Engineering of Semiconductor

:Semiconductor Physics and Devices

Chapter 2. Silicon Technology

Objectives

Overview of Silicon Technology

- Wafer preparation
- Oxidation
- Lithography
- Etching
- Doping
- Deposition
- Packaging

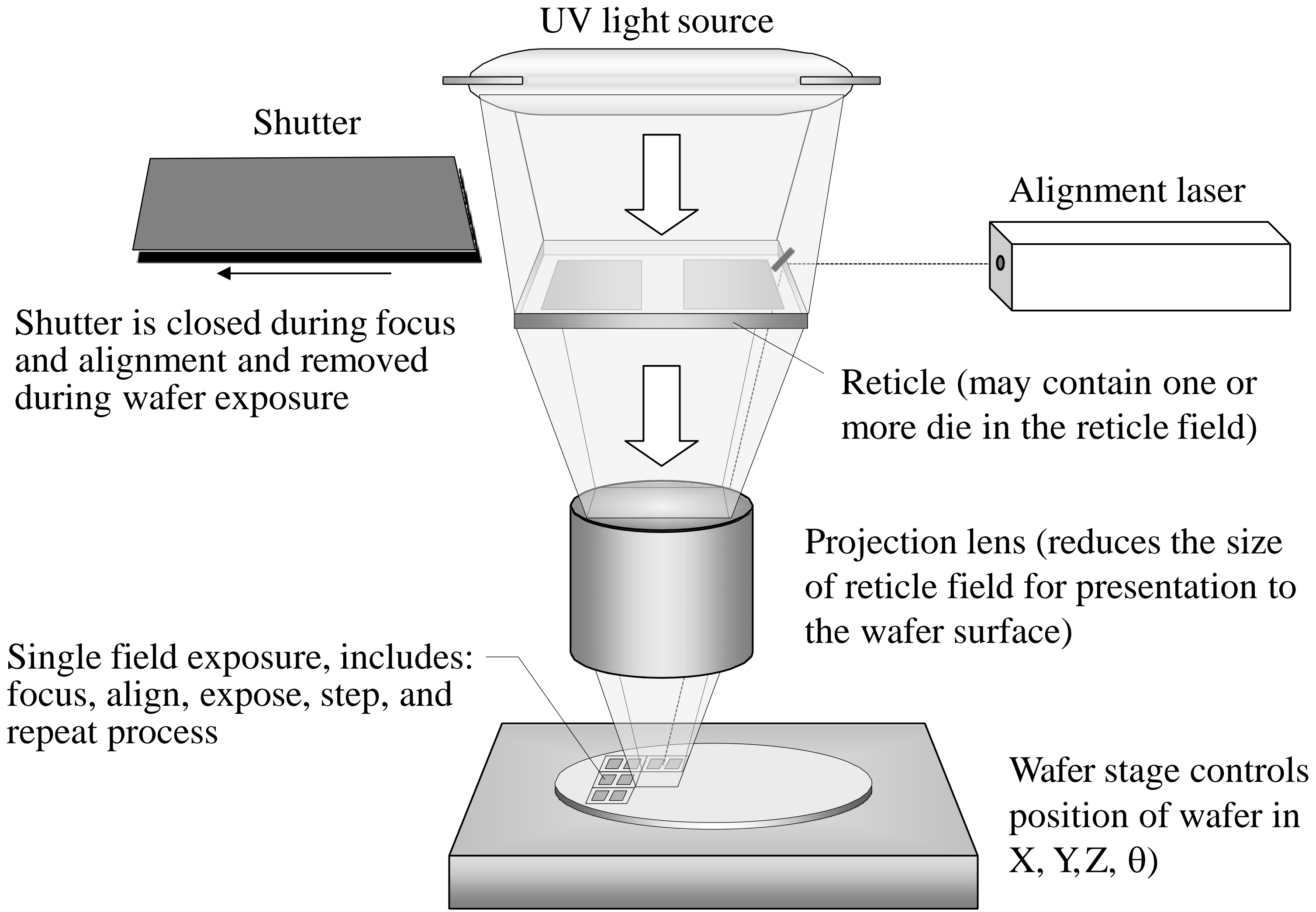
Eight Basic Steps of Photolithography

Step
1. Vapor prime
2. Spin coat
3. Soft bake
4. Alignment and exposure
5. Post-exposure bake
6. Develop
7. Hard bake
8. Develop inspect

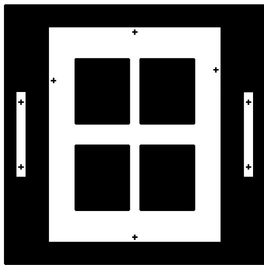
Three Functions of the Wafer Stepper

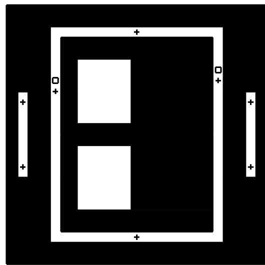
1. Focus and align the quartz plate reticle (that has the patterns) to the wafer surface.
2. Reproduce a high-resolution reticle image on the wafer through exposure of photoresist.
3. Produce an adequate quantity of acceptable wafers per unit time to meet production requirements.

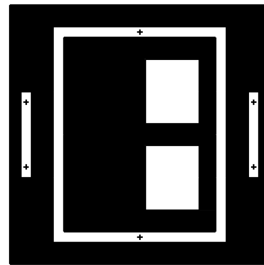
Reticle Pattern Transfer to Resist

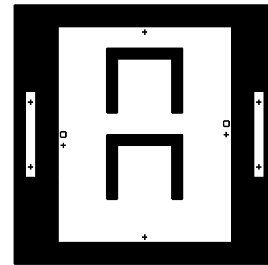


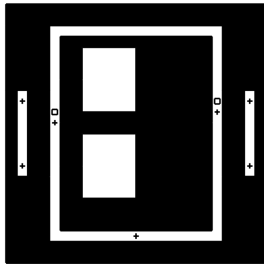
Layout and Dimensions of Reticle Patterns

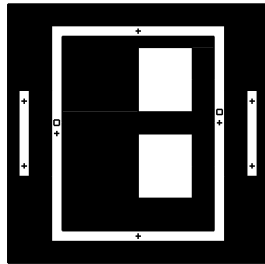

1) STI etch

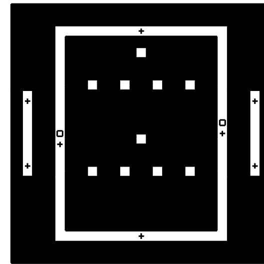

2) P-well implant

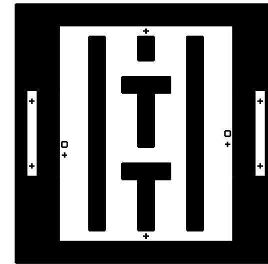

3) N-well implant


4) Poly gate etch

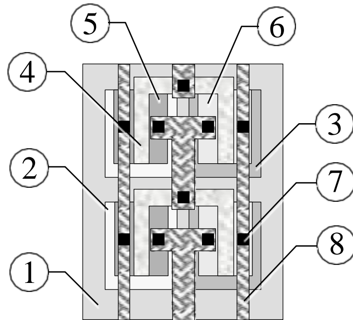

5) N^+ S/D implant


6) P^+ S/D implant

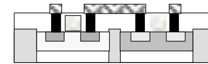

7) Oxide contact etch


8) Metal etch

Resulting layers



Top view


Cross section

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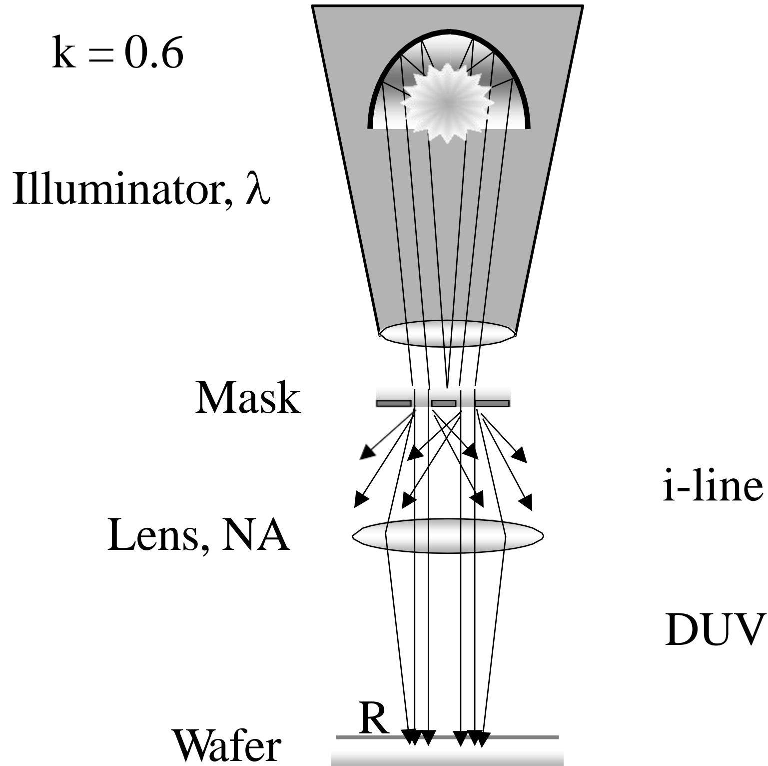
Resolution

- Calculating Resolution
- Depth of Focus
- Resolution Versus Depth of Focus
  - Surface Planarity

Resolution of Features

The dimensions of linewidths and spaces must be equal. As feature sizes decrease, it is more difficult to separate features from each other.

Calculating Resolution for a given λ, NA and k

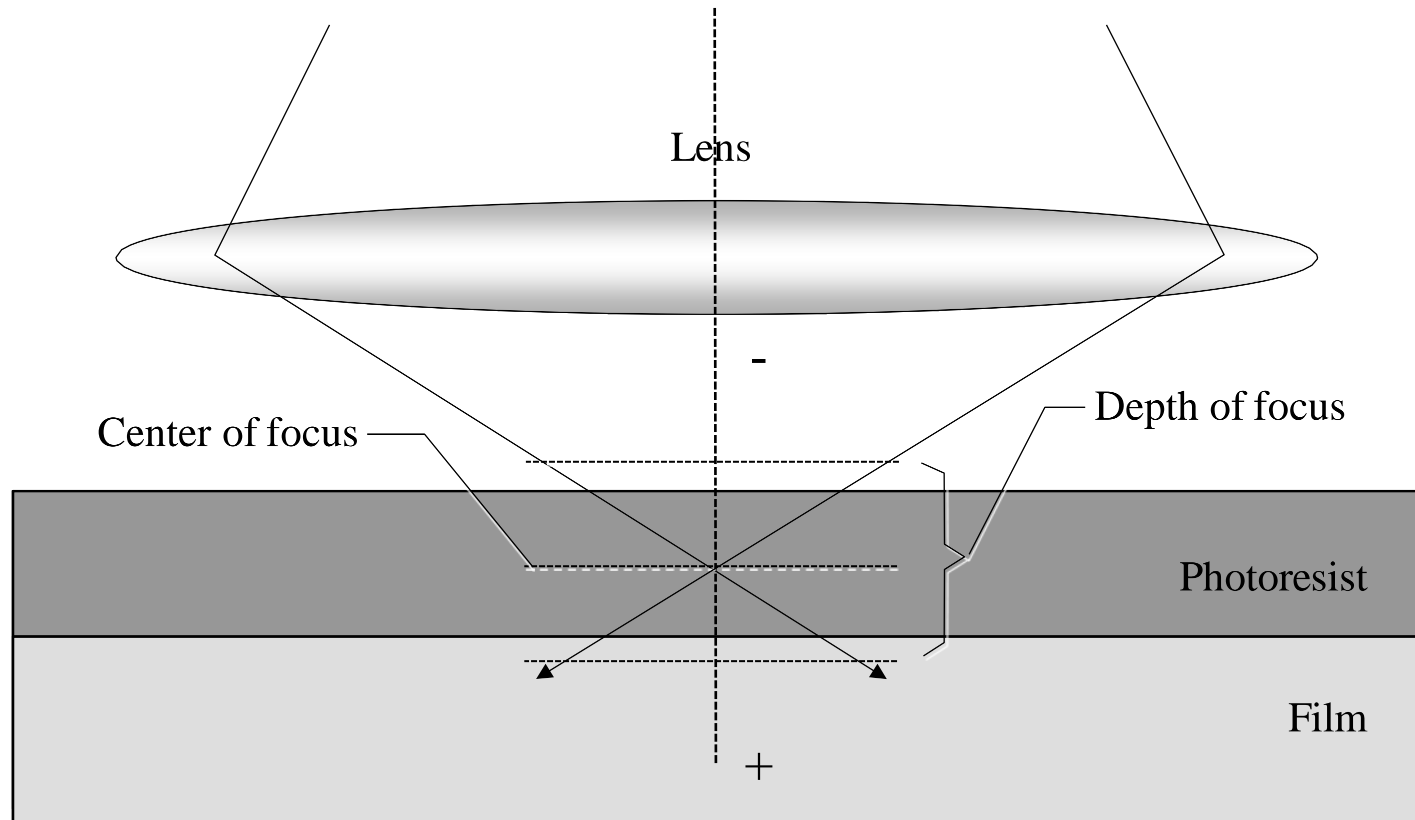


$$R = \frac{k\,\lambda}{NA}$$

	λ	NA	R
i-line	365 nm	0.45	486 nm
	365 nm	0.60	365 nm
DUV	193 nm	0.45	257 nm
	193 nm	0.60	193 nm

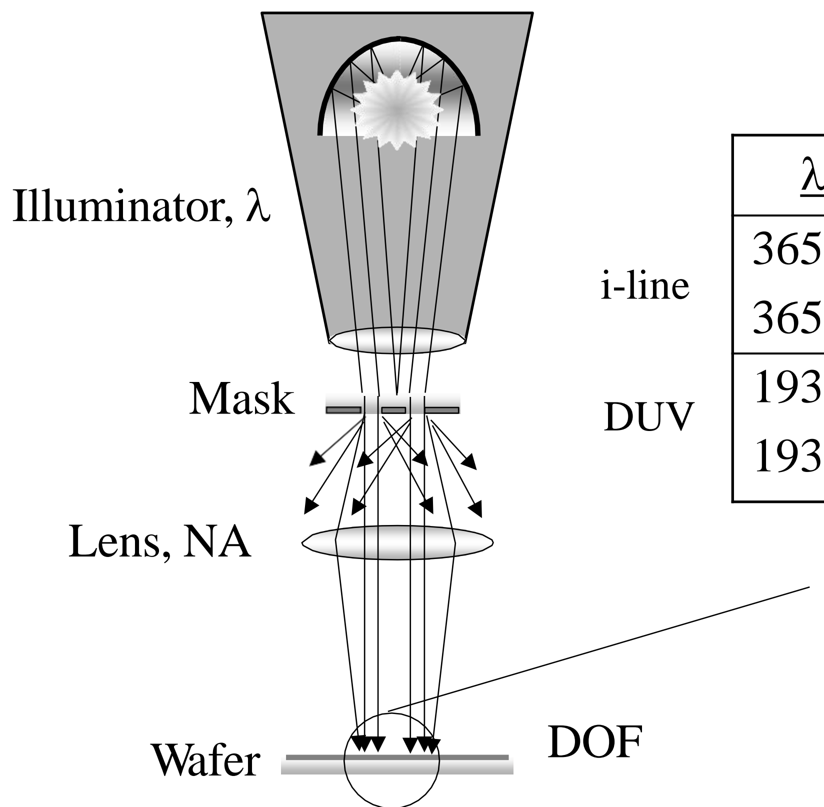
Numerical Aperture(NA):
In optics, the numerical aperture (NA) of an optical system is a dimensionless number that characterizes the range of angles over which the system can accept or emit light.

Depth of Focus (DOF)

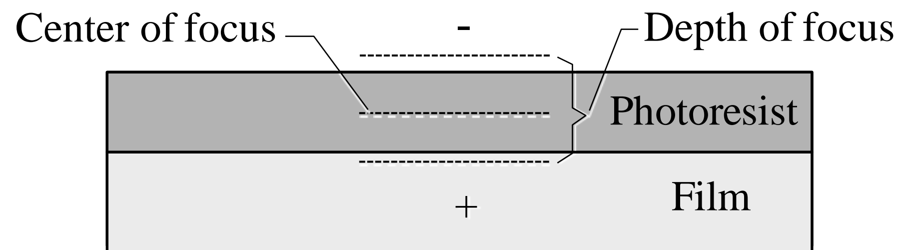


Resolution Versus Depth of Focus for Varying NA

$$DOF = \frac{\lambda}{2(NA)^2}$$



	λ	NA	R	DOF
i-line	365 nm	0.45	486 nm	901 nm
	365 nm	0.60	365 nm	507 nm
DUV	193 nm	0.45	257 nm	476 nm
	193 nm	0.60	193 nm	268 nm



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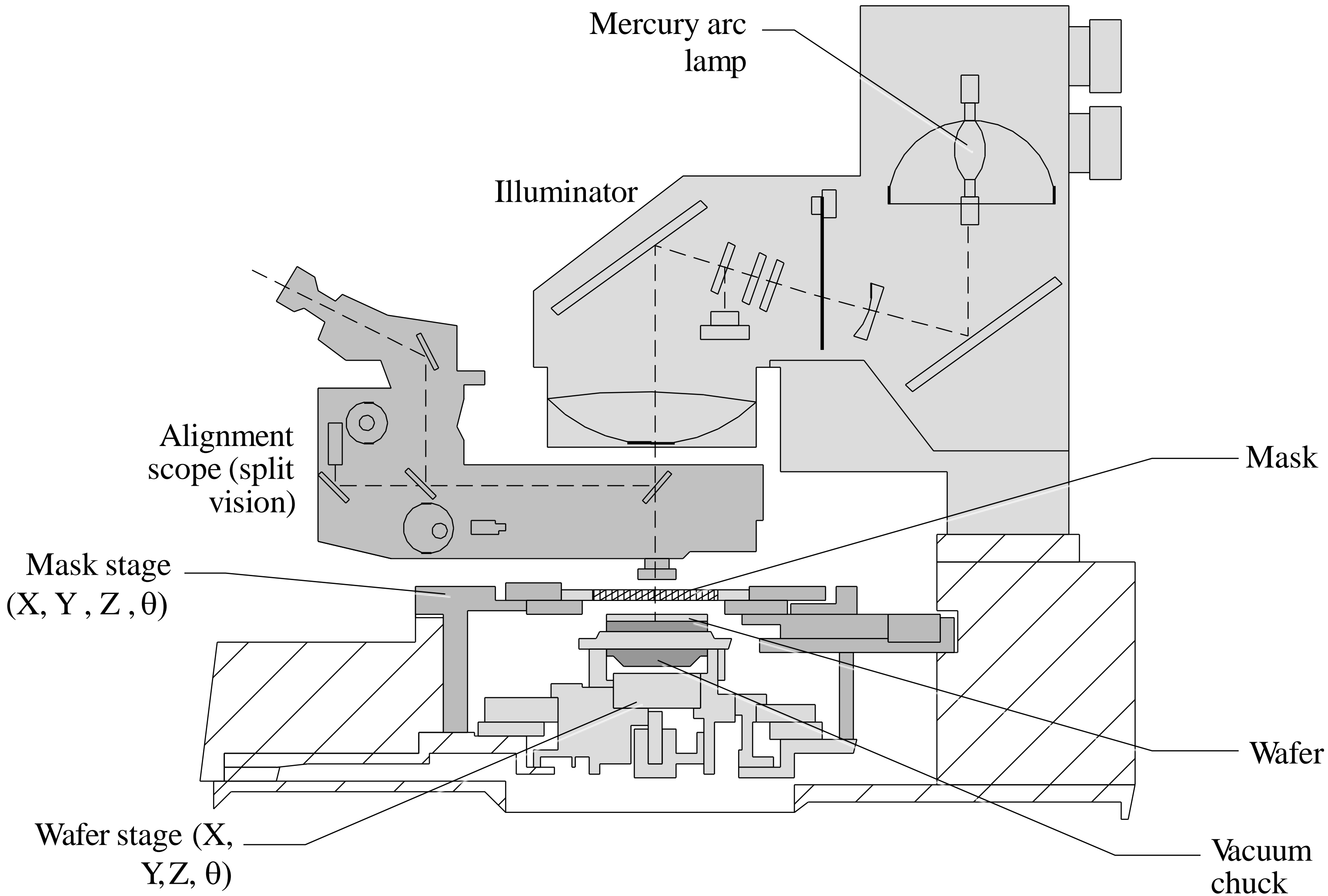
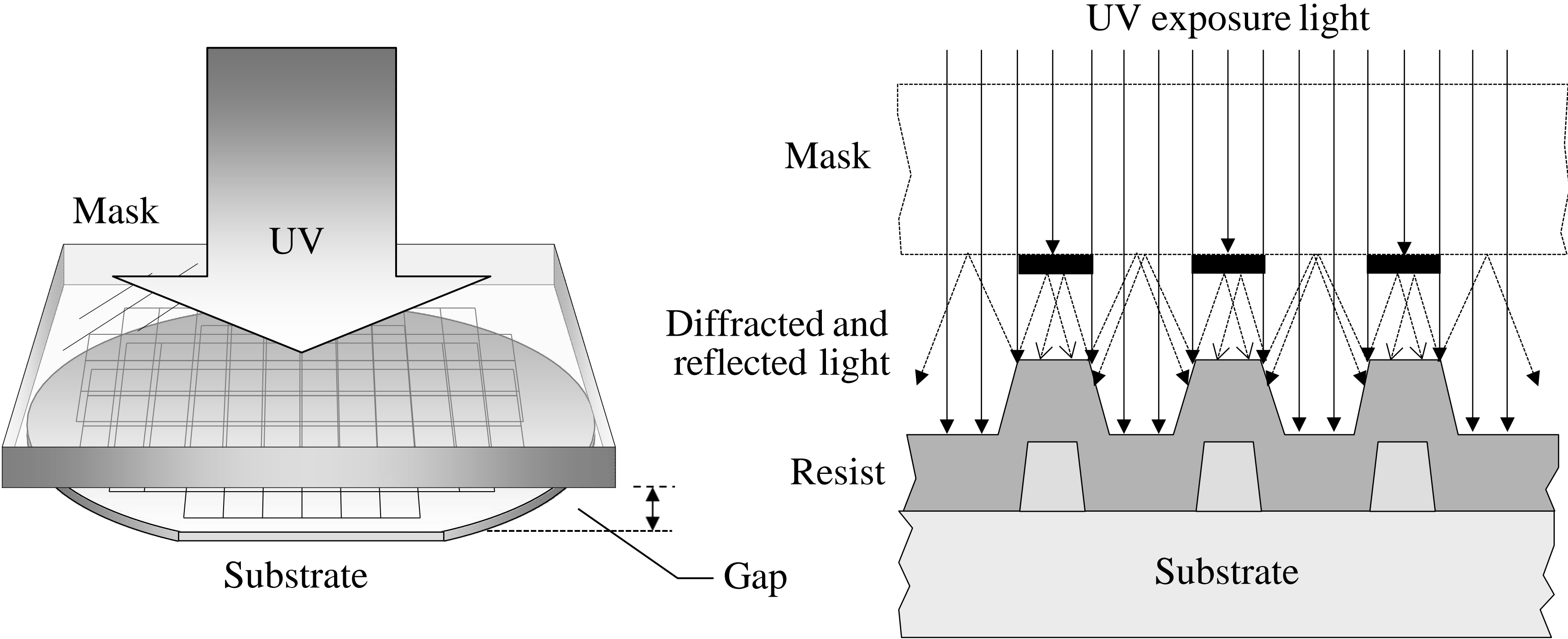
Photolithograhy Equipment

- Contact Aligner
- Proximity Aligner
- Scanning Projection Aligner (scanner)
- Step-and-Repeat Aligner (stepper)
- Step-and-Scan System

Contact/Proximity Aligner System

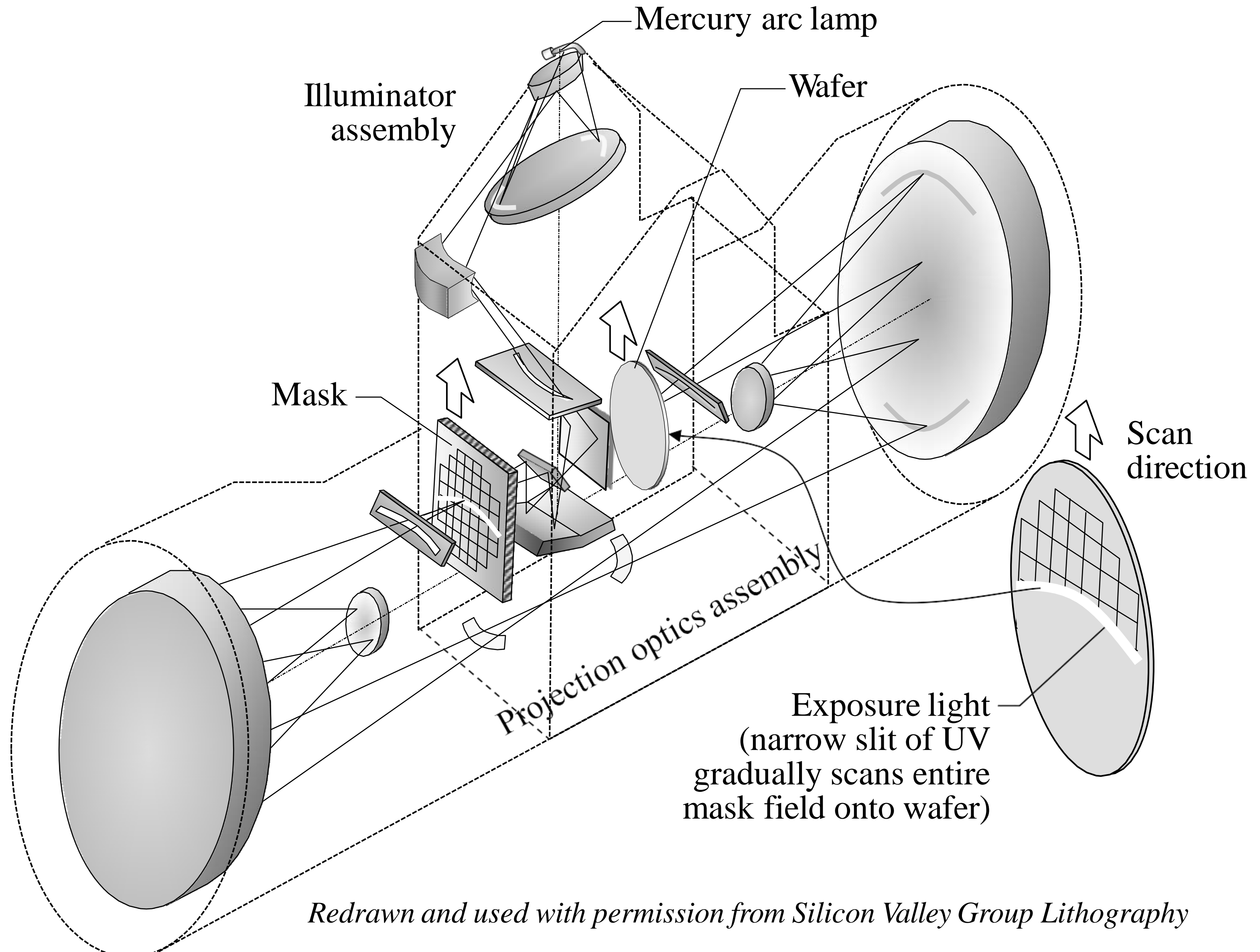


Edge Diffraction and Surface Reflectivity on Proximity Aligner



Diffraction of light on edges results in reflections from underside of mask causing undesirable resist exposure.

Scanning Projection Aligner



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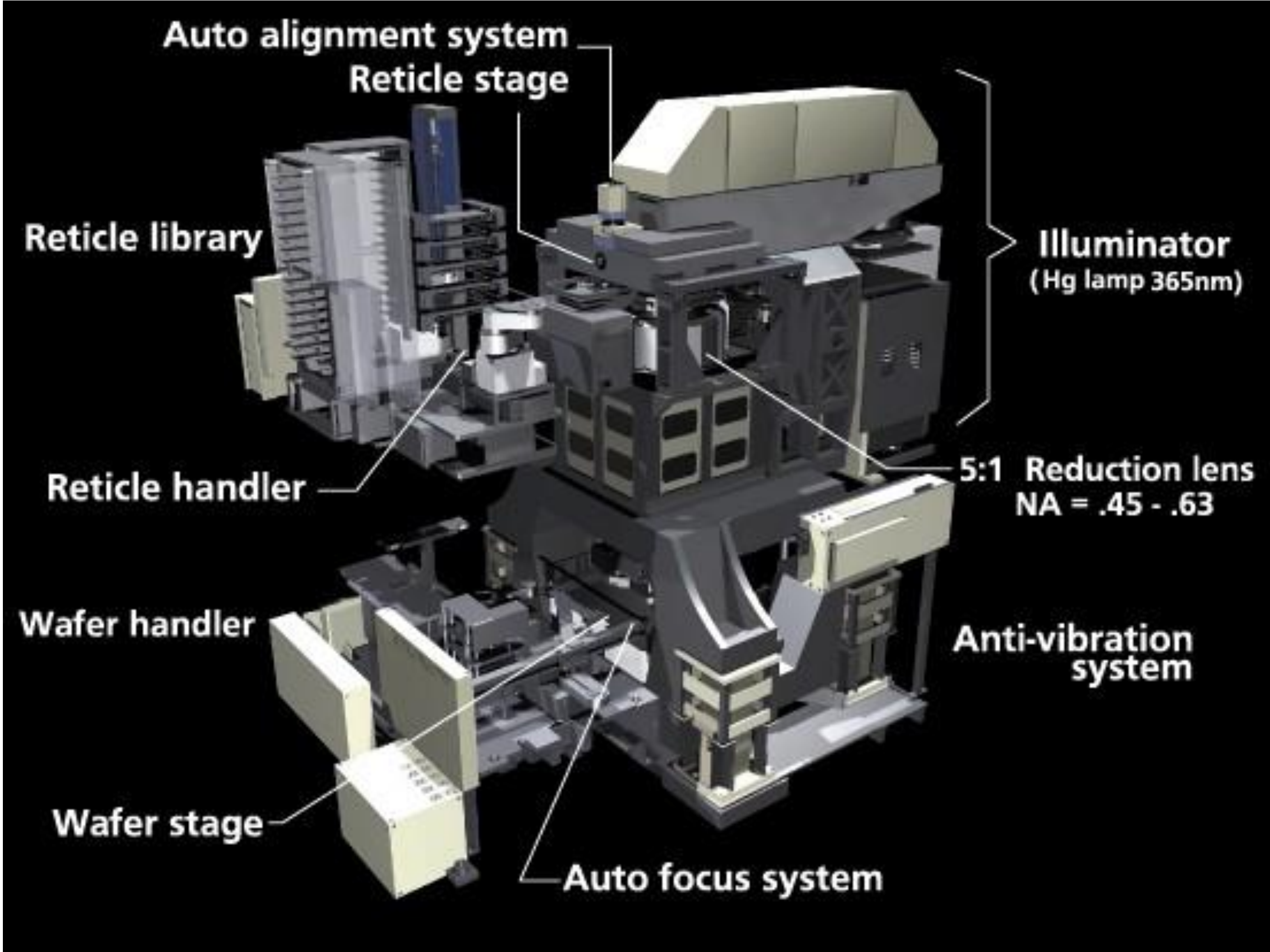
Step-and-Repeat Aligner (Stepper)



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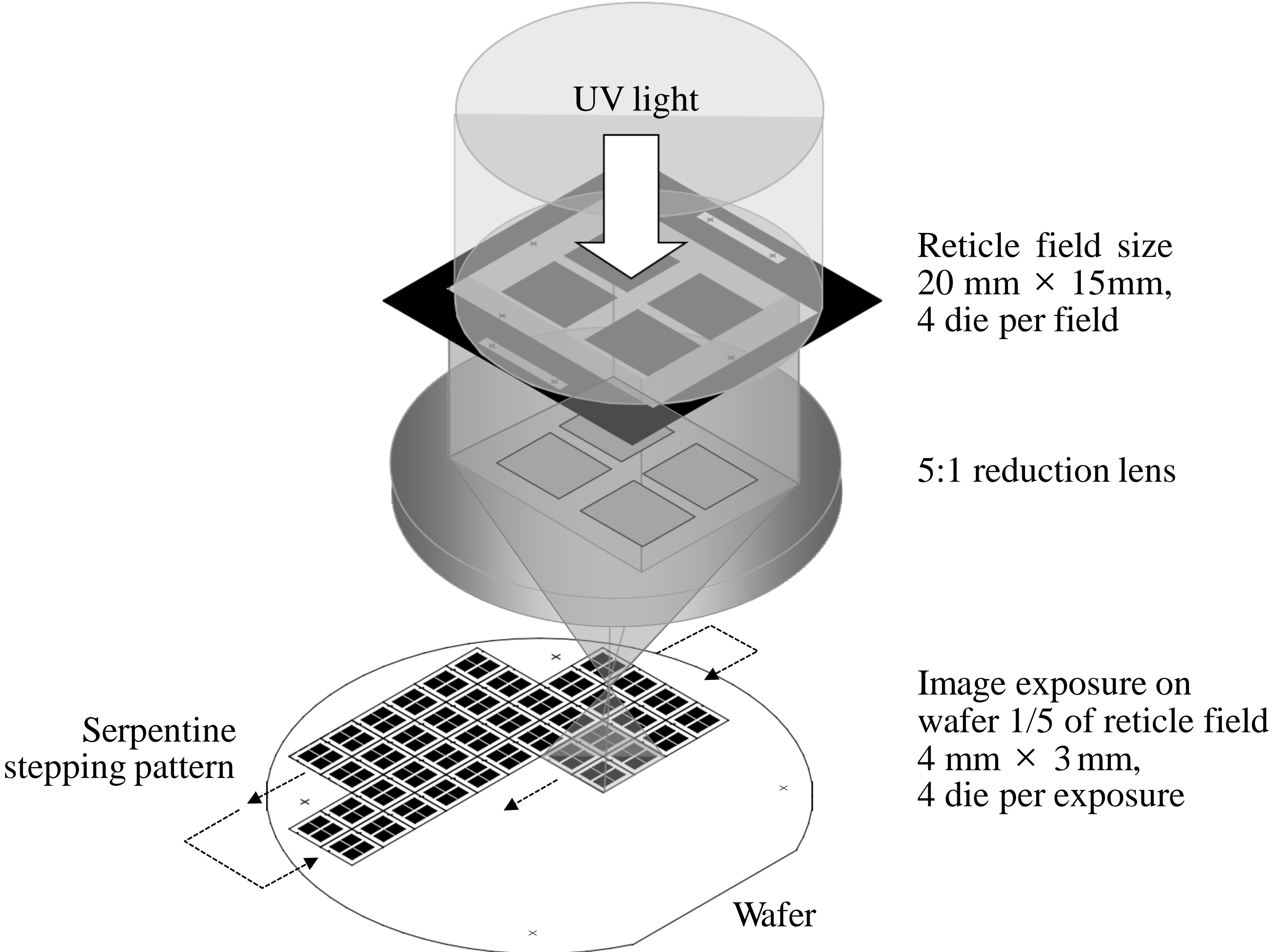
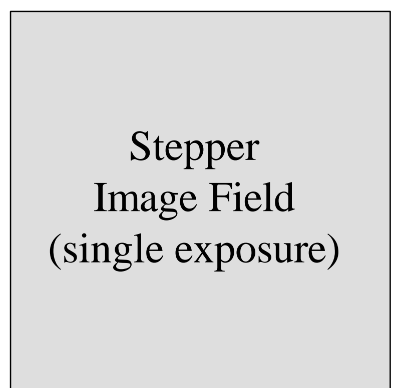
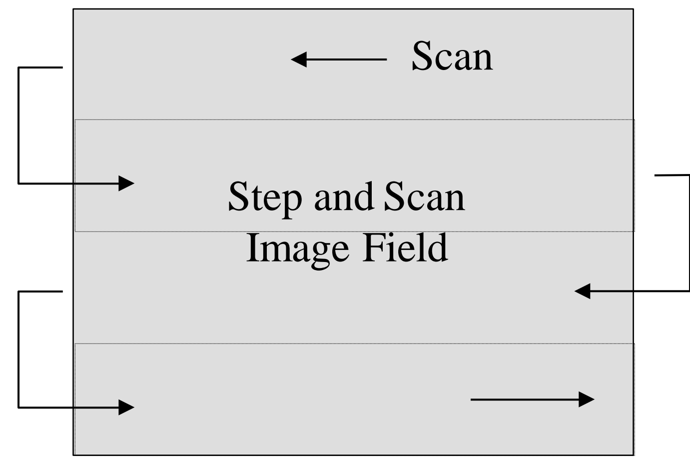
(original drawing by FG2, Austin, TX)

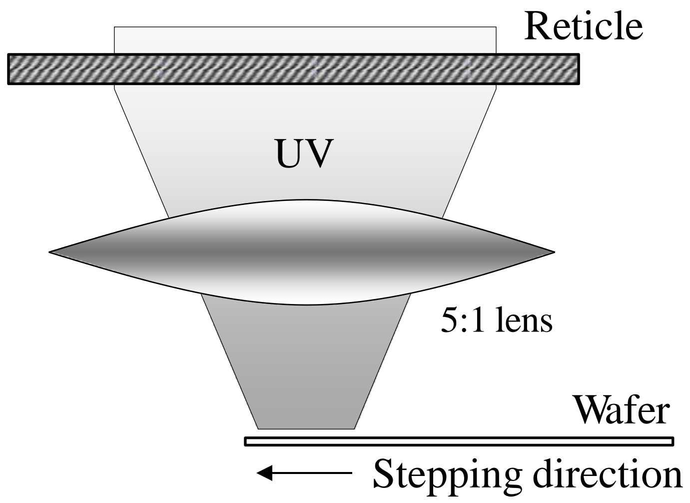
Stepper Exposure Field

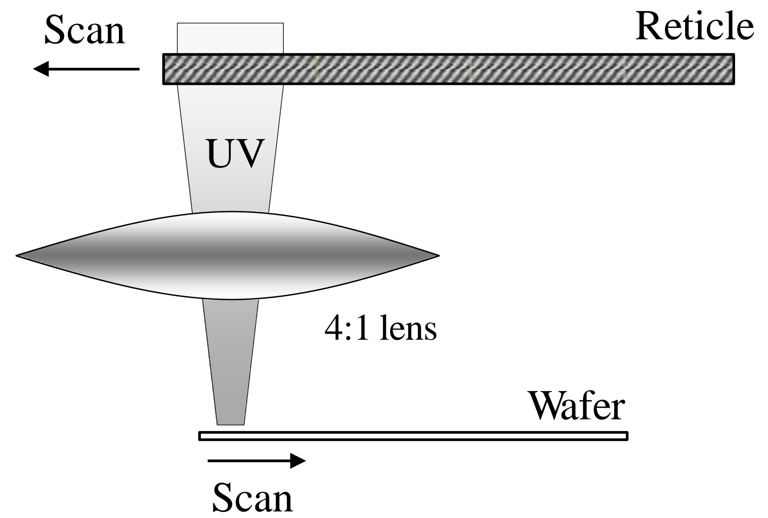


Wafer Exposure Field for Step-and-Scan









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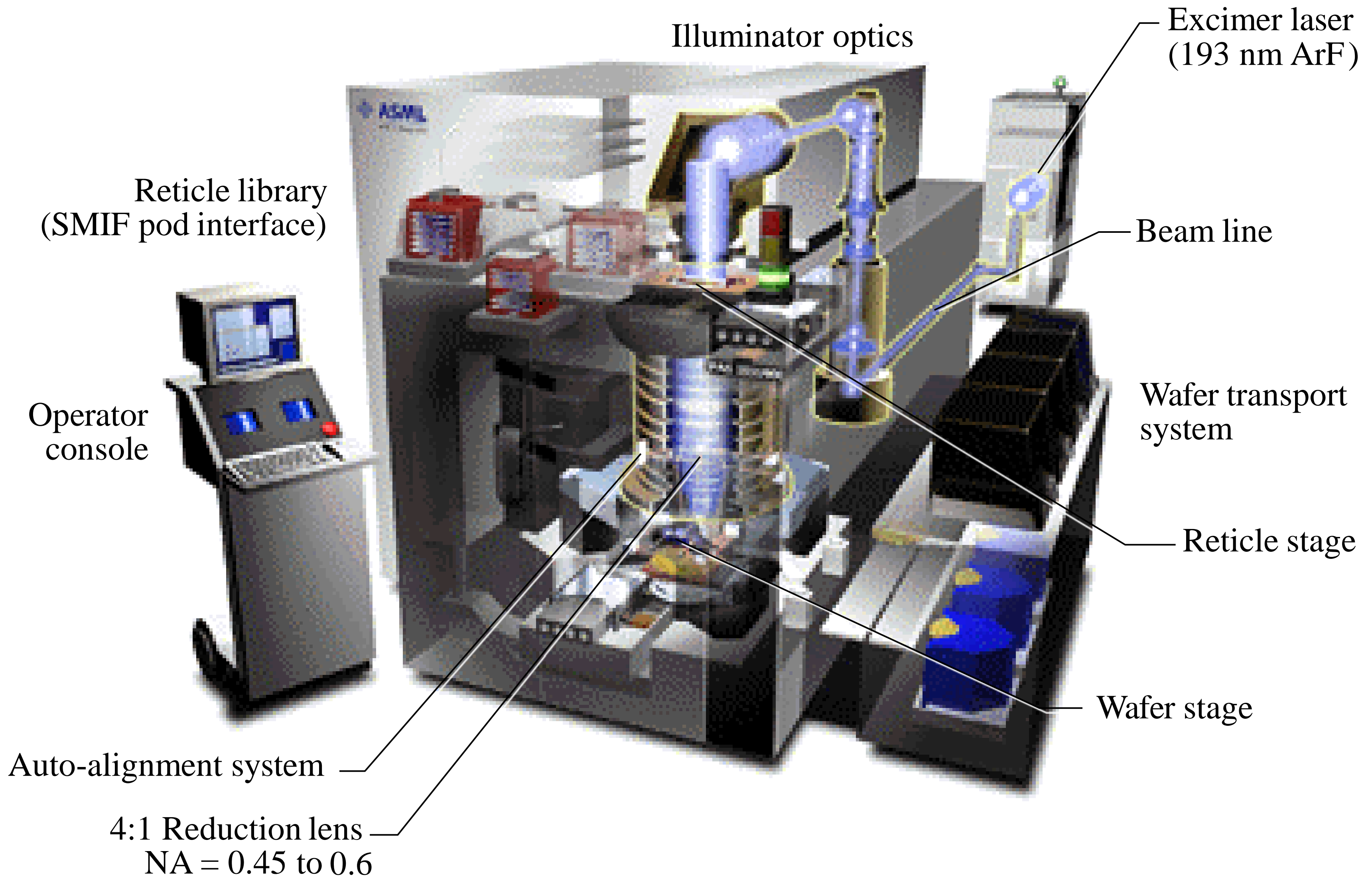
Step and Scan Exposure System



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Alignment

- Baseline Compensation
- Overlay Accuracy
- Alignment Marks
- Types of Alignment

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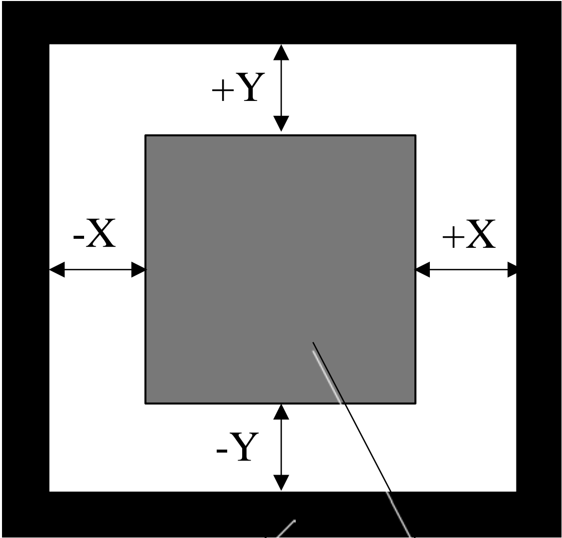
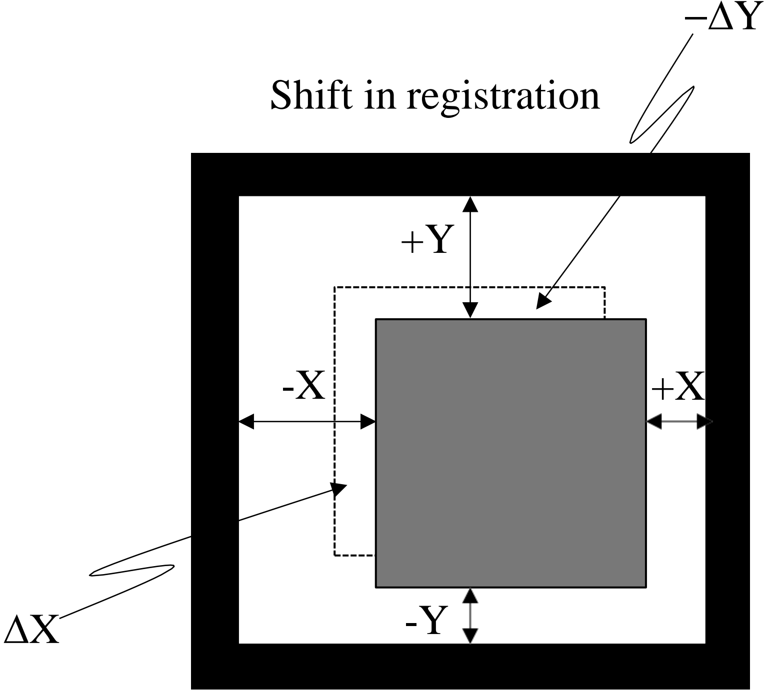
Overlay Budget

Perfect overlay accuracy

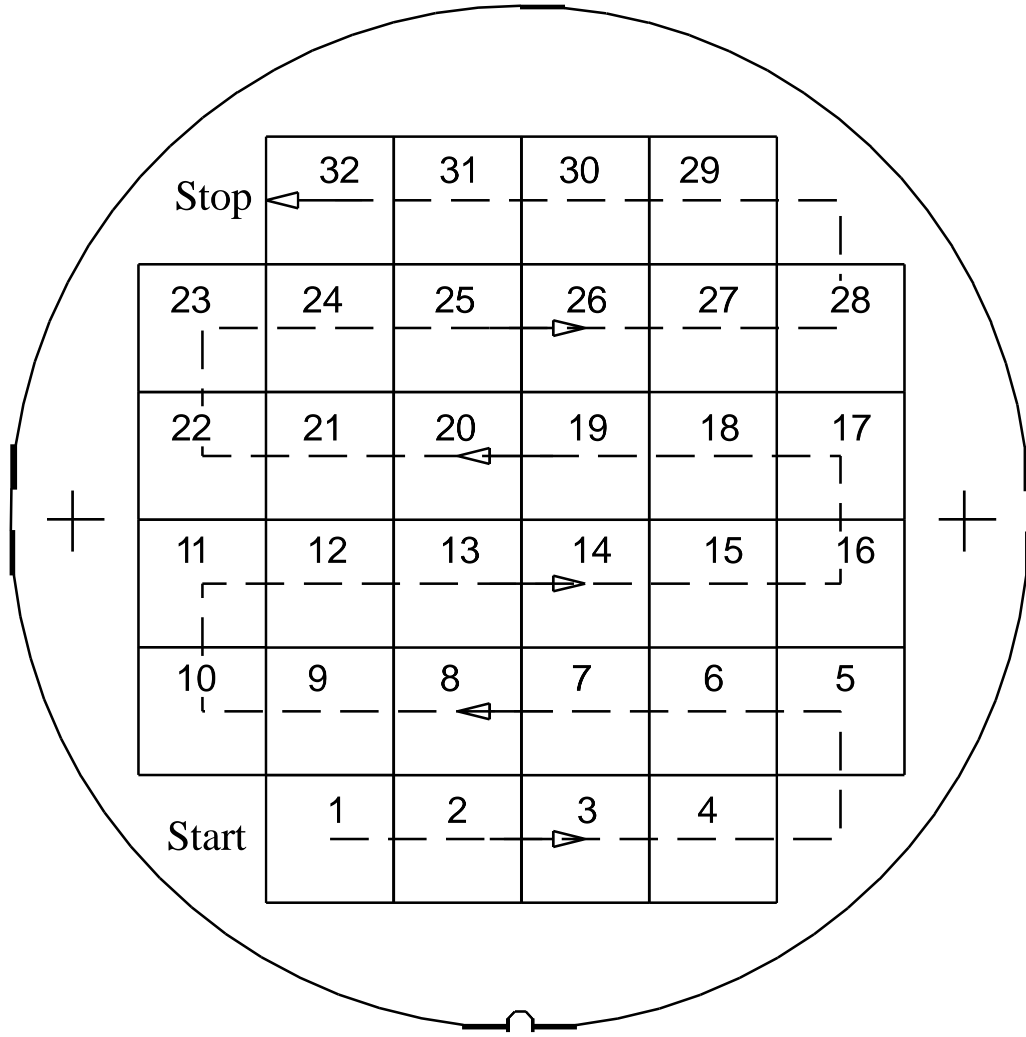




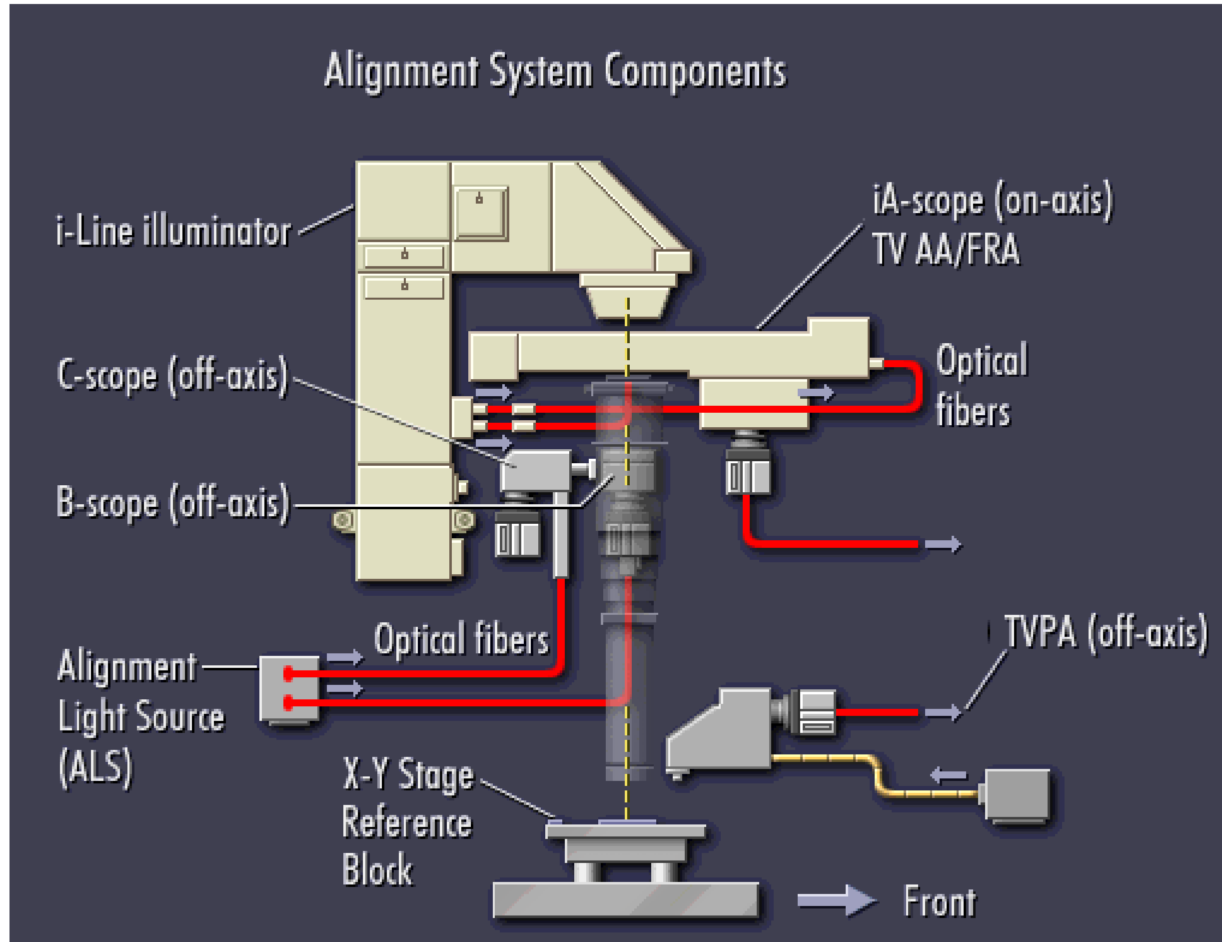
Reticle pattern

Wafer pattern

Grid of Exposure Fields on Wafer



Step-and-Repeat Alignment System



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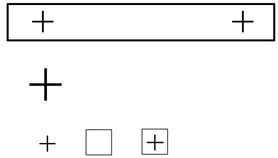
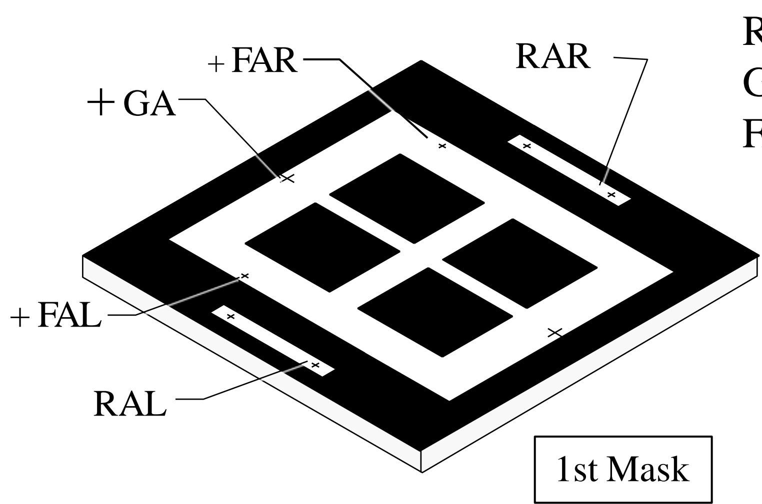
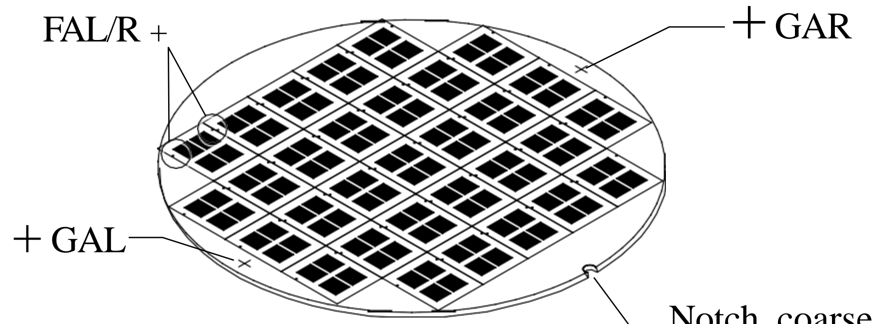
Alignment Marks

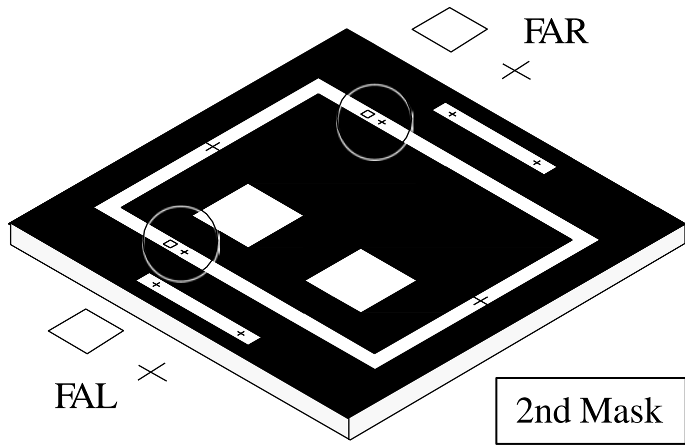
RA, Reticle alignment marks, L/R
GA, Wafer global alignment marks, L/R
FA, Wafer fine alignment marks, L/R

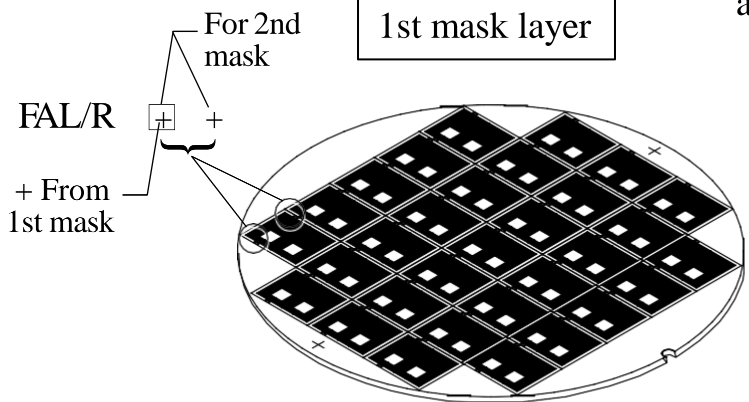






1st mask layer





2nd mask layer

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Environmental Conditions

- Temperature
- Humidity
- Vibration
- Atmospheric Pressure
- Particle Contamination

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