



# Metrology by pupil imaging

Mike Adel, March 2014



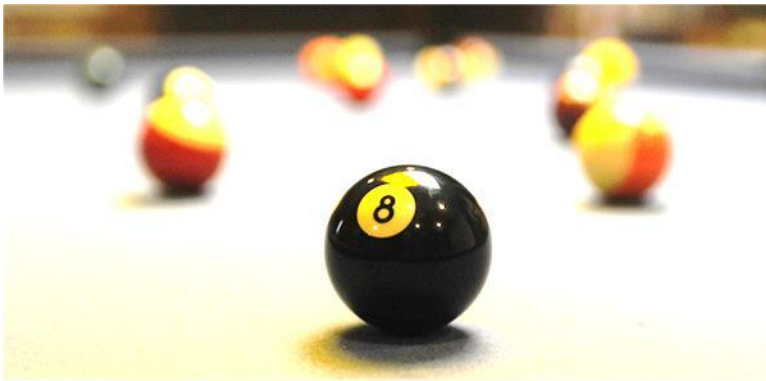
# Outline

- The pupil
  - Animal kingdom
  - Optics
- Pupil imaging
  - Optical architecture
  - The Fourier domain
- Overlay metrology by pupil imaging
  - What is overlay?
  - Target architecture
  - Quantification

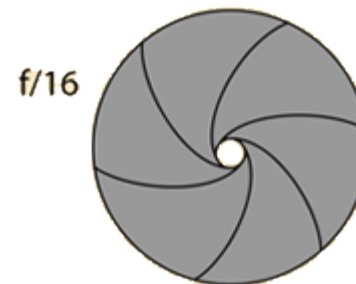
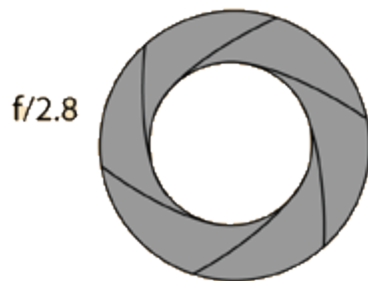
# Evolution has generated diversity in pupil structure.



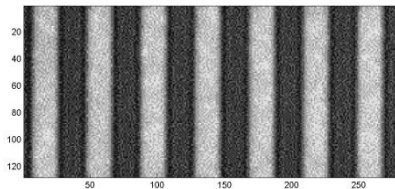
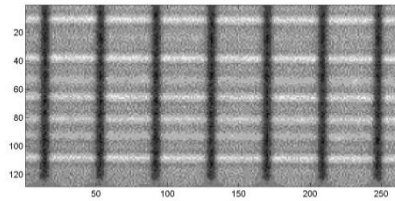
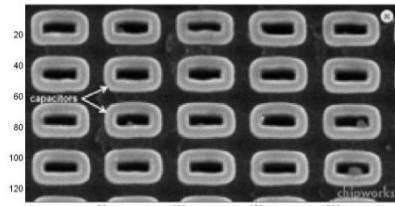
# The pupil means many things



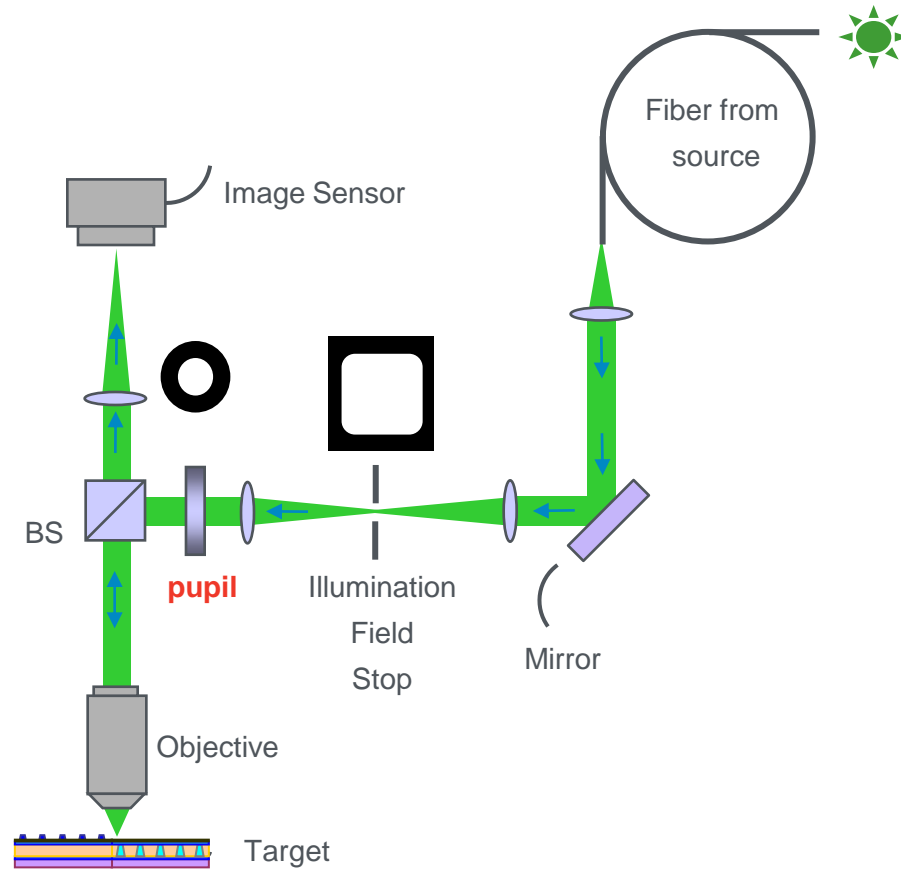
Exposure vs Depth of field



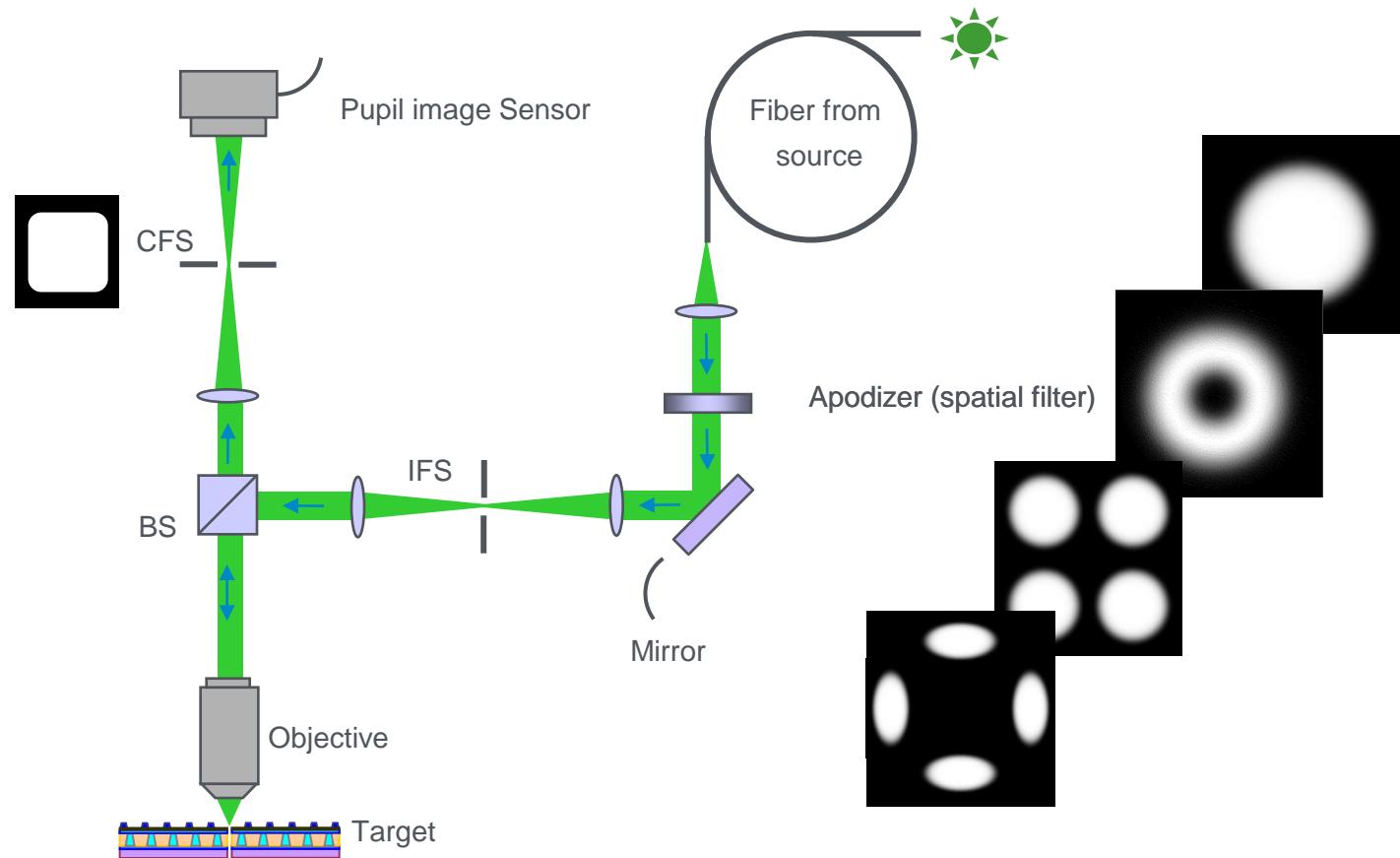
# What happens when we put the image sensor in the pupil?



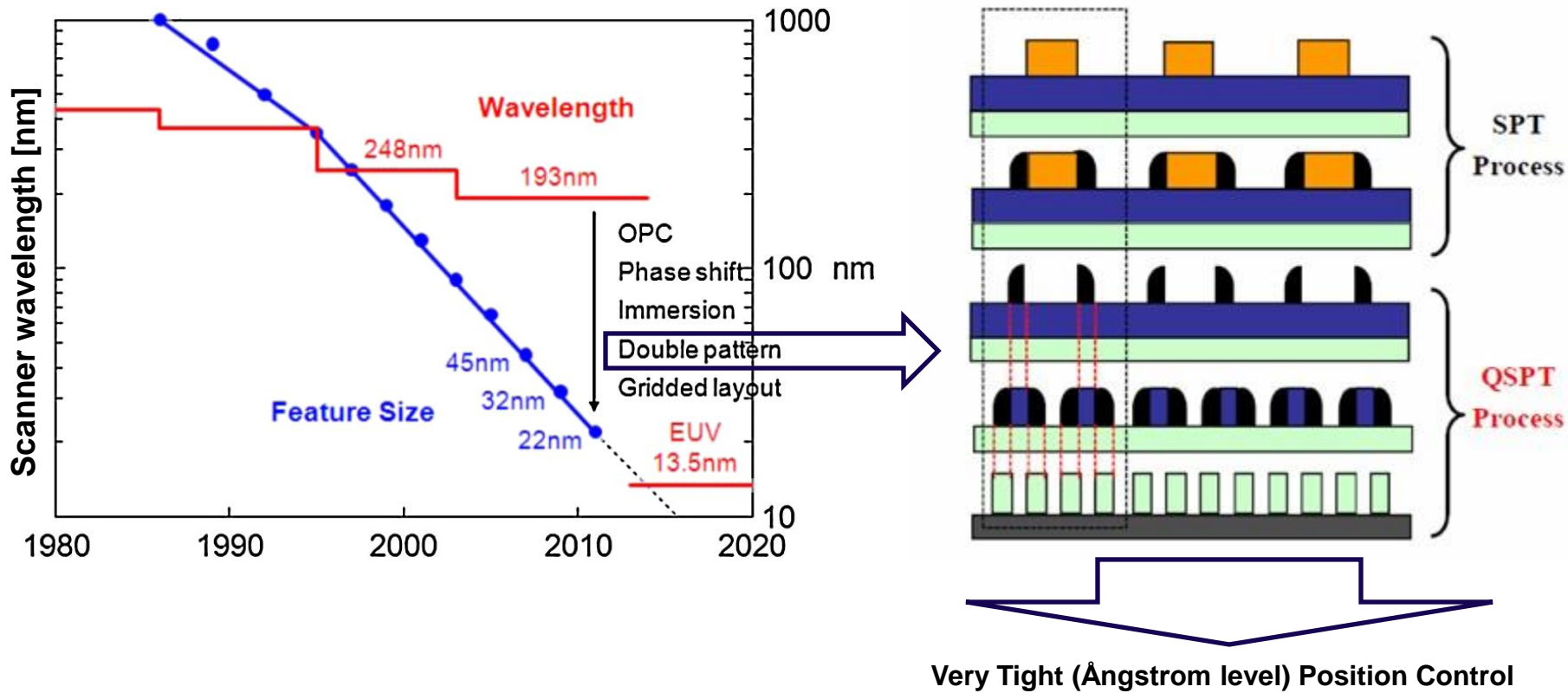
# Field imaging architecture



# Pupil imaging architecture



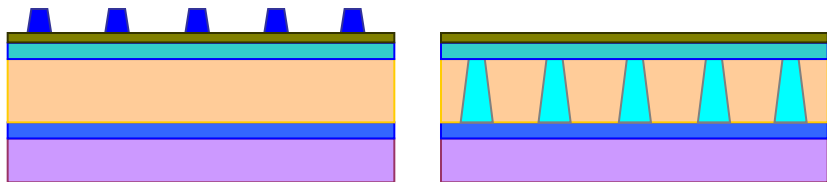
# What is overlay metrology and why is it important?



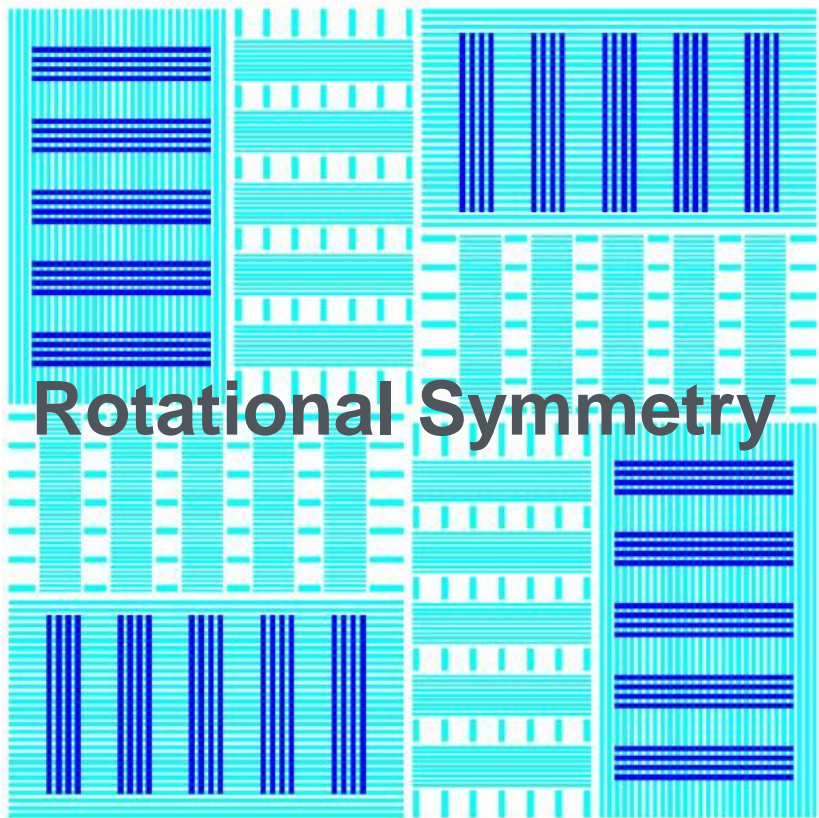
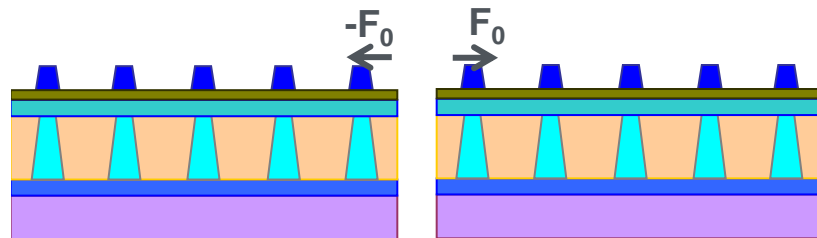


# Overlay metrology is enabled by quantification of symmetry breaking.

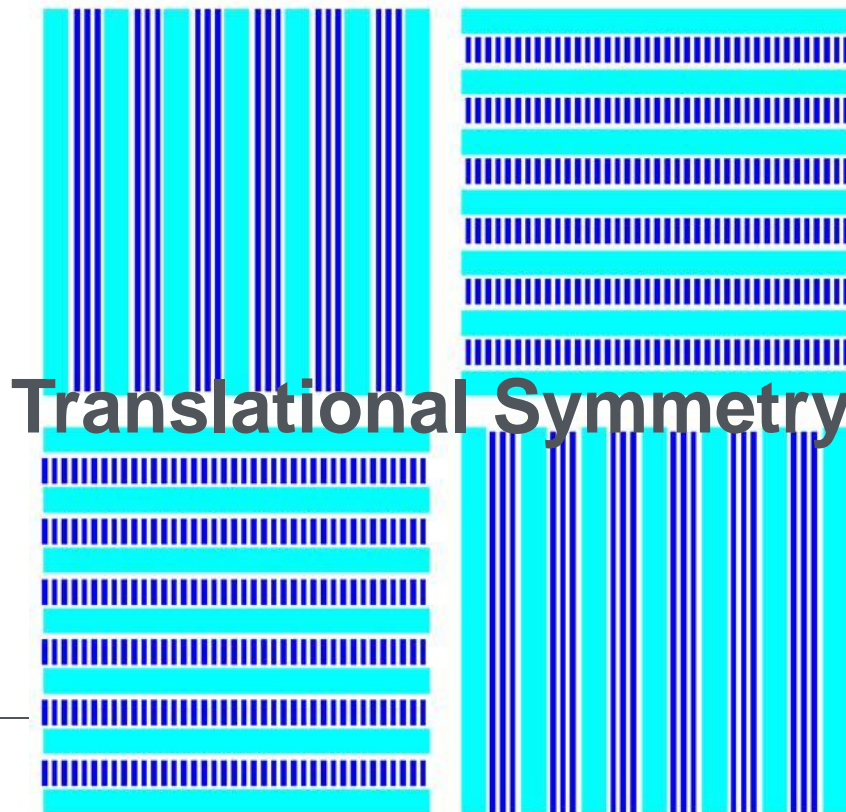
Field imaging



Pupil imaging

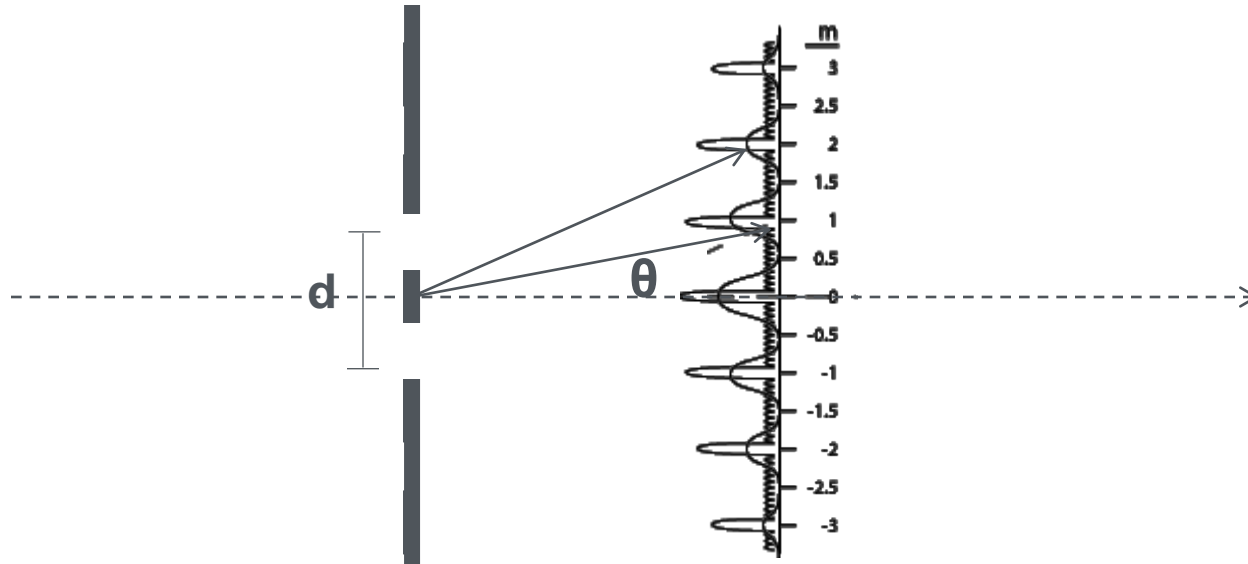


**Rotational Symmetry**



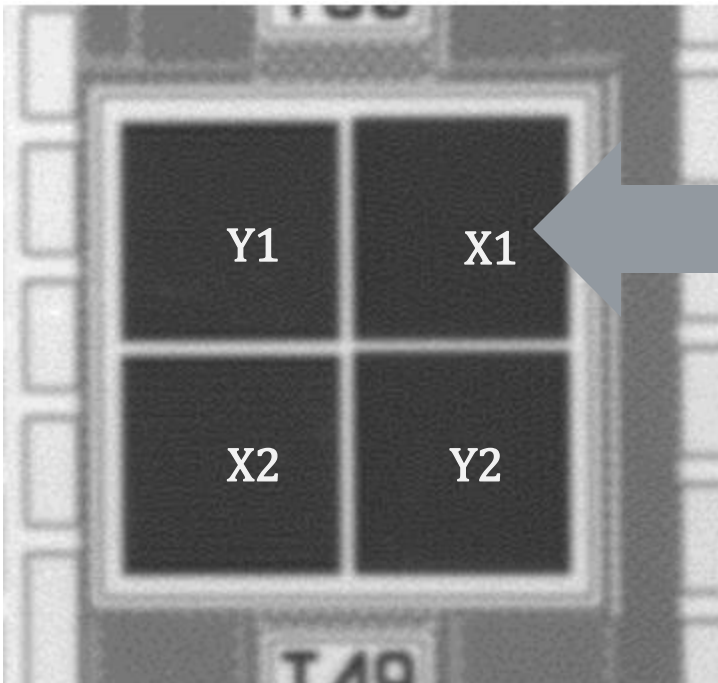
**Translational Symmetry**

# It's all about diffraction

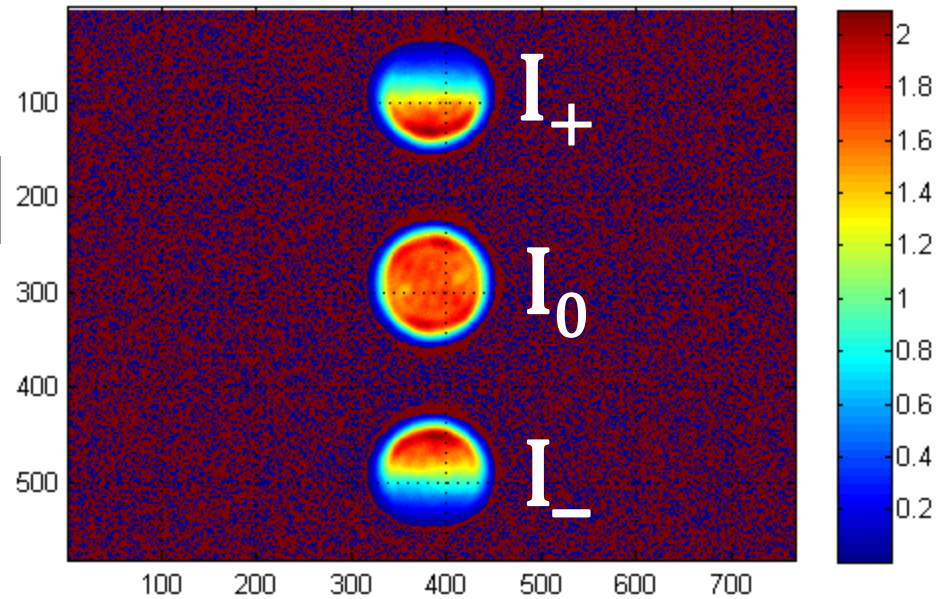


$$d \sin \theta = m \lambda$$

# For zero offset, first orders are symmetric.

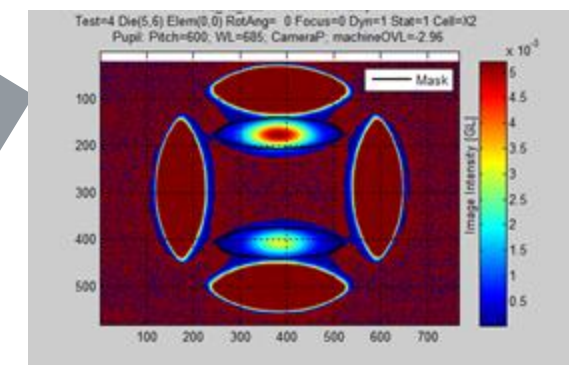
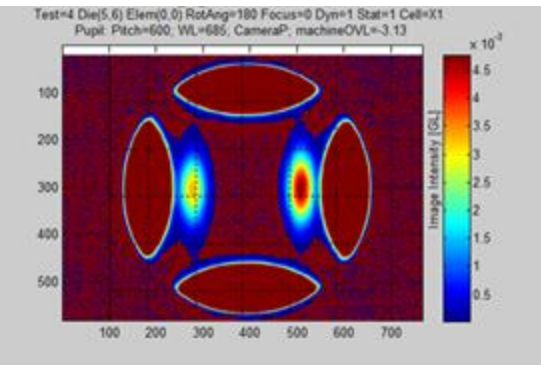
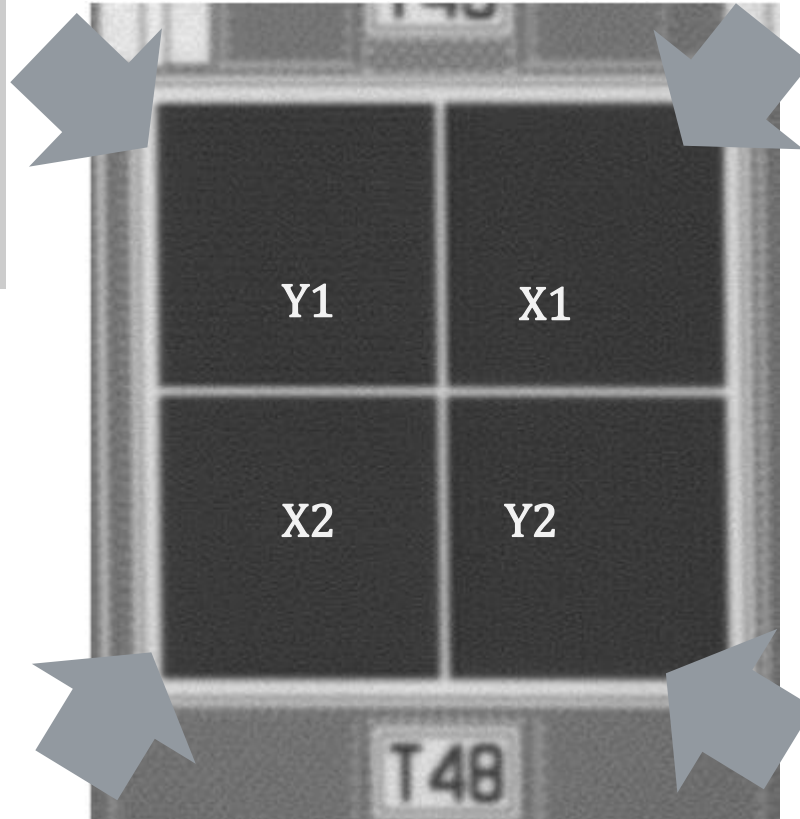
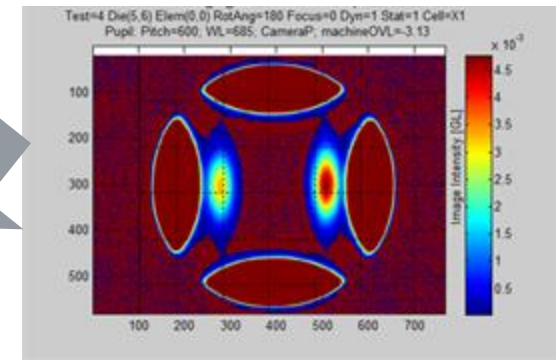
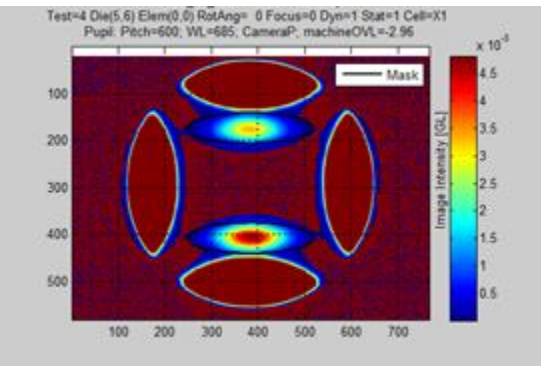


K:\MTD\REPORTS\  
1st\_order\_testing\_FEB2014\CTDrev4\Measured\  
Pitch600nm\_1to1\S\  
AROL\_X1\_121013.192017.778.api



$$A_{x1} = I_- - I_+$$

# With 4 cells, overlay can be measured in x & y



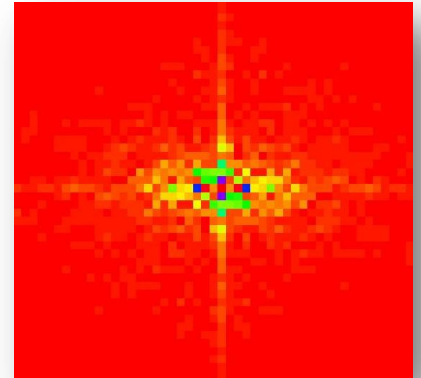
$$OVL_x \approx F_0 \frac{A_{x1} - A_{x2}}{A_{x1} + A_{x2}}$$

# Summary

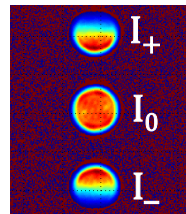
- The *pupil* has many meanings and uses in optics.



- The pupil is also a location in the optical path which enables the image to be viewed in the *Fourier domain*.



- Overlay metrology is enabled by pupil imaging of *overlaid* periodic structures.



- *Translational offsets* between periodic structures are required in order to quantify symmetry breaking in the pupil image.

# Thank You

Acknowledgements: Thanks to Mark Ghinovker for DFTs...

# Shorter wavelength = higher resolution

## Evolution of lithography light sources

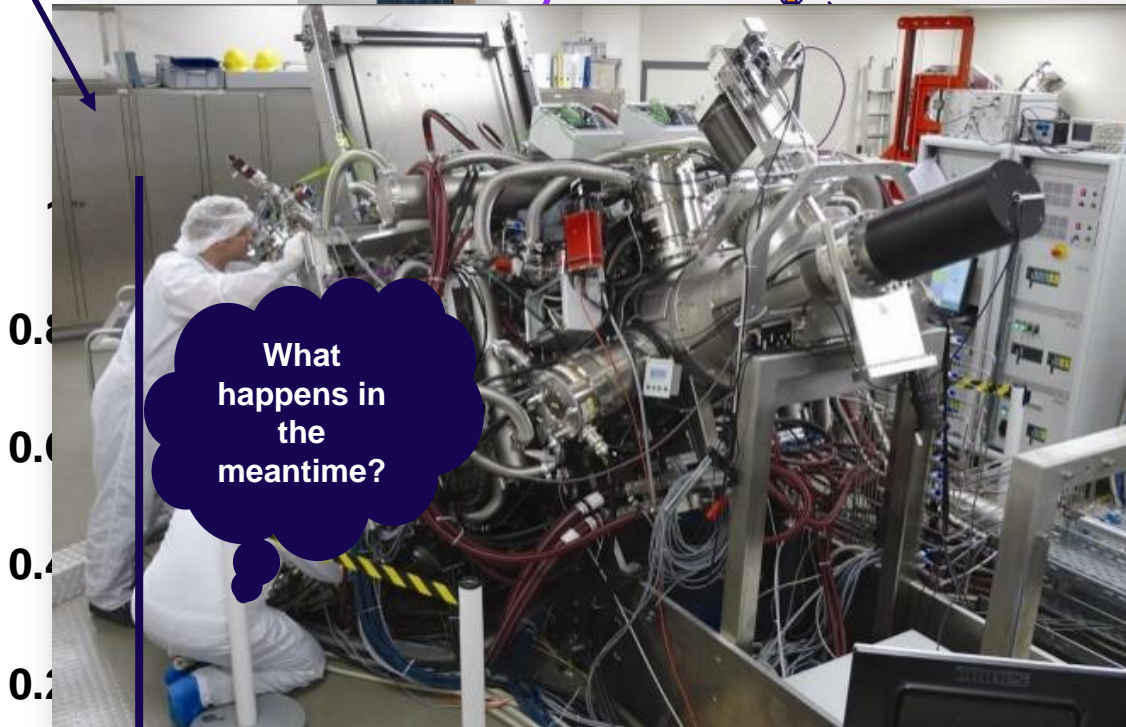
EUV light source  
~ 5m\$?  
Circa 2015?

Excimer Laser &  
beamline ~\$500k  
Circa 2005

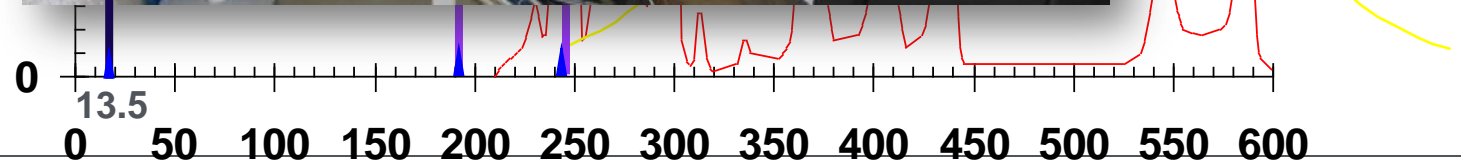
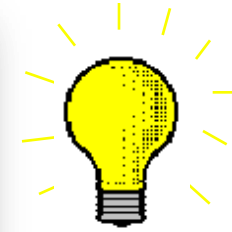
Mercury  
lamp & power  
supply ~\$5k  
Circa 1985

Tungsten filament  
light source & power  
supply ~\$500  
Circa 1965

Relative Intensity



What happens in the meantime?



Wavelength (nm)