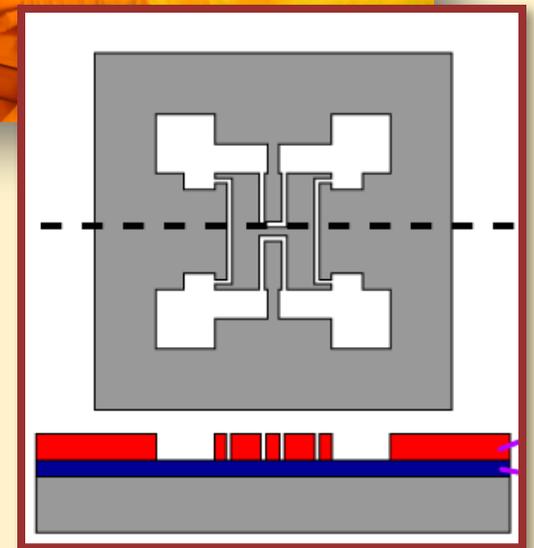
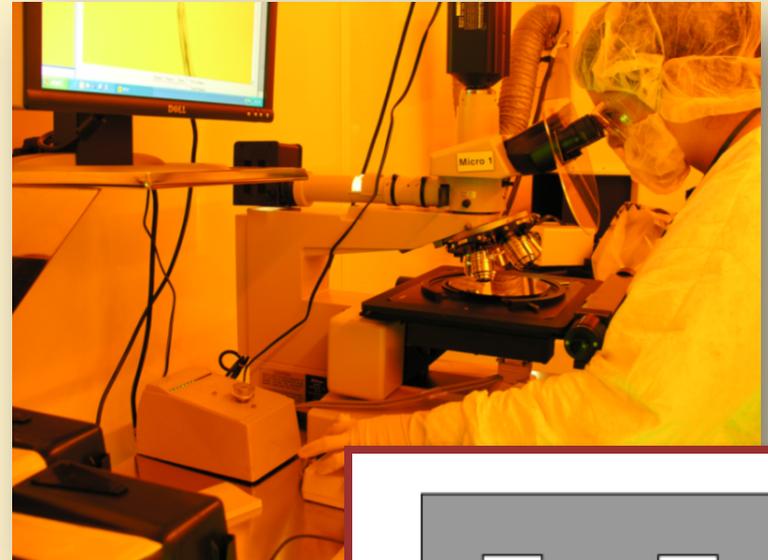


Hardbake

Inspect

Three critical parameters

- ❖ Alignment – the pattern must be positioned accurately to the previously layer.
- ❖ Line width or critical dimension (CD) – the pattern images are in focus and have the correct size.
- ❖ Defects – things that could affect subsequent processes and eventually the operation of the devices



Summary

Photolithography uses three basic process steps to transfer a pattern from a mask to a wafer: coat, develop, expose.

The pattern is transferred into the wafer's surface layer during a subsequent process.

In some cases, the resist pattern can also be used to define the pattern for a deposited thin film.

Acknowledgements

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