Joint Requirements

ASML, Canon, Nikon

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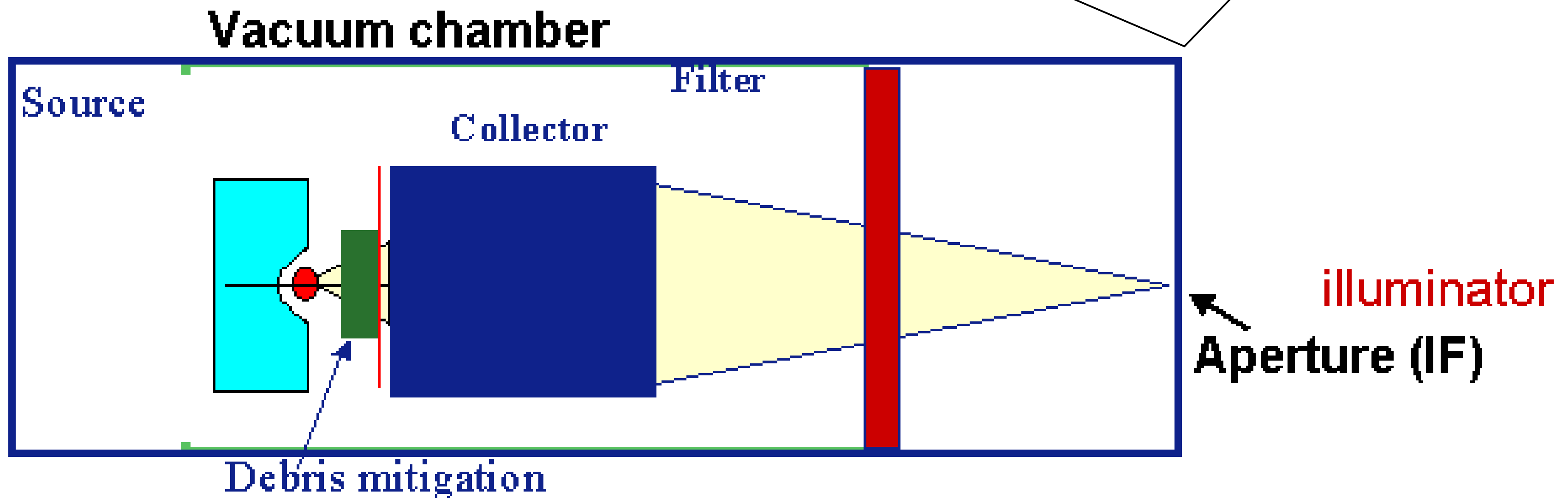
Definition of clean photon spot at intermediate focus (IF)

Source specifications are defined at intermediate focus (IF) which is illuminator entrance



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Joint Requirements for EUV Source

SOURCE CHARACTERISTIC	REQUIREMENT
•Wavelength	13.5 [nm]
•EUV Power (in-band)	115 [W] *
•Repetition Frequency	> 7-10 kHz ***
•Integrated Energy Stability	±0.3%, 3σ over 50 pulses
•Source Cleanliness	≥ 30,000 hours **
•Etendue of Source Output	max 3.3 mm²sr ***
•Max. solid angle input to illuminator	0.03 - 0.2 [sr] ***
•Spectral Purity:	
130-400 [nm] (DUV/UV)	≤ 3 - 7% ***
≥ 400 [nm] (IRVis) at Wafer	TBD ***

*** At IF**
**** After IF**
***** Design dependent**

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ASML

Canon

Introduction of a book on EUV Sources for Lithography

1. Source Power
2. Repetition Frequency
3. Influence of the source on imaging
4. Etendue of Source Output and Positioning Stability
5. Spectral Purity Cost of Ownership

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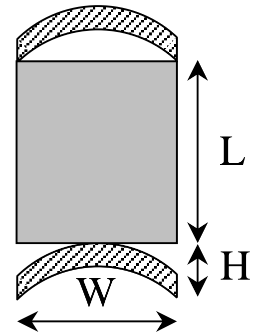
Source Power Requirement

- A wafer throughput model is introduced.

$$T = T_{scan} * N + T_{oh} = N\,(\,t_{acc} + t_{settle} + t_{exp} + t_{settle} + t_{dec}\,) + T_{oh}$$

$$= N \left(\frac{2P}{a_w * W * R} + 2t_{settle} + \frac{(L+H) * W * R}{P} \right) + T_{oh}$$



T_{scan}: scanning time per field, N: field number per wafer,

T_{oh}: overhead time (wafer exchange, wafer alignment, ...),

t_{acc}: acceleration time, t_{dec}: deceleration time, t_{exp}: field exposure time

t_{settle}: stage settling time (after accelerating and before decelerating)

P: EUV intensity on wafer, a_w: acceleration of wafer stage,

W: field width, L: field height, H: arc height + slit, R: photoresist sensitivity

- Relationship between the wafer throughput and reticle stage acceleration is considered.

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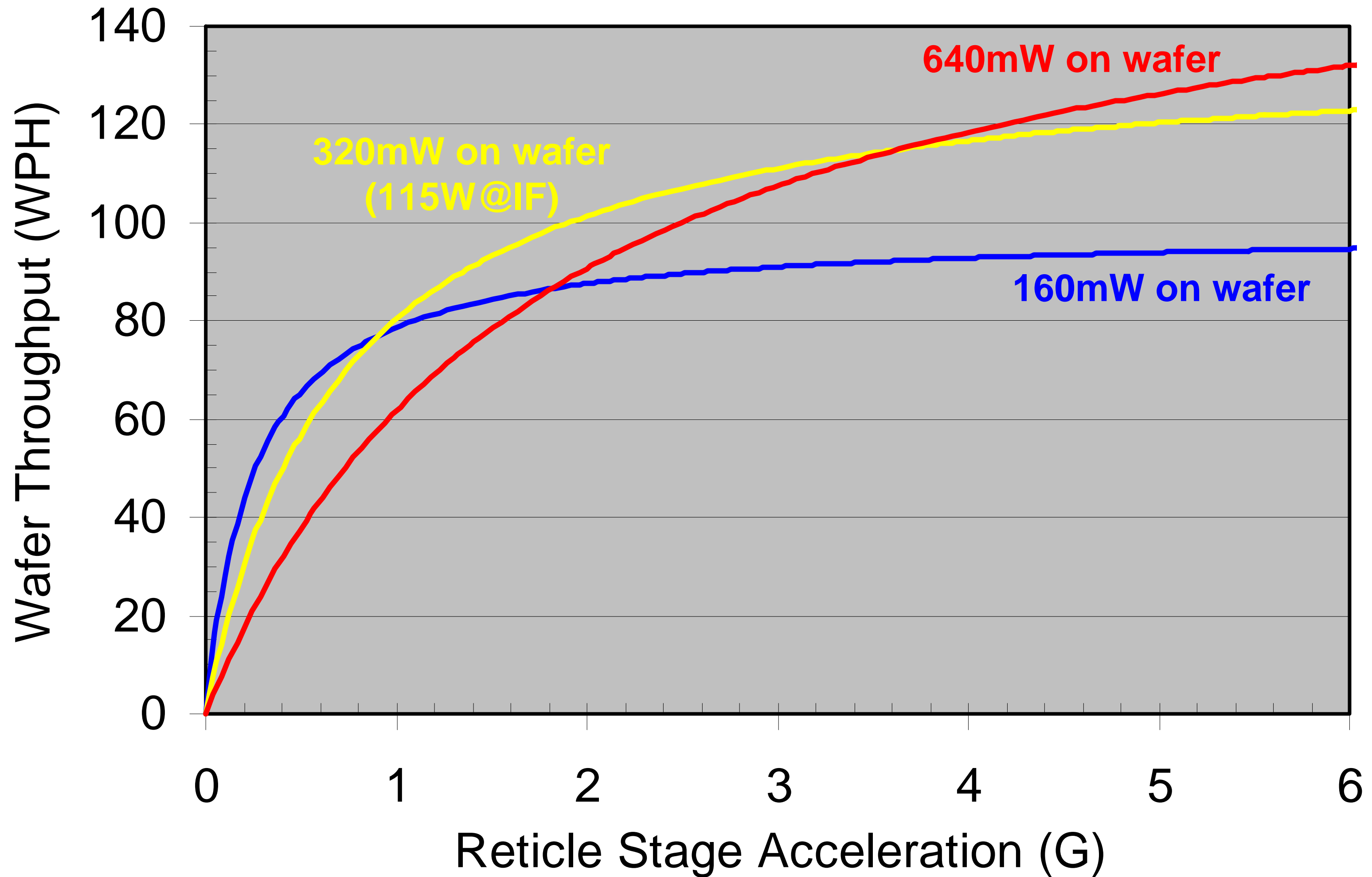
Source Power Requirement



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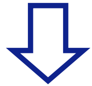
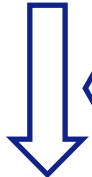
Repetition Frequency

Power at Wafer 0.321 W [1)]
Slit exposure area 2 x 25 mm^2 [3)]



Average EUV power 642 mW/cm^2



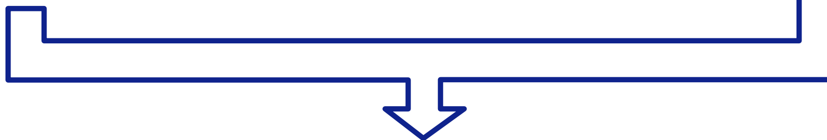
Resist Sensitivity
5 mJ/cm^2 [1)]

Exposure time at a point
7.8 msec

Budget of energy stability of EUV source for dose control
0.2% (3σ) 0.25% (3σ) 0.3% (3σ) [3)]

Integrated energy stability over 50 pulses
0.3% (3σ) [2)]

Required pulses at a point
113 72 50



Repetition frequency
14.4 kHz 9.2 kHz 6.4 kHz

Joint requirements: > 7-10 kHz

1) Typical throughput model
2) Joint requirements
3) Assumptions

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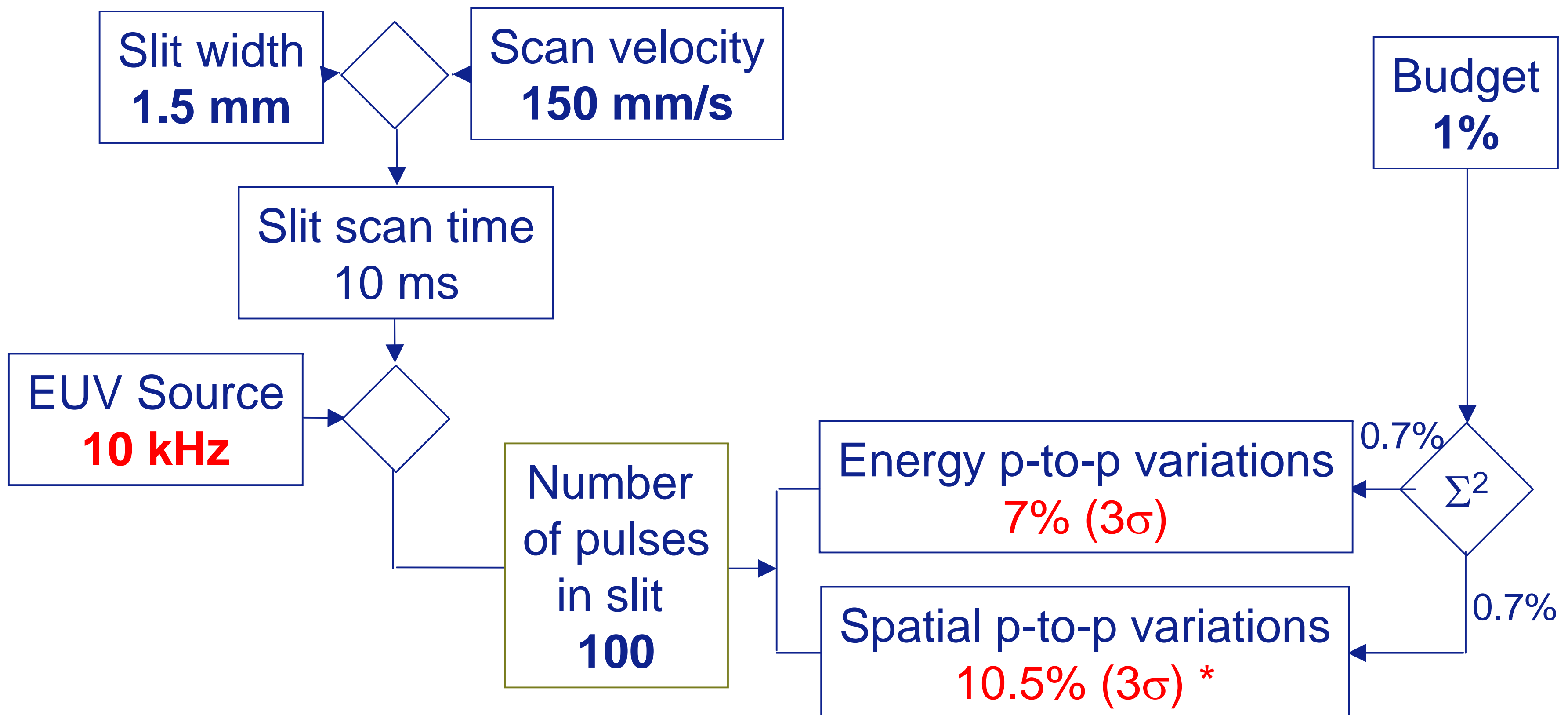
Influence of the source on imaging

Main influence of the source on imaging is through the source induced dose accuracy



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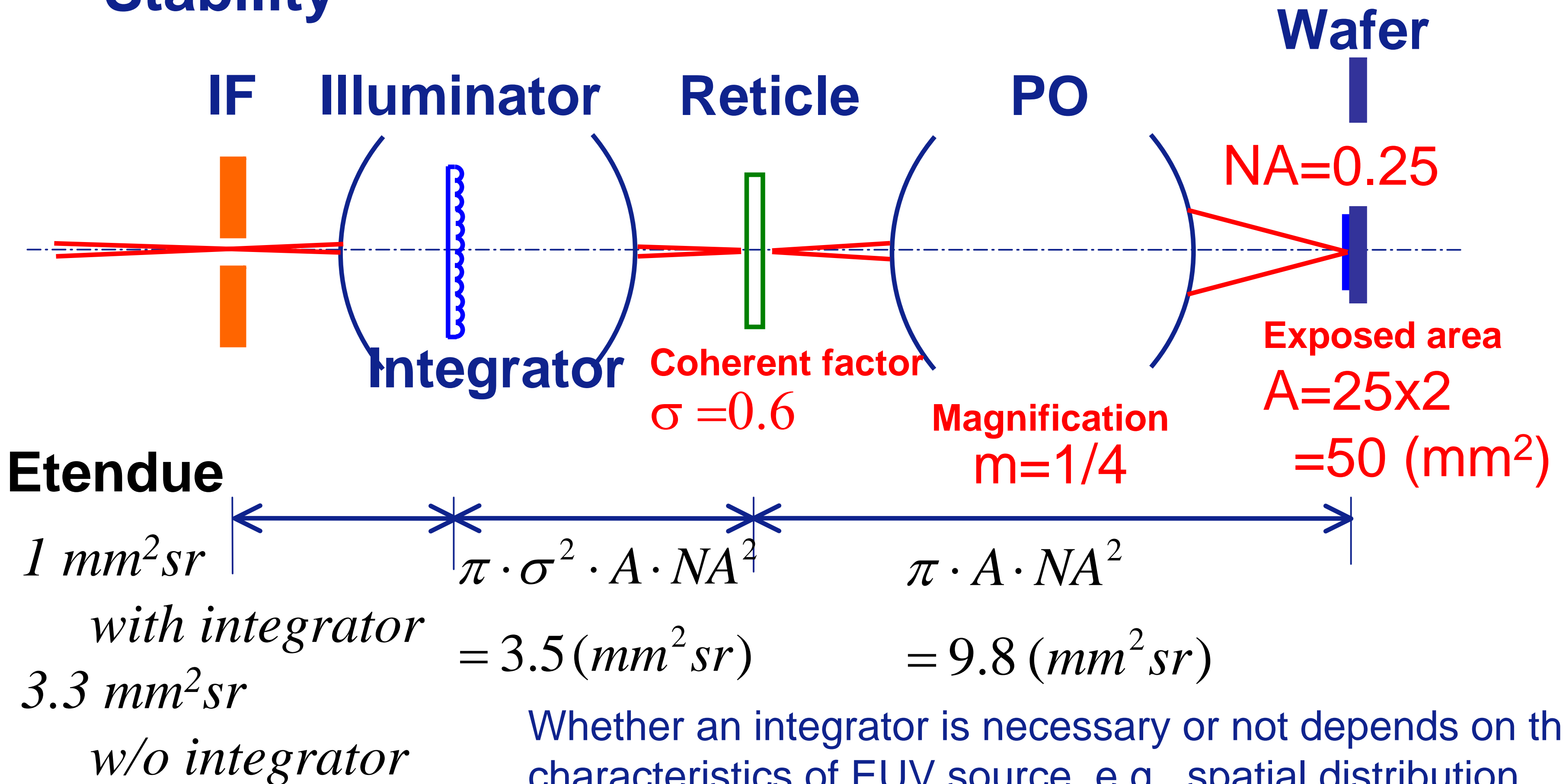
* Example for critical illumination

Etendue of Source Output and Positioning Stability



Whether an integrator is necessary or not depends on the characteristics of EUV source, e.g., spatial distribution, angular distribution and their temporal stability.
Positional instability results in both etendue enlargement and deterioration of illumination uniformity.

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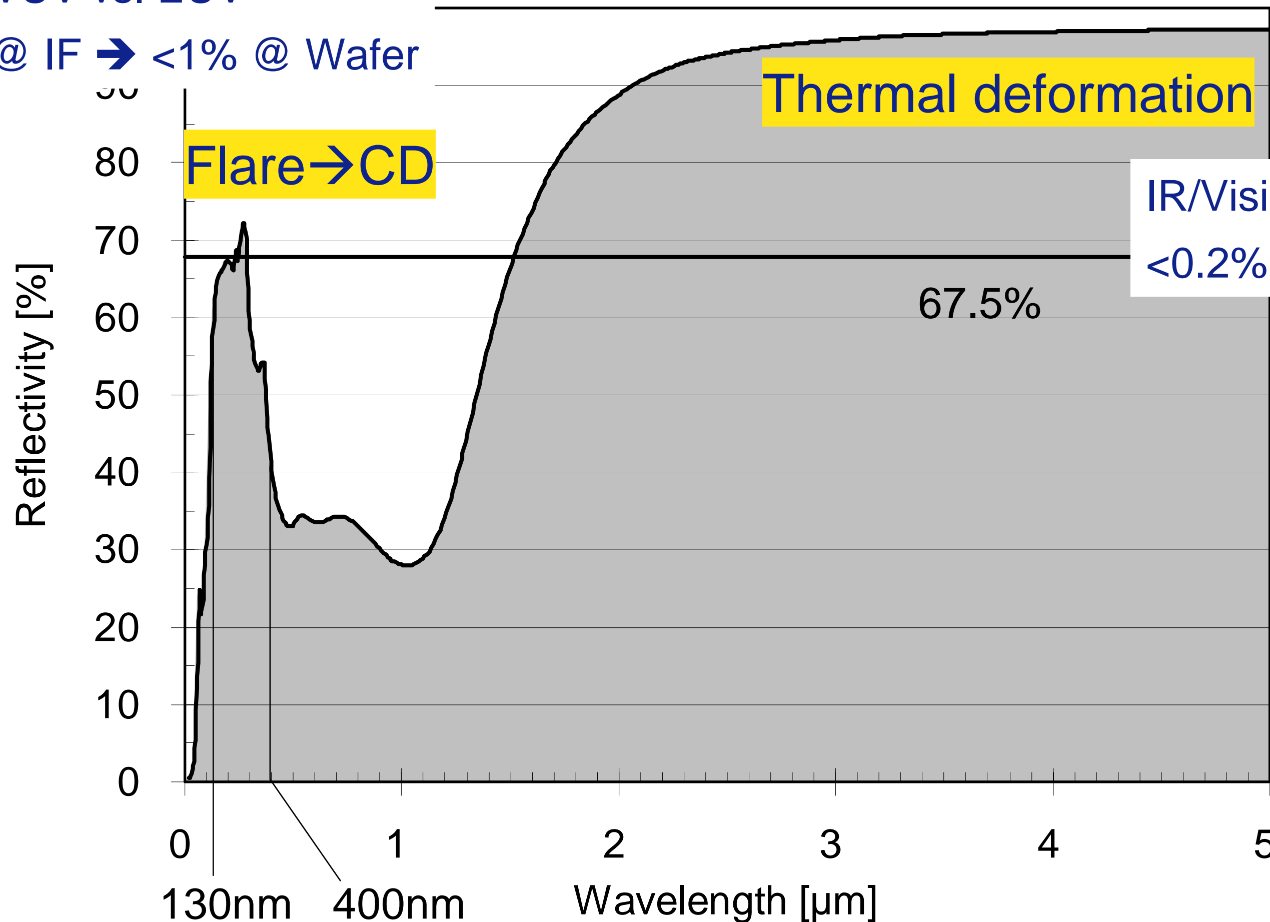
Spectral Purity

Spectral reflectivity of multilayer coated mirror

DUV/VUV vs. EUV

<3% @ IF ➔ <1% @ Wafer



IR/Visible vs. EUV

<0.2%@IF ➔ 10%@Wafer

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Cost of Ownership

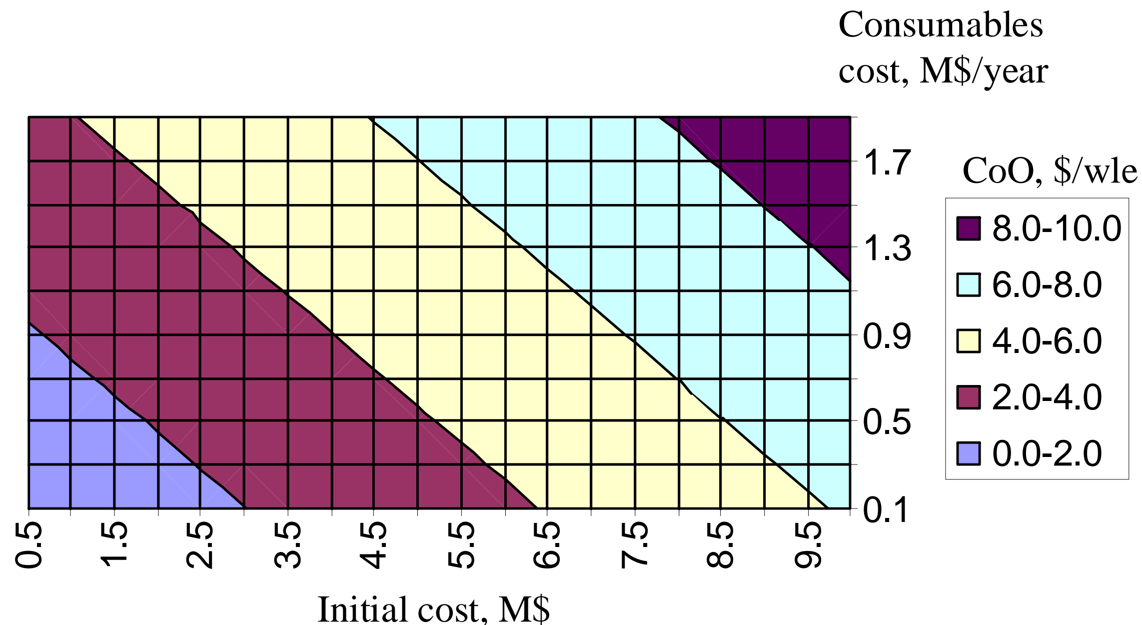
$$CoO = \frac{Size \times Price - per - m^2}{Throughput \cdot Hours - year}$$

$$+ \frac{Initial - cost}{Throughput \cdot Hours - year} \cdot \left[\frac{1}{5} + \frac{1}{10} + \frac{1}{25} \right]$$

$$+ \frac{Consumables}{Throughput \cdot Hours - year}$$

Assumptions:

- **500 \$ /m² has been assumed for the cost of the clean room floor;**
- **Hours-year equals 24 x 365 x 65% utilization = 5700 hr;**
- **1/5 represents 5 year depreciation , 1/10 10% interest and 1/25 4% service cost;**
- **Footprint +service area :20 m²;**
- **Throughput :100 wph**



Summary

- Joint requirements has been updated.
  - Etendue of Source Output: <1-3.3 mm^2sr to **<u><3.3</u>** mm^2sr
- Some parts in the book on EUV Sources for Lithography (ISMT) have been introduced.
  - Some items in the joint requirements are design dependent, and some examples are described.

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