Requirement for EUV source from exposure system design

October 29, 2001
EUVL Source Workshop

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Outline

1. EUV source specifications
2. Required information
3. Development plan
4. Summary

EUV source specifications

Central Wavelength [nm]	13-14nm
EUV Power [W]	50-150W

Captured by condenser in 2% BW @13.5nm

Condenser Lifetime	1 year or 1.6 E+11 pulses
Etendu [mm^2str]	0.4-0.8

Product of source size and condenser solid angle

Repetition rate [Hz]	> 5000
Pulse to pulse repeatability	< 2%

According to EUV Source Working Group, March, 2000

EUV source specifications: central wavelength

High reflectance multilayers

Mo/Si: High reflectance (67%) in longer λ region than Si-L edge (12.4nm)

Mo/Be: High reflectance (70%) in longer λ region than Be-K edge (11.1nm), toxicity of Be

Required resolution

If $k_1 = 0.5$, NA = 0.25, λ = 13nm, then resolution = $k_1 \lambda$ /NA = 26nm

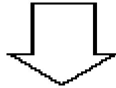
Sufficient resolution for 50-35nm node

13-14nm λ region using Mo/Si multilayers is preferable.

EUV source specifications: EUV power (1/2)

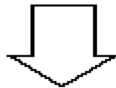
Rough estimation of required EUV power

Resist sensitivity $5 mJ/cm^2$



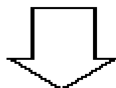
300mm wafer, $700 cm^2$

Required energy for exposure: 3.5J/wafer



80wph, $T_{exp} = 45 s/wafer$

Required EUV power on wafer: 0.08W



Optical throughput = $R^{13}T^2 = 1E\text{-}3$

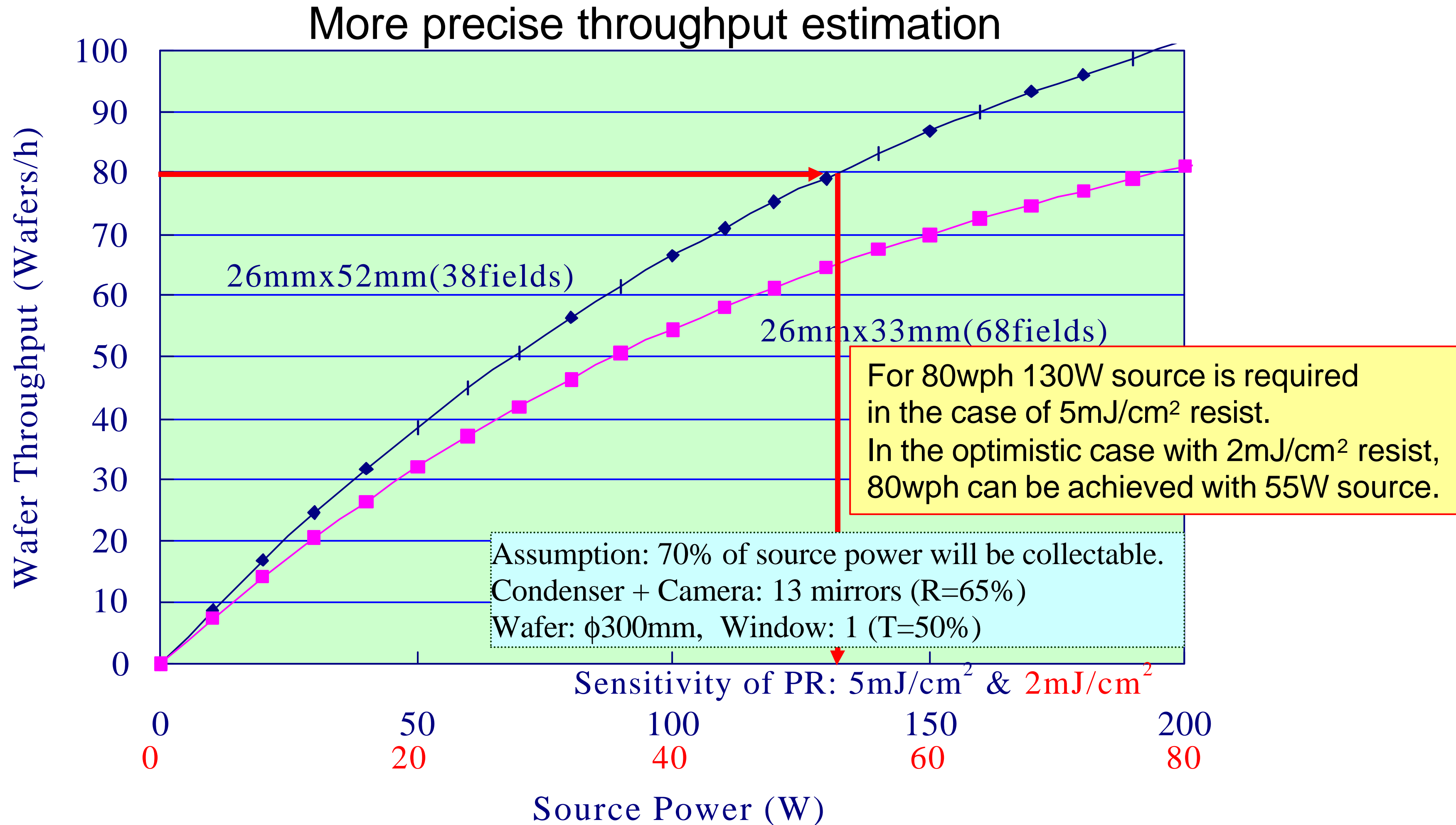
R=65%, T=50%, IO 6 mirrors, PO 6 mirrors

EUV power captured from source: 80W

Wafer load/unload, stage stepping time etc. are ignored in the above estimation.

Higher EUV power (roughly twice) is required.

EUV source specifications: EUV power (2/2)



EUV source specifications: repetition rate

From CD control requirement, illumination uniformity should be within ±1%.

Pulsed source ⇨ Discrete illumination dose

$T_{exp\ slit}$: slit exposure time, $T_{exp\ wafer}$: wafer exposure time
S_{slit} : slit area, S_{wafer} : wafer area

$T_{exp\ slit} = T_{exp\ wafer}\ S_{slit} / S_{wafer}$

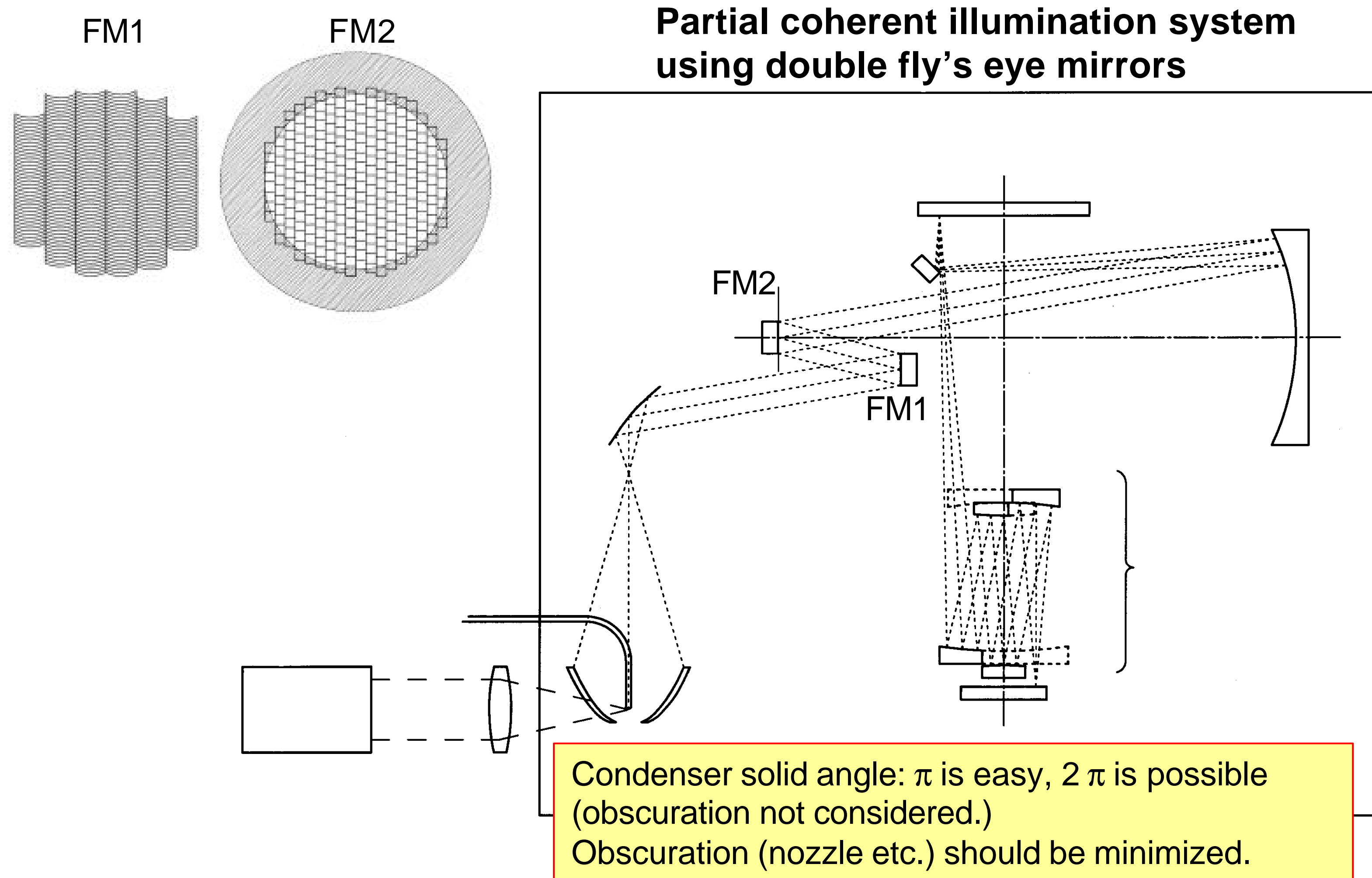
If $T_{exp\ wafer} = 45s$, $S_{slit} = 0.5cm^2$, $S_{wafer} = 700cm^2$, then $T_{exp\ slit} = 30ms$

If repetition rate = 30Hz,
then single pulse exposure, no dose controllability

If repetition rate = 3kHz, ← Lower limit
then exposed by 100 pulses, 1% dose controllability

(Repetition rate of present KrF scanner is 2kHz with 8mm slit width.)

Concept design of illumination optics



Condenser solid angle: π is easy, 2 π is possible
(obscuration not considered.)
Obscuration (nozzle etc.) should be minimized.

Required information (1/2)

1. Angular distribution of EUV

Angular distribution of EUV radiation has impact on pupil fill uniformity of projection optics which affect imaging performance.

2. Wide range spectrum

Only small portion of spectrum of EUV sources is used for exposure. The rest becomes heat load on optics. Thermal management of EUV exposure system is a critical issue. For detailed investigations, we need wide range spectrum of EUV sources. Black body ? or not ?

3. In-band spectrum

Phase change due to reflection by multilayer mirrors has violent impact on optical performance. (see Poster presented by H. Komatsuda)
The phase change depends on in-band spectrum.

Required information (2/2)

4. Debris characteristic

Size, energy, material, angular distribution etc.

The damage of multilayer coatings is only deposition ? or another impact ?

5. Capture angle

Is there any limitation of capture angle from source design ?

(Especially for discharge source)

6. Issues of high power source

Scaling of EUV power depends mainly on increased repetition rate.

In high repetition rate operation, is there any unknown issues ?

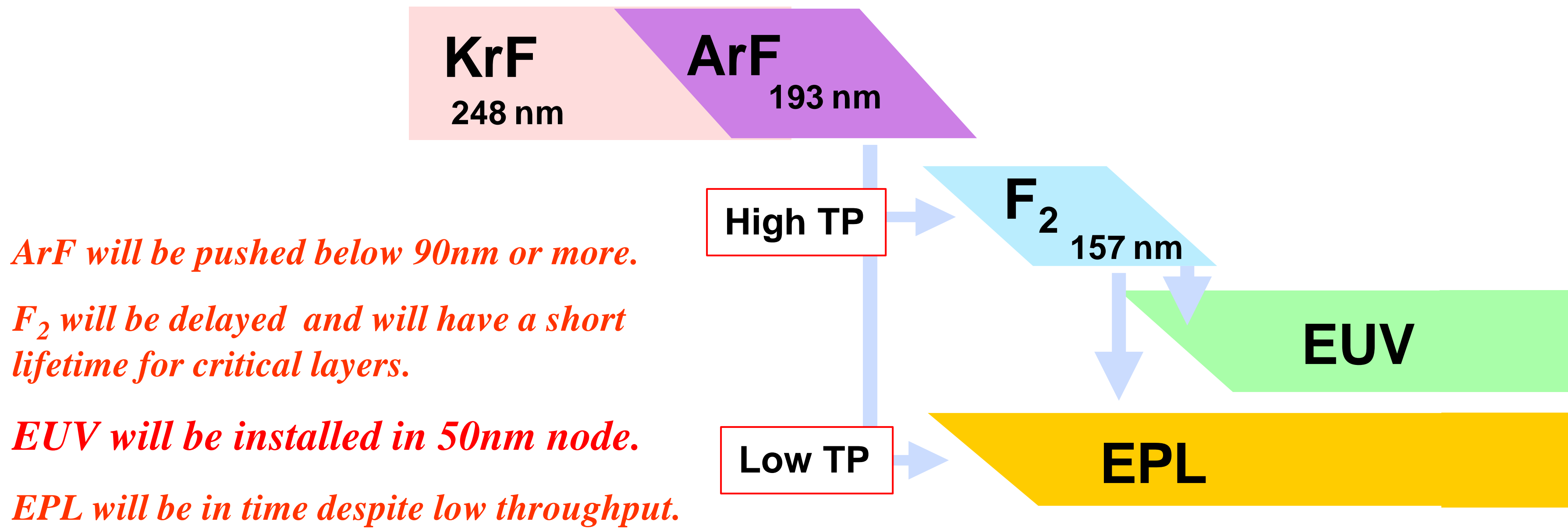
ex. Evacuation of target material, etc.

7. Stabilities (pulse to pulse & drift)

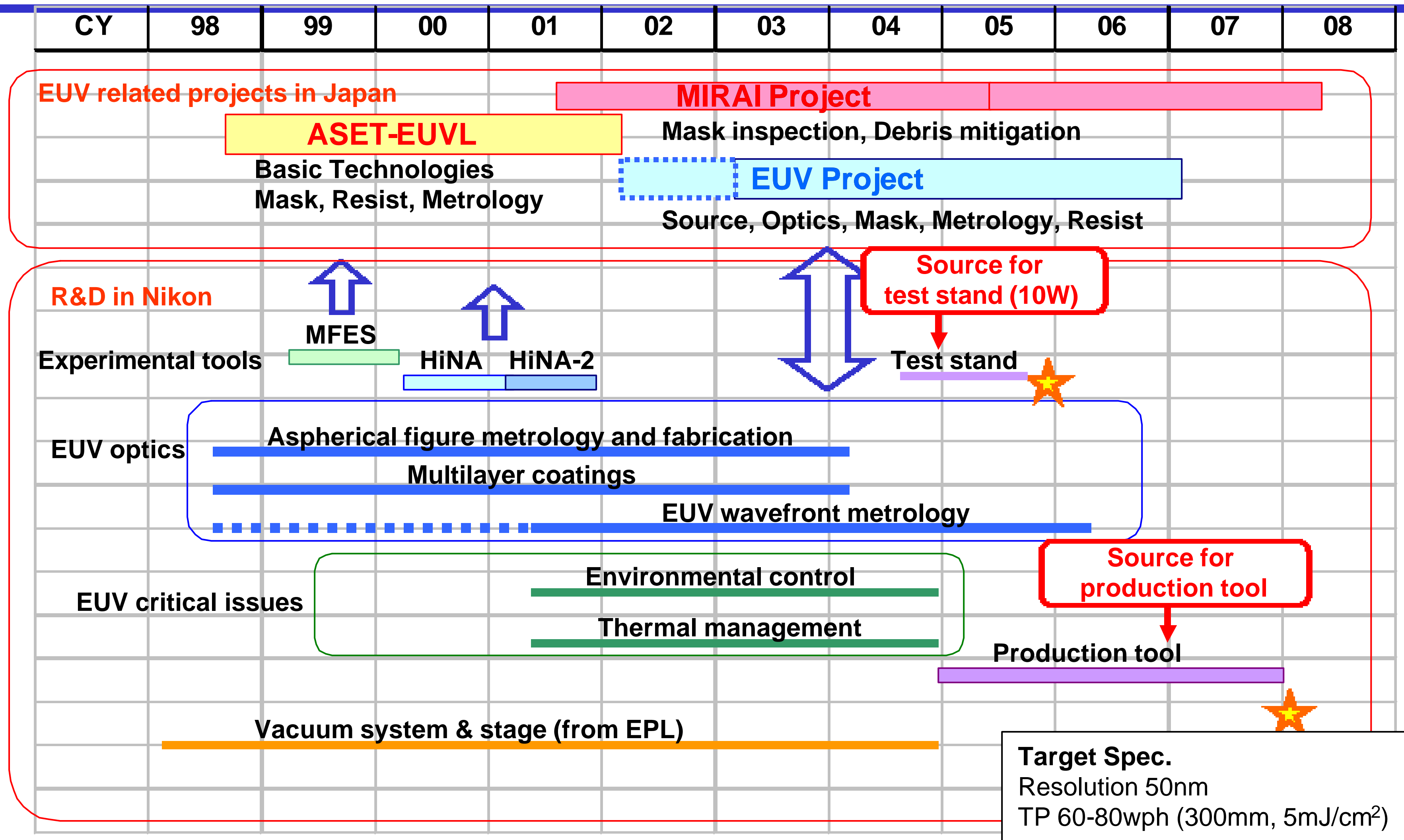
Source position, source (3D) shape, EUV power, angular distribution, spectrum, Jitter, etc.

Nikon Lithography Roadmap *(for critical layers)*

CY	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13
ITRS2000 DRAM(1/2pitch)	180		130			90			65			45			33
SC.2.0 MPU(gate in resist)	140		90			60			45			32			23



EUVL tool development plan in Nikon (Tentative)



Summary

- ✓ The EUV source specifications should be pursued.
- ✓ Further detailed information is helpful to design EUV exposure tools.
- ✓ Middle power EUV sources (10W) will be required in 2004.
- ✓ High power EUV sources (50-150W) will be required in 2006.