# IBM EUV Pellicle Update

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**IEUVI Pellicle TWG – February 21, 2016 – San Jose, CA**

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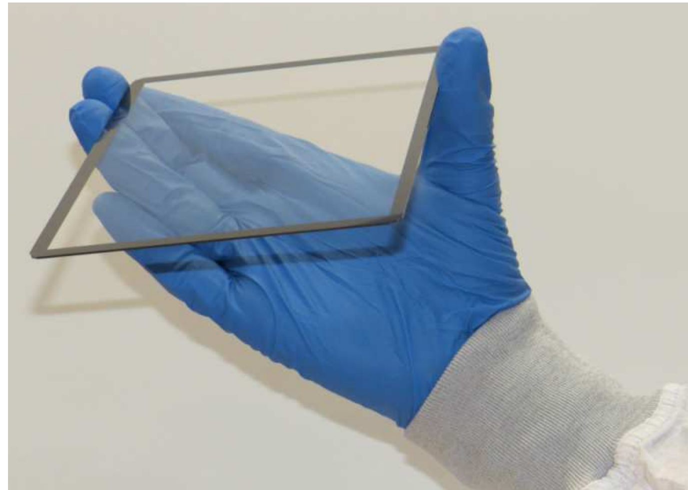
# EUV Pellicle Program (IBM)

**Goal: enable through-pellicle ArF inspection of EUV masks (>125W EUV Source Power)**

**Demonstrated generalized fabrication method of full field silicon nitride EUV pellicle (BACUS 2015)**



- SiNx, 19.6nm
- EUV T%= 87.3% (single pass)*
- ArF semi-transparent
- Tensile, no wrinkles
- Tensility loss upon heating
- Limited EUV power compatibility

*EUV T = 90% (single pass, full field) achieved, requires tensility adjustment

**Learning vehicle to understand**

- Through-pellicle EUV mask inspection feasibility
- Thermophysical behavior & impact on imaging

**Use current learning and capabilities to incorporate**

- Heat dissipation layer with EUV/193 transmission

( WORK IN PROGRESS… )

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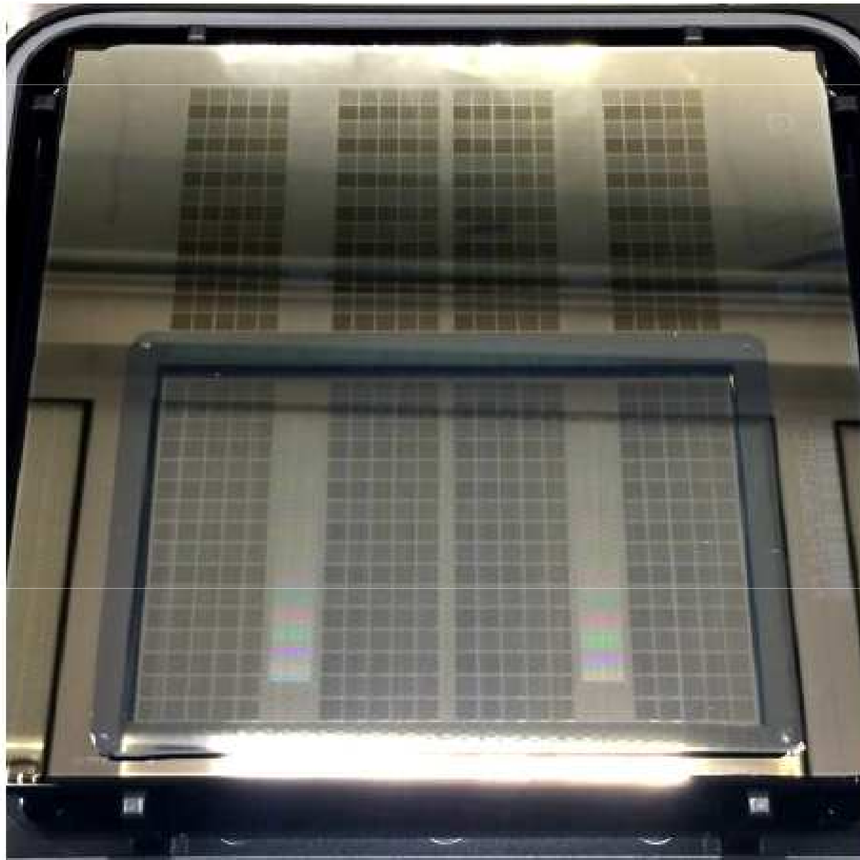
# Through-Pellicle EUV Mask Defect Inspection

**Actual Test Vehicle**



- 20nm SiNx pellicle passed initial 193nm inspection tests
  - –pellicle durability
  - –optical properties impact
  - –transmittance / reflectance impact
- Standard thru-pellicle 193nm inspection had good defect performance
- Pellicle properties at 193nm had little impact on inspection performance

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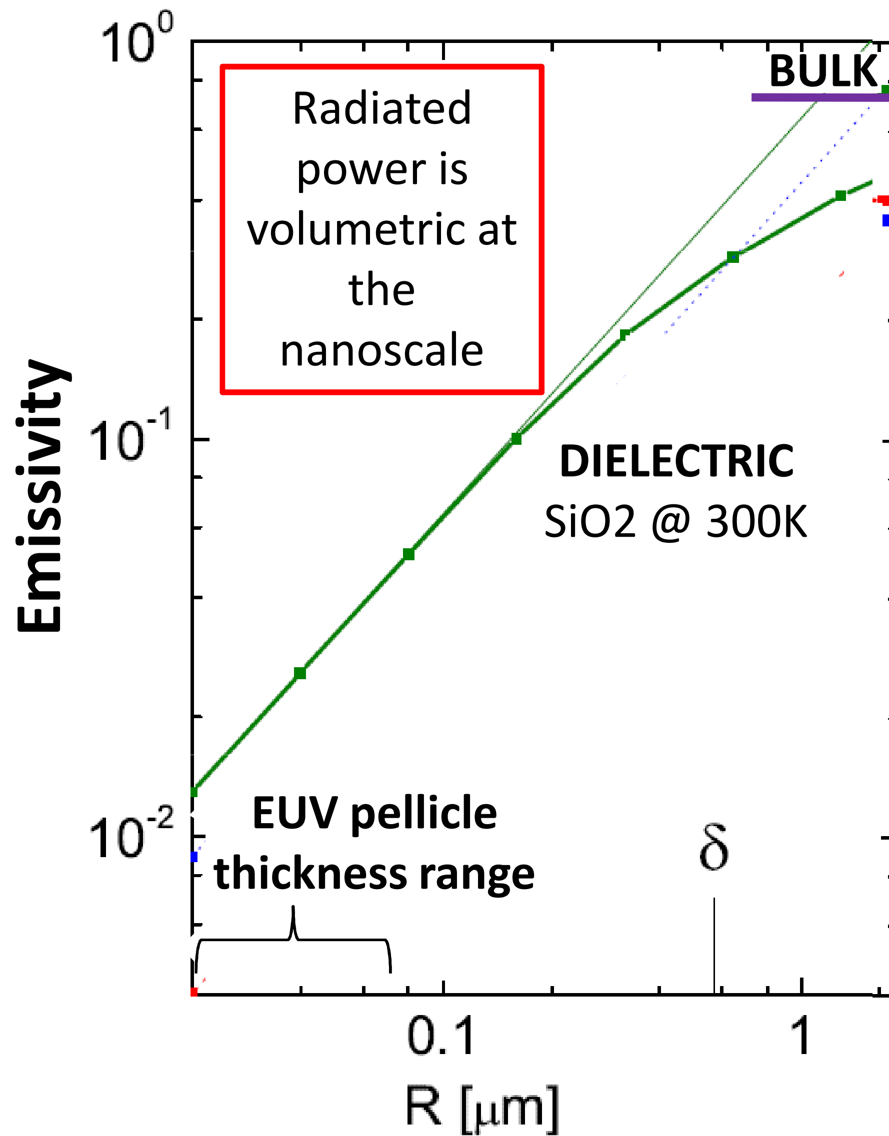
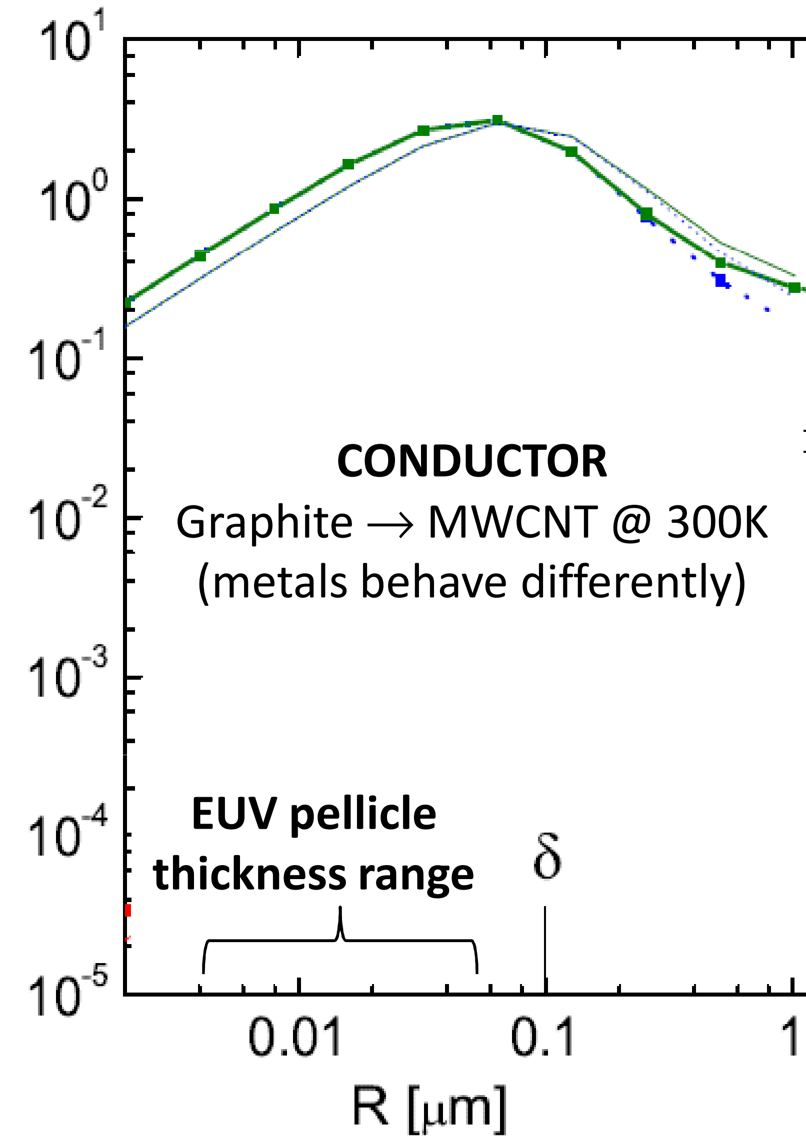
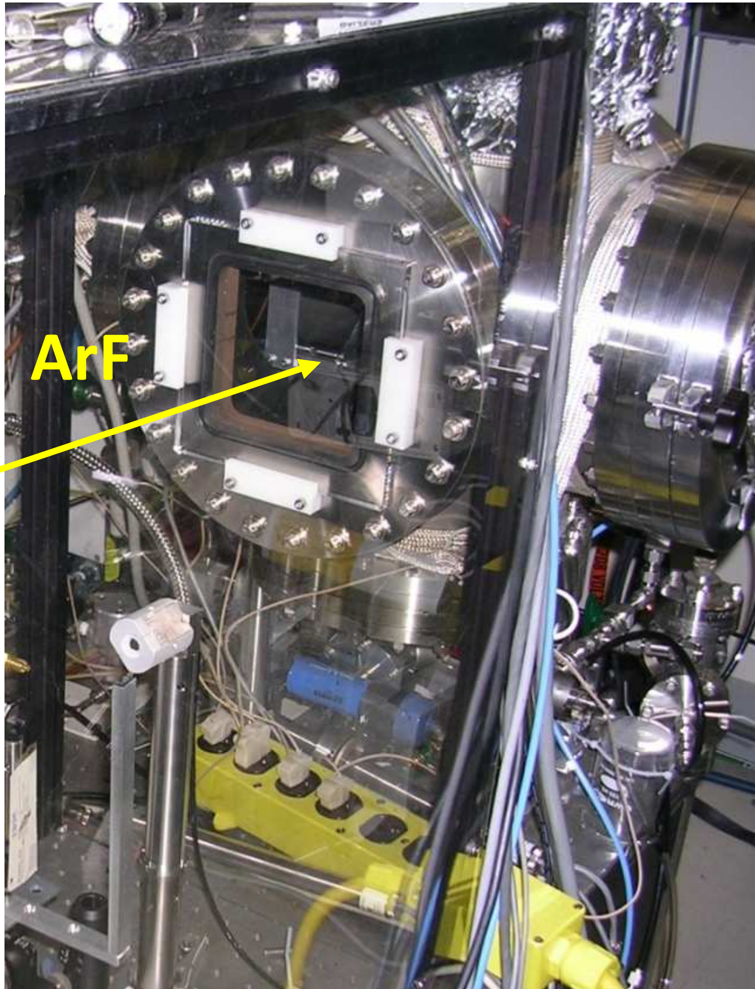
# EUV Pellicle Emissivity (ε)




V.A. Golyk, M. Krüger and M.Kardar, "Heat radiation from long cylindrical objects", *Phys.Rev.E* 85, 046603 (2012)

# EUV Pellicle Emissivity (ε)




**193nm laser beamline and exposure chamber**

**SiNx 20nm pellicle marginally compatible with 80W EUV source under steady state conditions**

$$H_{fail} = \varepsilon.\sigma_{SB}\,(T_m^4 - T_0^4) \rightarrow \text{extract } \varepsilon$$

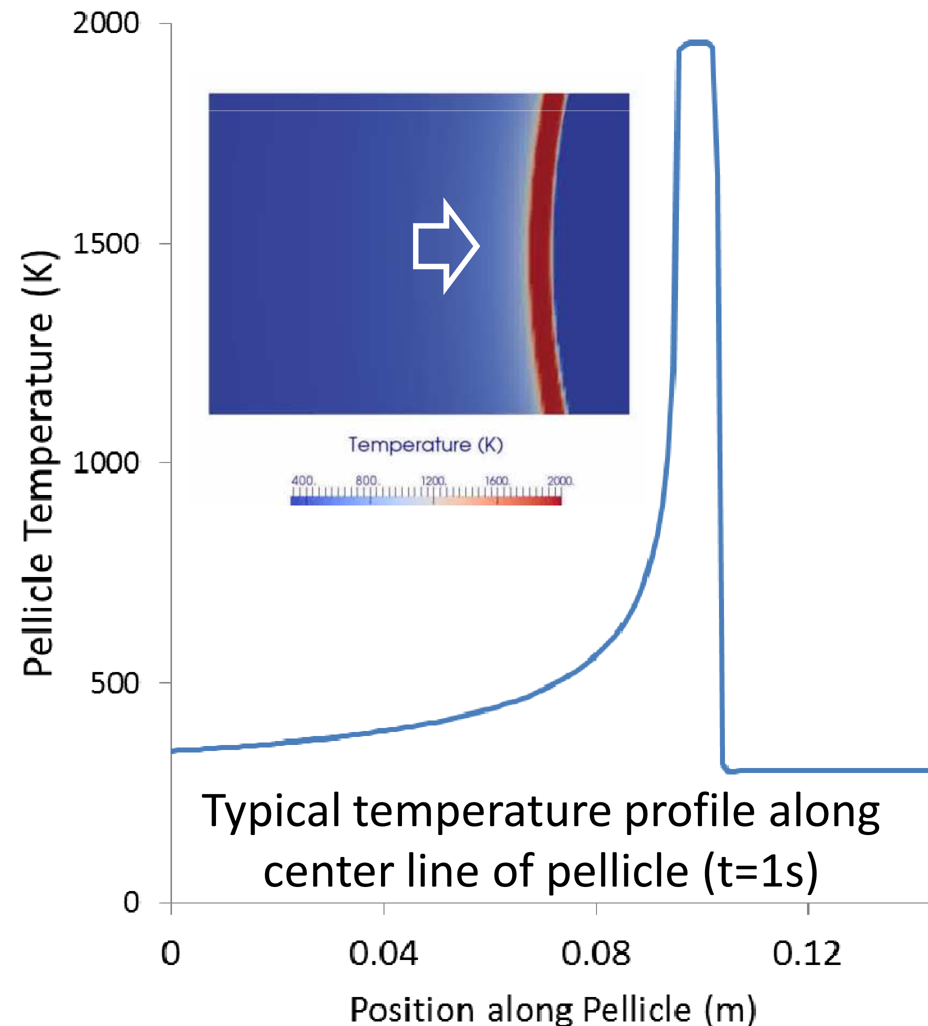
$$\varepsilon\ (\text{SiNx, 20nm}) = 0.0035$$

| Emissivity | SiN |
|---|---|
| 50nm film (@100°C) | 0.008 |

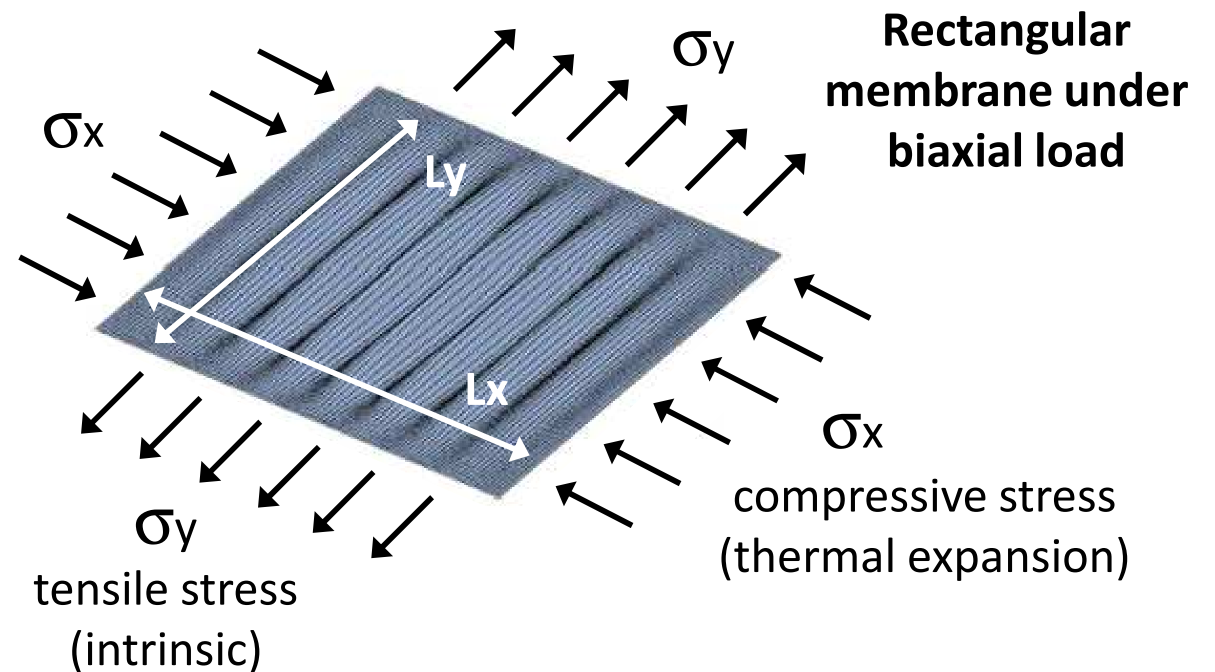
Sungwon Kwon, Samsung
IEUVL 2015

# EUV Pellicle (SiNx, 20nm) @ 60W EUV Source Power

SiNx pellicle operating limit (2123K)




Typical temperature profile along center line of pellicle (t=1s)




**Rectangular membrane under biaxial load**

Damil et al. Advanced Modeling and Simulation in Engineering Sciences 2014, 1:6

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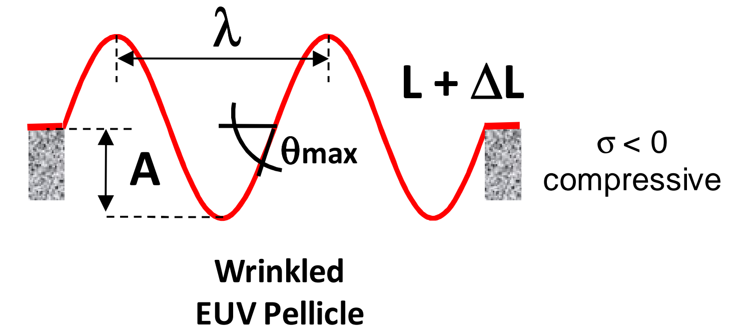
# EUV Pellicle Wrinkling

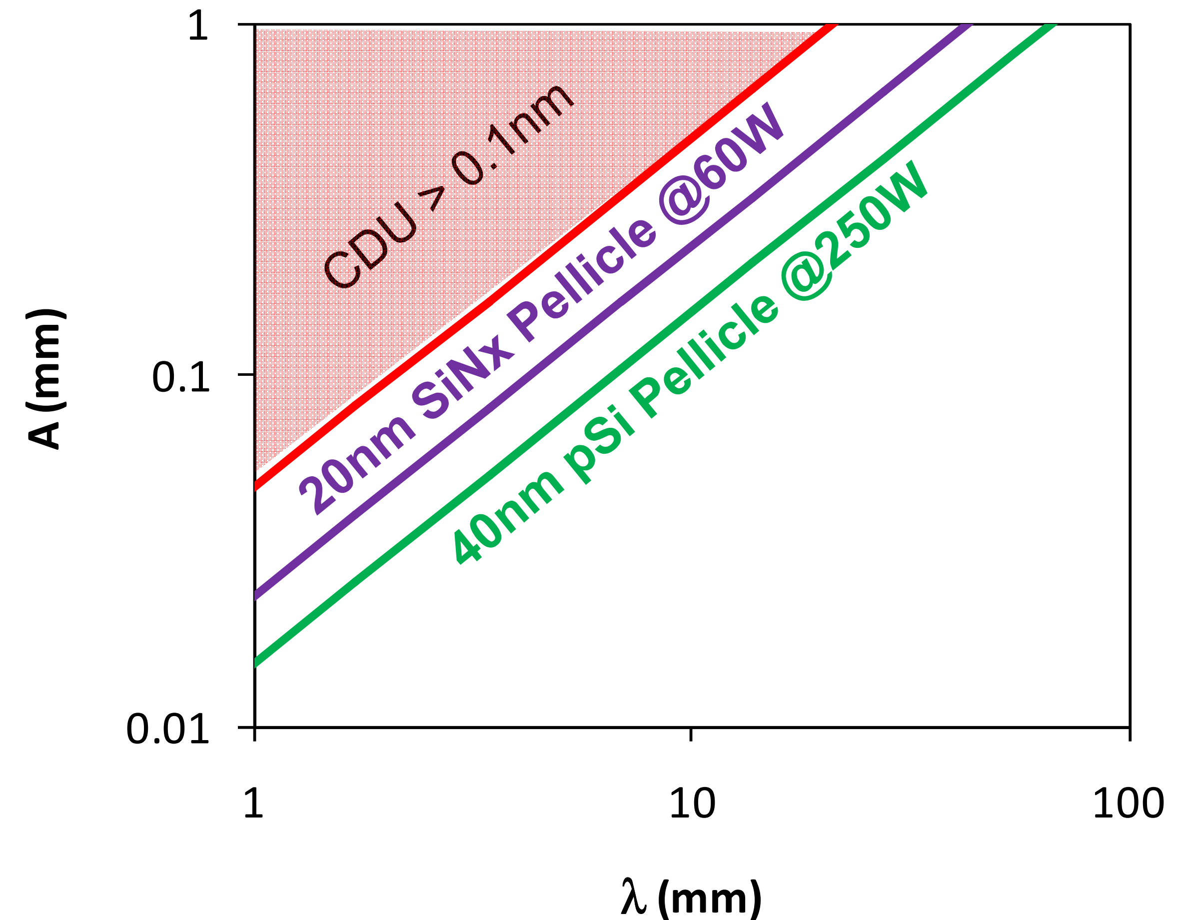
**RESULTS (20nm SiNx pellicle @ 60W)**

- Small pellicle deformation, $(\Delta L/L) = 0.44\%$
- Transient compressive stress present during scanning




**Pellicle wrinkling not expected to impact imaging**

| Parameter | θmax = 2π A/λ (mrad) |
|---|---|
| Specification | 300 |
| 20nm SiNx @60W | ✓ 148 |
| 40nm pSi @250W | ✓ 95 |
| 40nm pSi @250W [1] | ✓ 134 |




[1] F. Dhalluin et al., Proc. of SPIE Vol. 9658, 96580J (2015)

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# IBM EUV Pellicle Presentations @ SPIE Advanced Lithography

**Through-Pellicle Defect Inspection of EUV Masks Using a ArF-based Inspection Tool**

**Paper [9776-54] - WEDNESDAY 6pm**

**Thermo-mechanical Behavior of EUV Pellicle Under Dynamic Exposure Conditions**

**Paper [9776-74] - THURSDAY 5pm**

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# Thank you
# for your attention

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