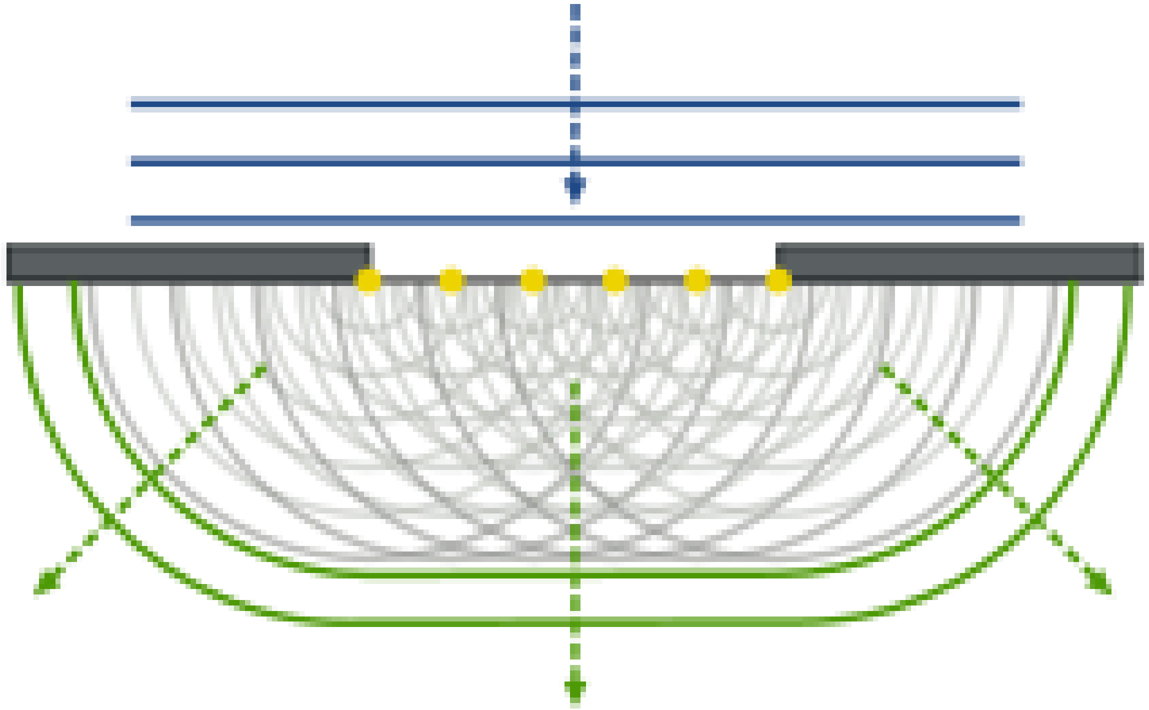
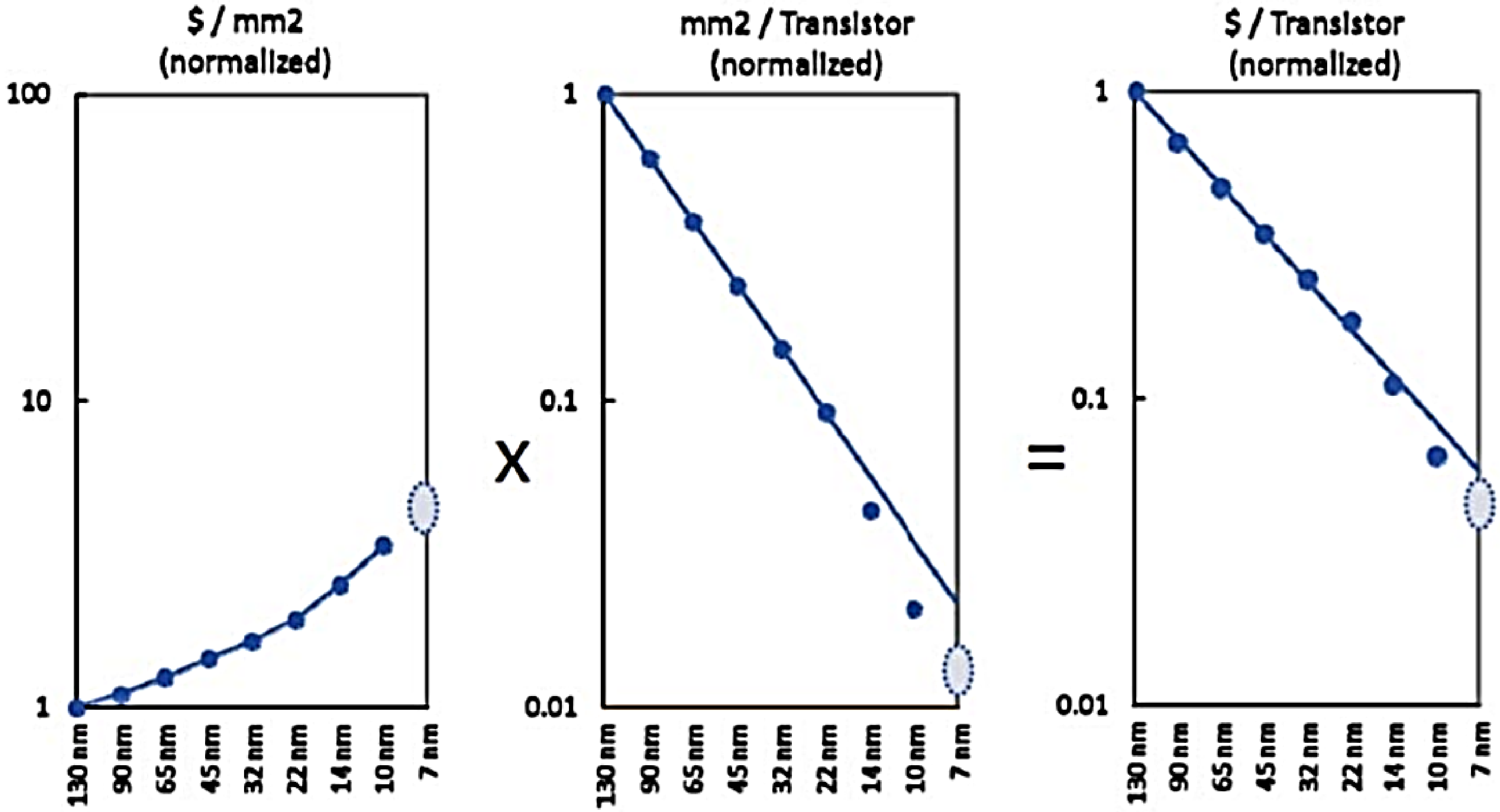
Lecture 3

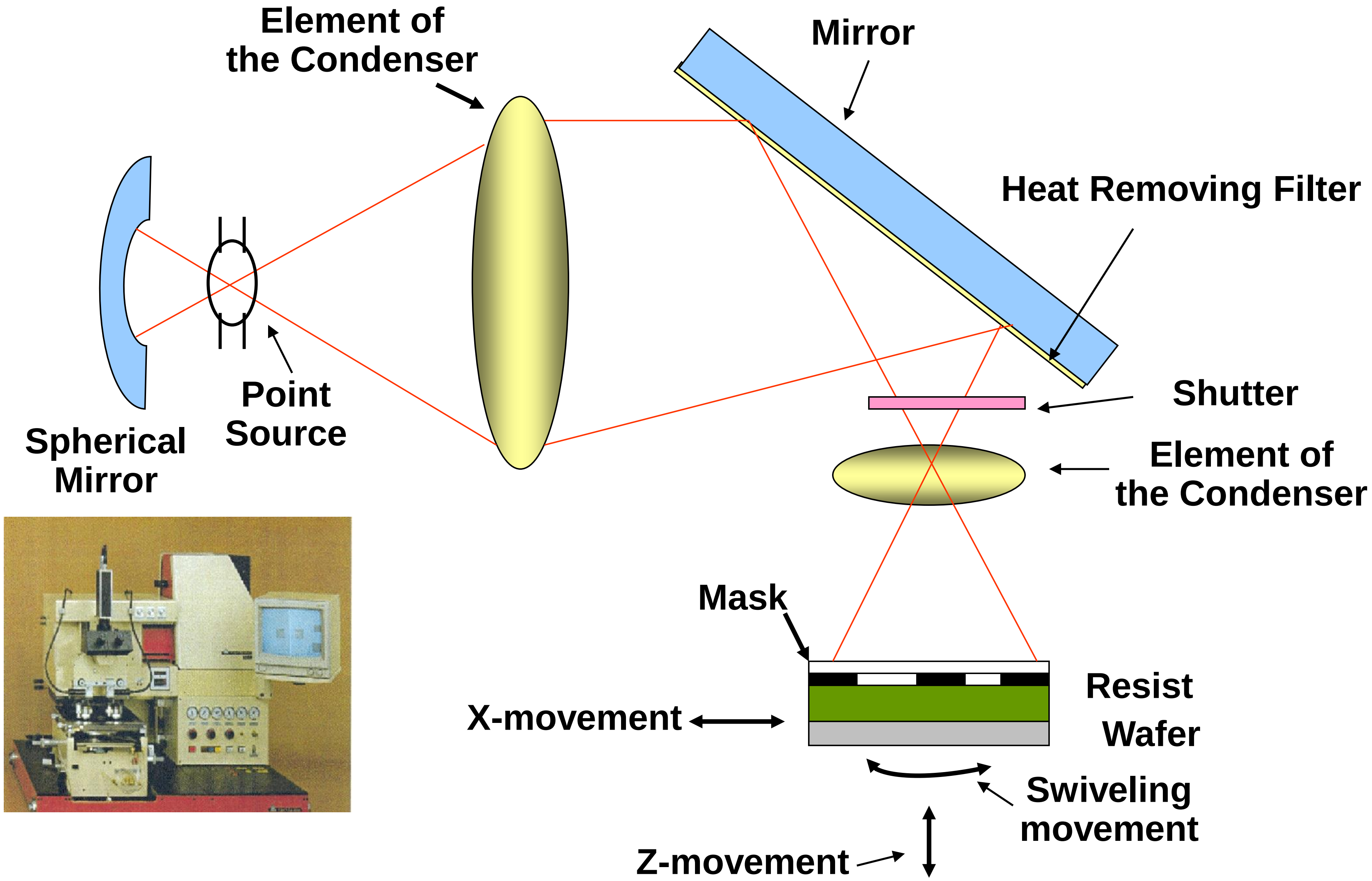
Chemical Engineering for Micro/Nano Fabrication



How to Continue Moore's Law

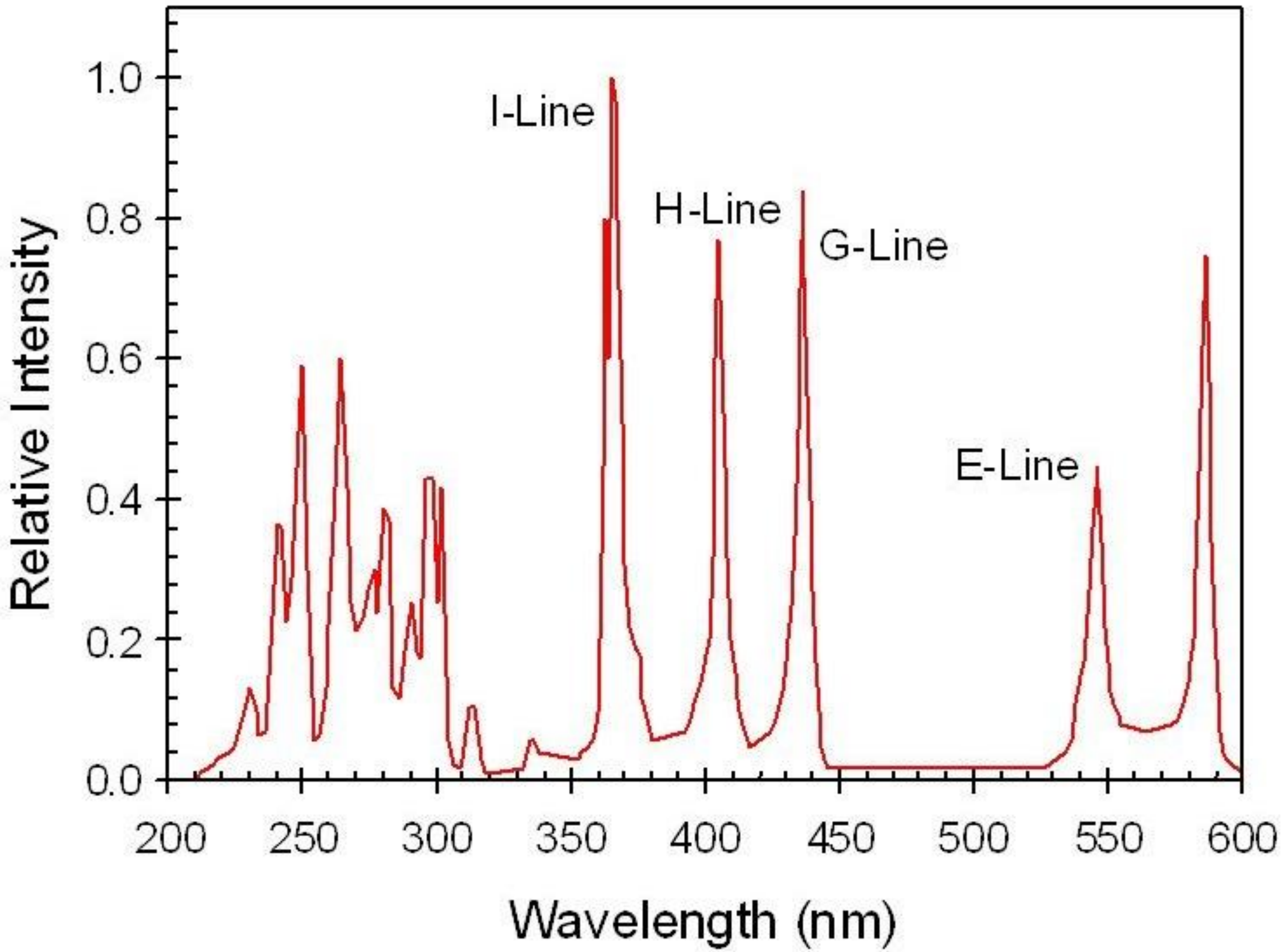


It all Started With Contact Printing



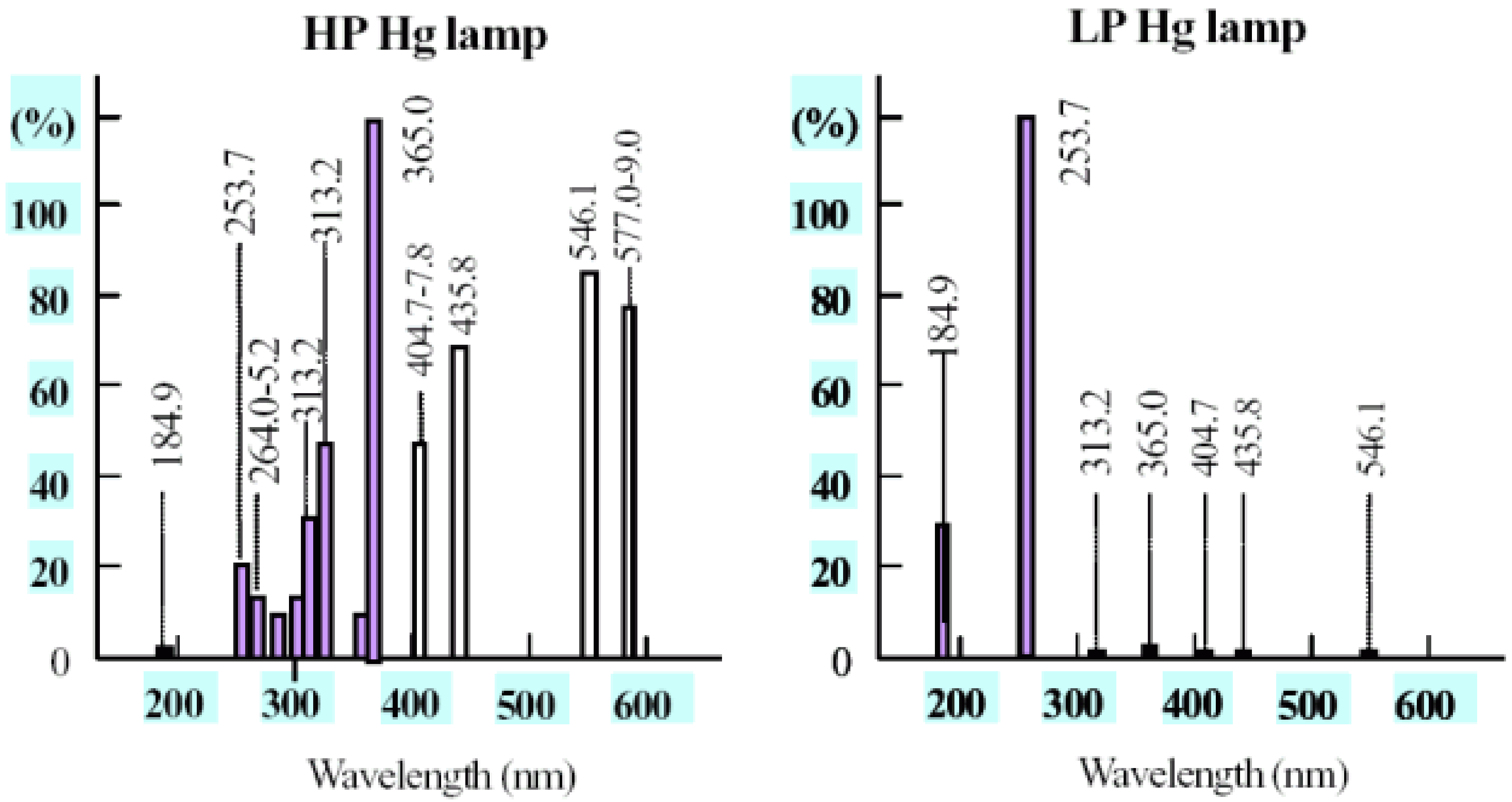
High Pressure Hg Lamp

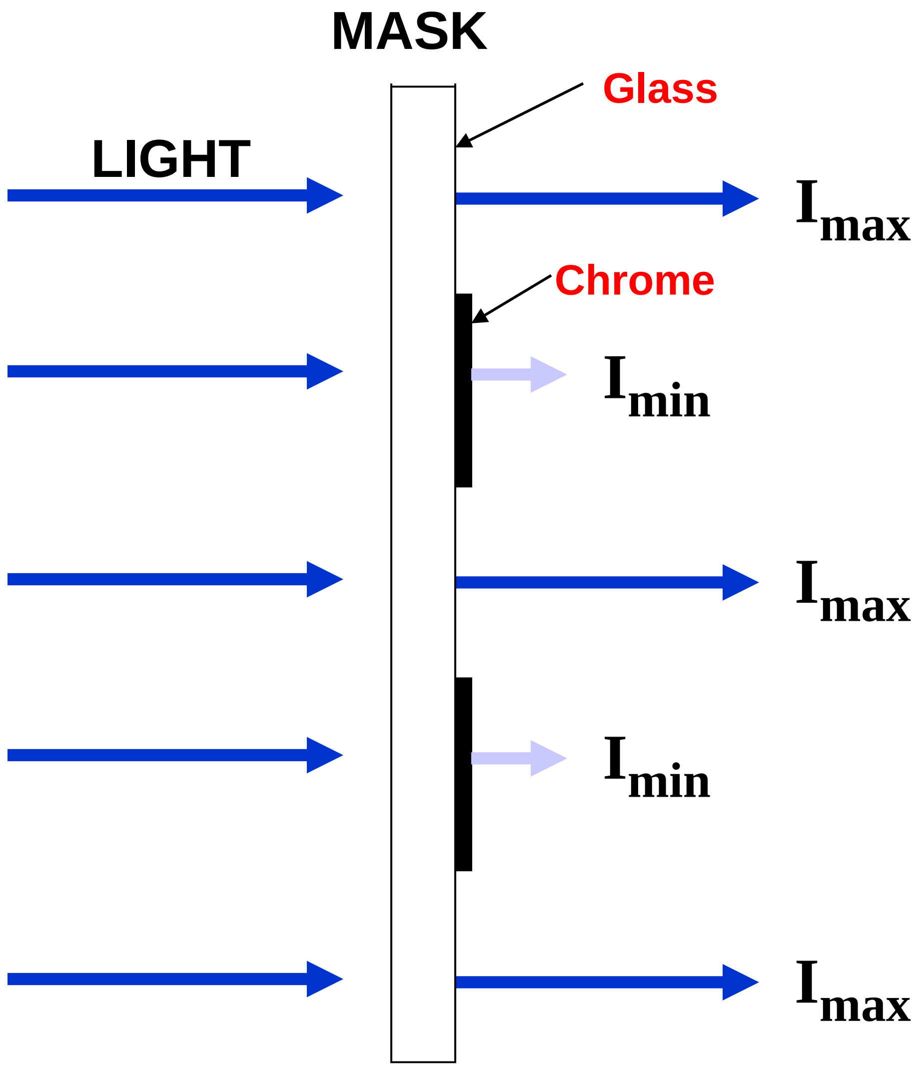
High Pressure Hg Lamp Output



Cl

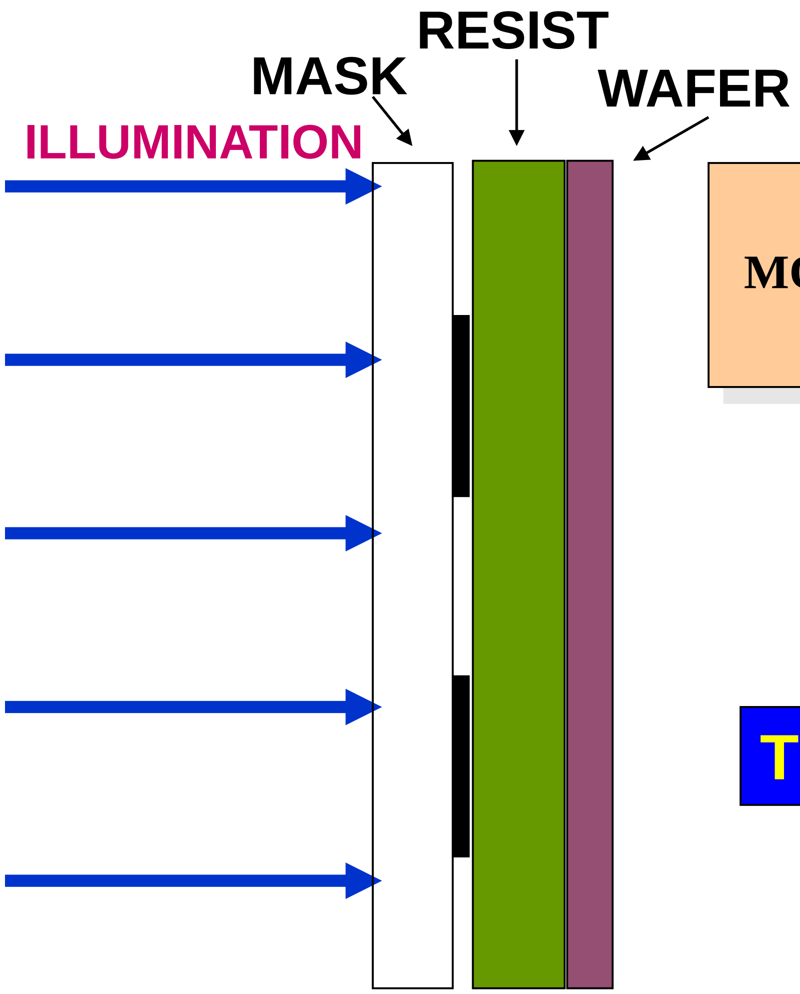
High and Low Pressure Hg Lamps





$$\text{MODULATION} = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

Modulation in Contact Printing



$$\text{MODULATION} = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$

- Modulation of the mask is 1
- Modulation of the image is ~1

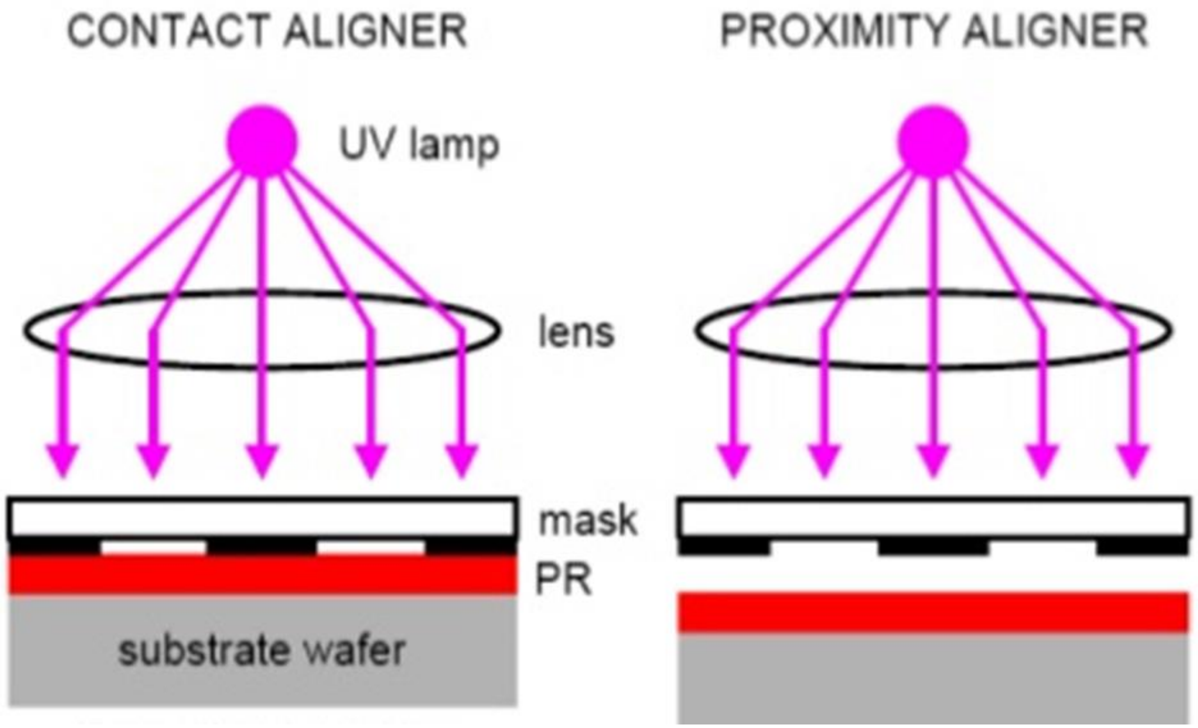
The image is almost perfect!

Rubylith Mask Making

This was Successful but….For Contact Printing…

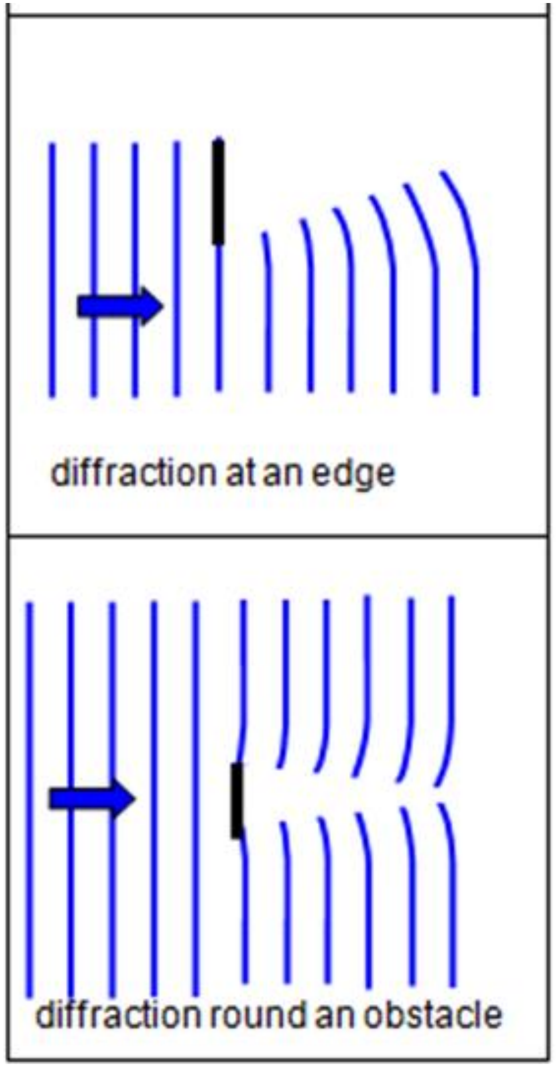
- As dimensions decrease, so do yields!
- Serious Problems with Mask Contamination
  - Rubber resist and Emulsion Masks
  - Introduction of Chromium on glass masks
- Alignment was done external to the Exposure system
  - Slow production and low yield = ☹
- Just move the mask away and do…
  - "Proximity Printing"

Nothing is Simple



Nothing is Simple…it seems

Newton vs Fresnel
Diffraction rears it's head



Diffraction effects at an edge

Diffraction round a sphere

Figure 2(a)

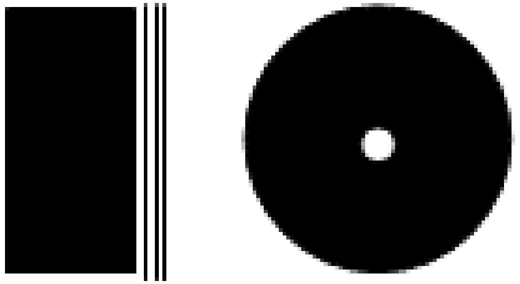
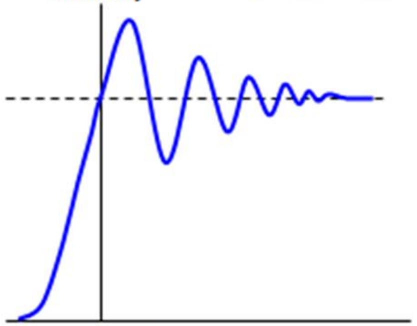


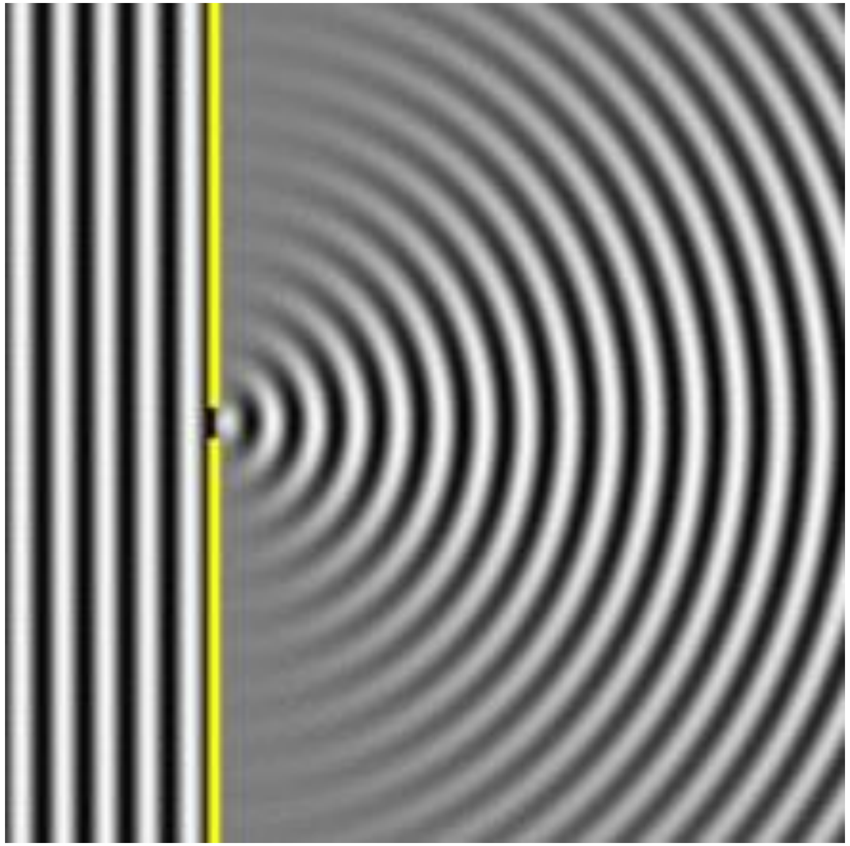
Figure 2(b)

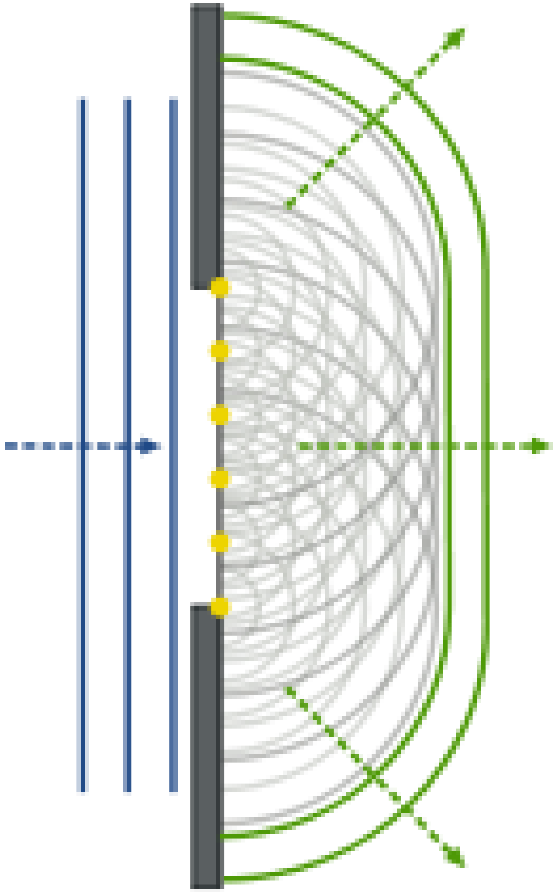


Huygens' Theory

When w = λ 1 wavelet

Many wavelets that interact

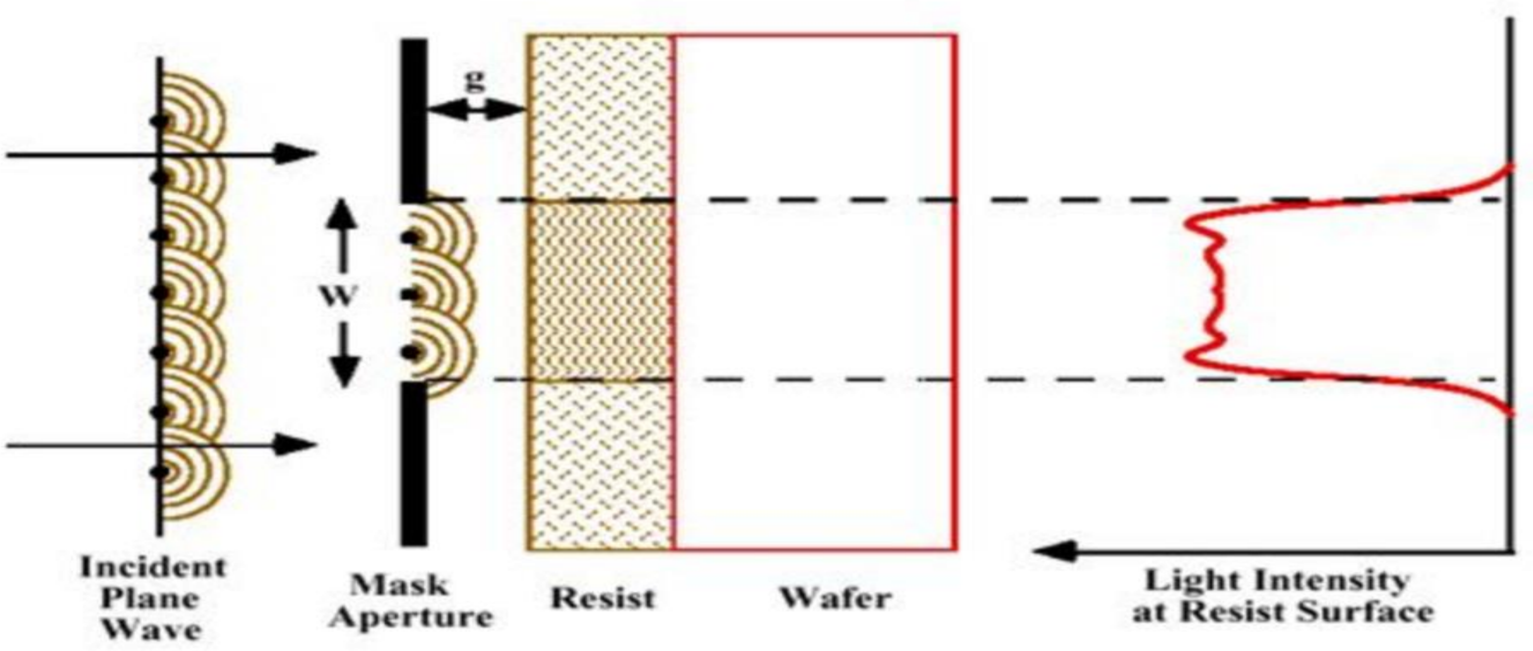




- Wavelets

Fresnel Diffraction in Proximity Printing

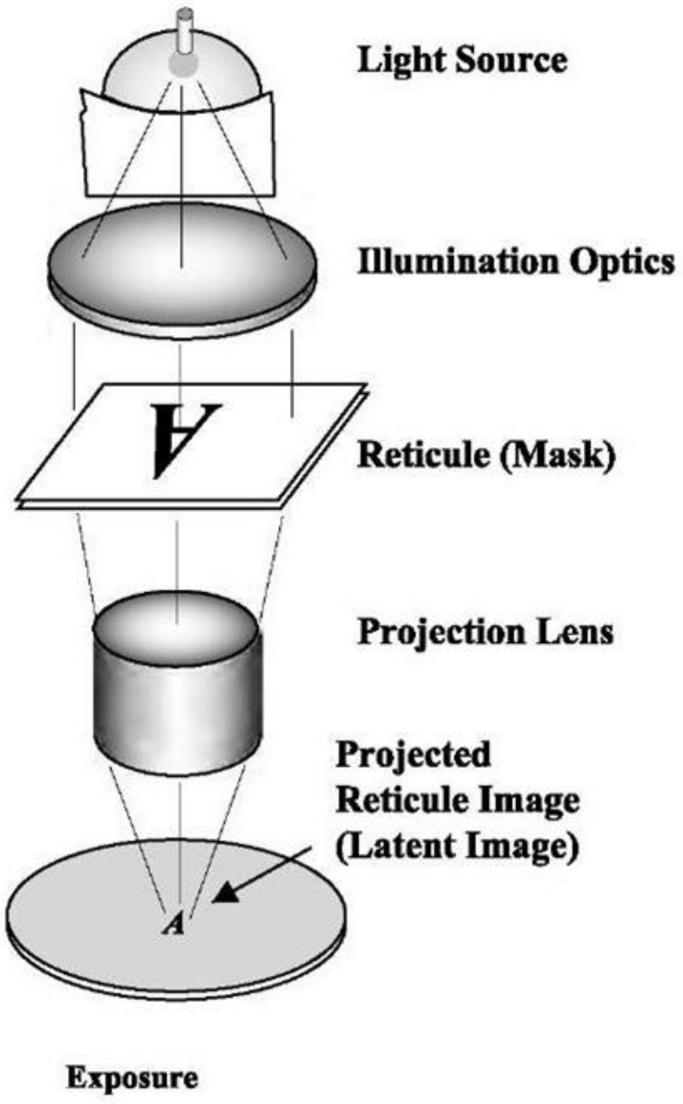
Near field or Fresnel Diffraction Regime When $g < W^2/\lambda$



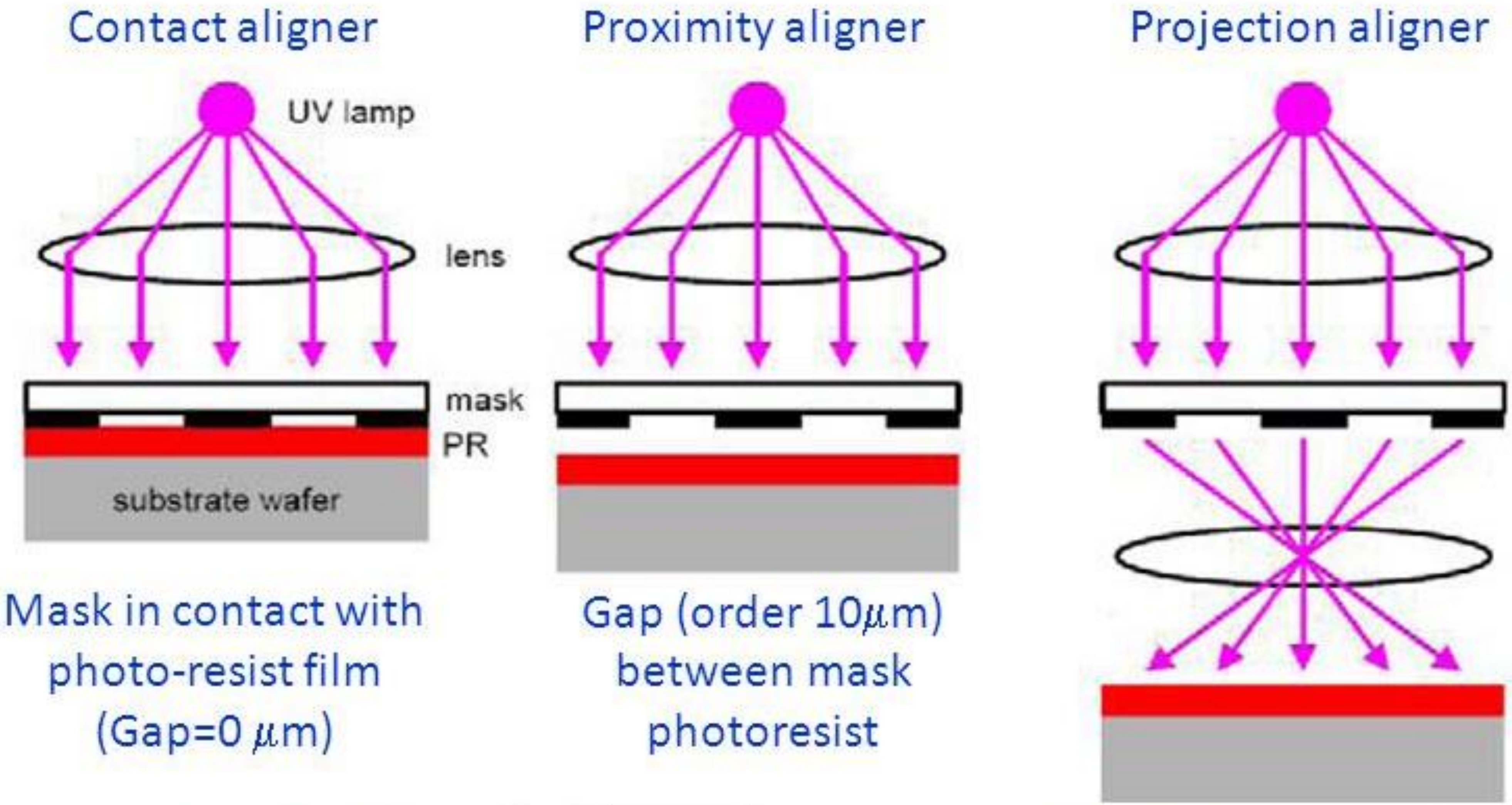
- Image can be constructed from point sources of spherical wavelets in the opening (Huygens' Theory)
- There is interference between these waves that causes "ringing"
- Here the minimum feature size is $W \sim \sqrt{\lambda g}$
- For g = 20 μm and 365 nm light, W is on the order of 2.7 μm

So…when the with is small the gap must be small

- So ….. we can do projection printing And get the mask far away from the wafer



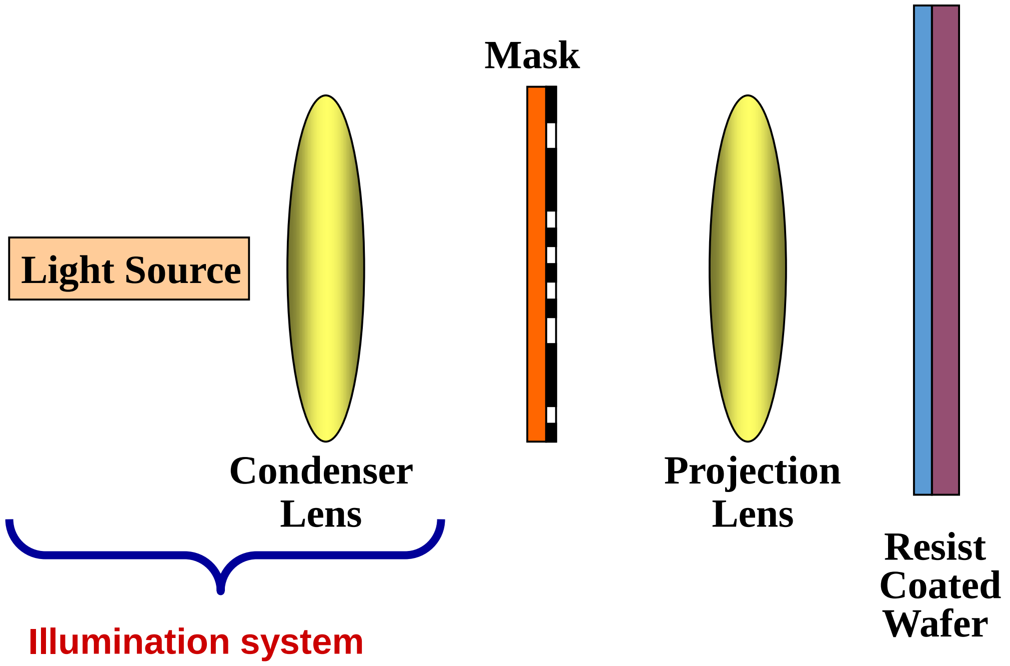
Optical Aligner Design Principles

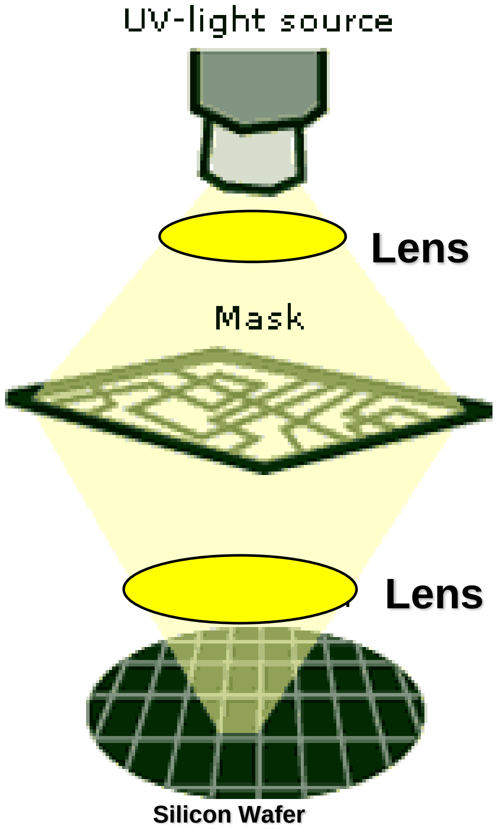


Advantages of Projection Printing

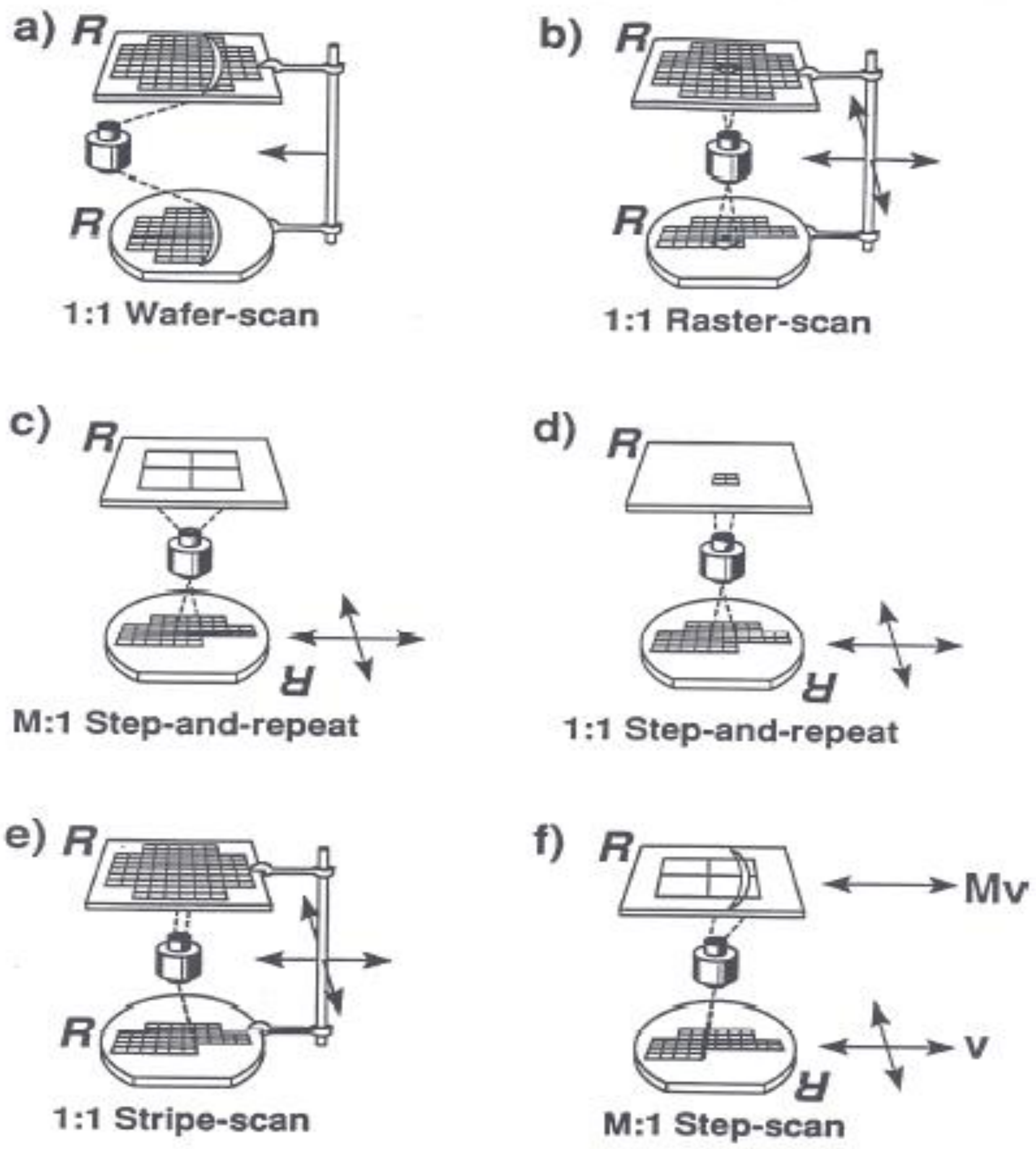
- Non-contact operation which prevents the mask from introducing defects and wearing out.
- No need for replacement masks.
- Wafer images are potentially more uniform because a single "mask" is used for all of them.
- Improved alignment accuracy – no need to move the wafer after alignment.
- Reduction capability makes masks easier to fabricate and repair.
- Mask can be protected with a pellicle

The Basic Components of a Generic Optical Projection System

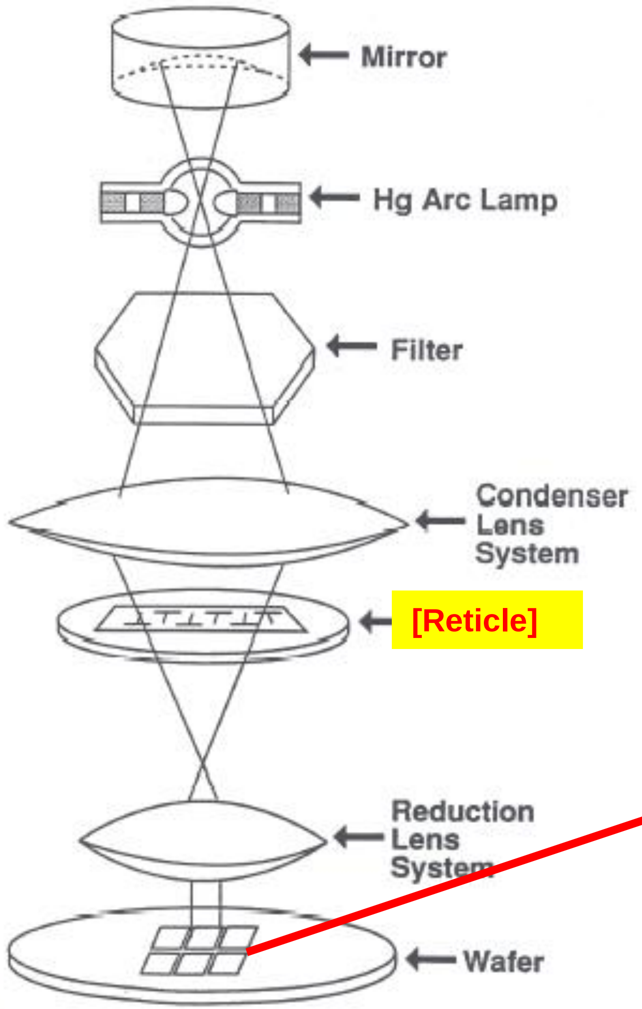


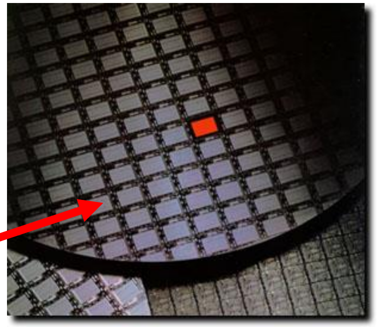


Many Projection Design Options

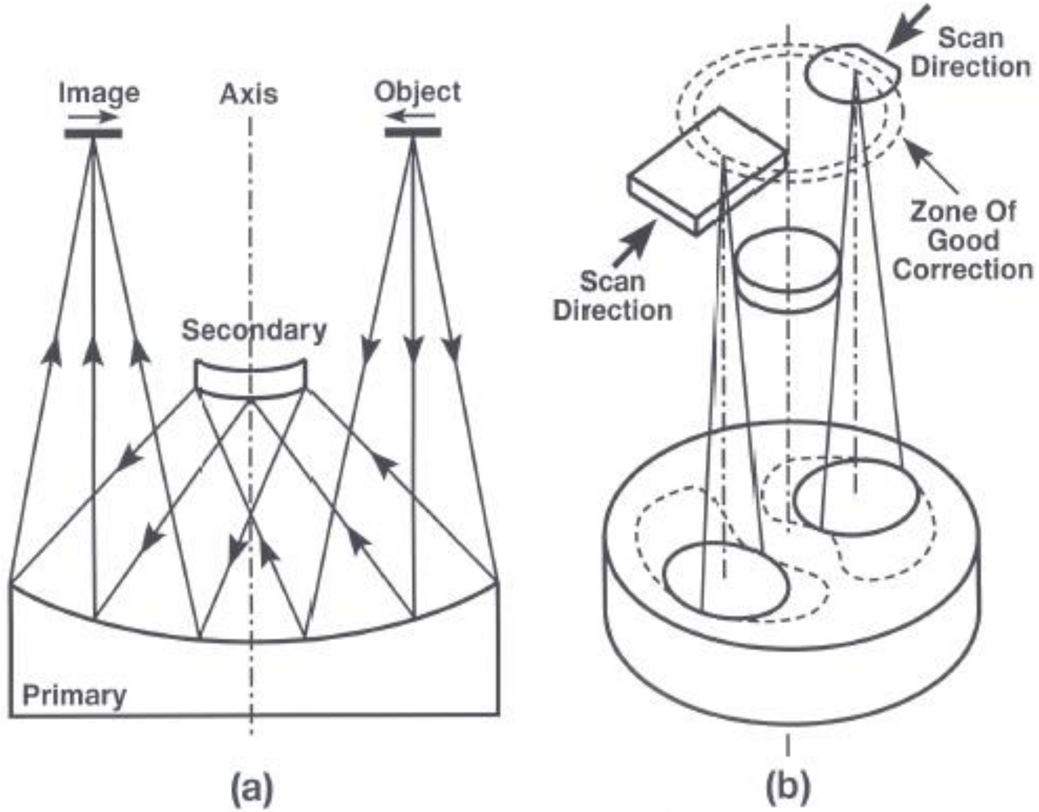


Step and Repeat Principle





Principle of the Micralign® Scanner System



Micralign Full Wafer Scanner Design