



ASML

EUV Mask thermal overlay analysis

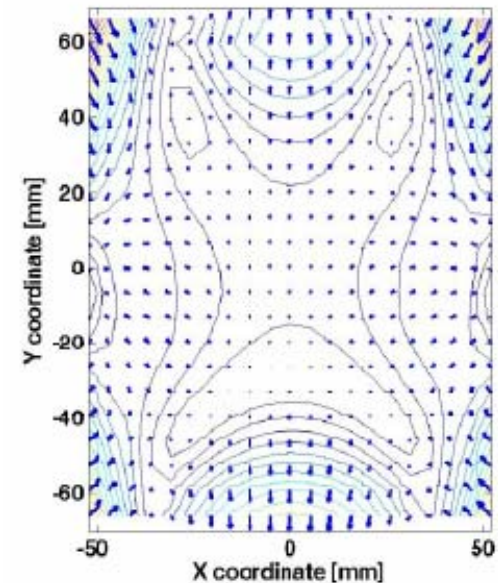
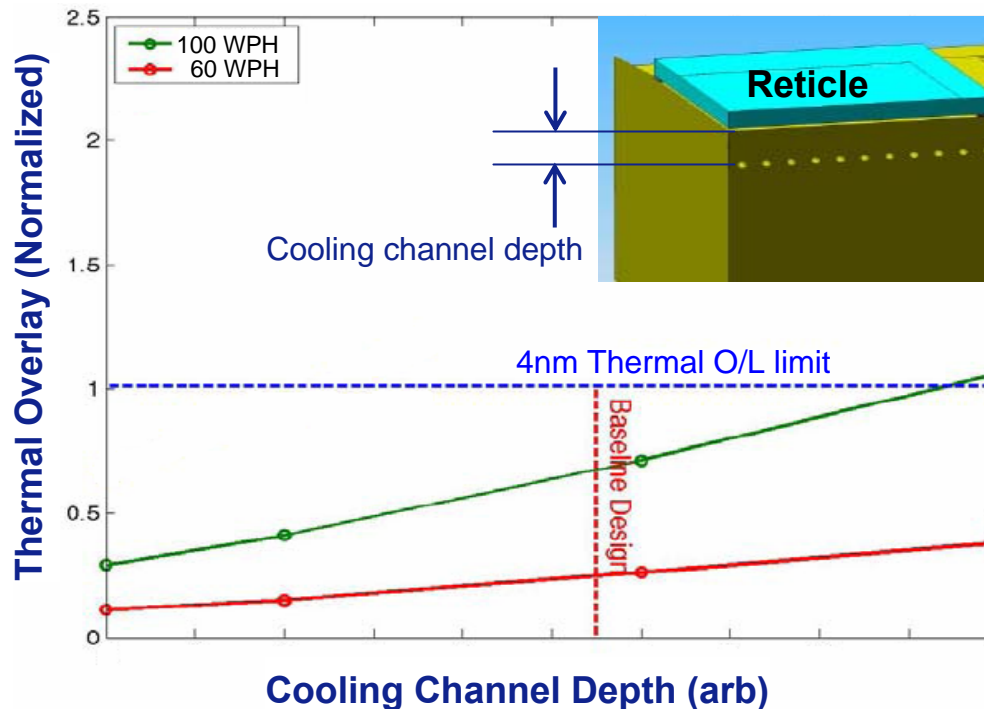
John Zimmerman

EUV Mask TWG

October 2, 2008

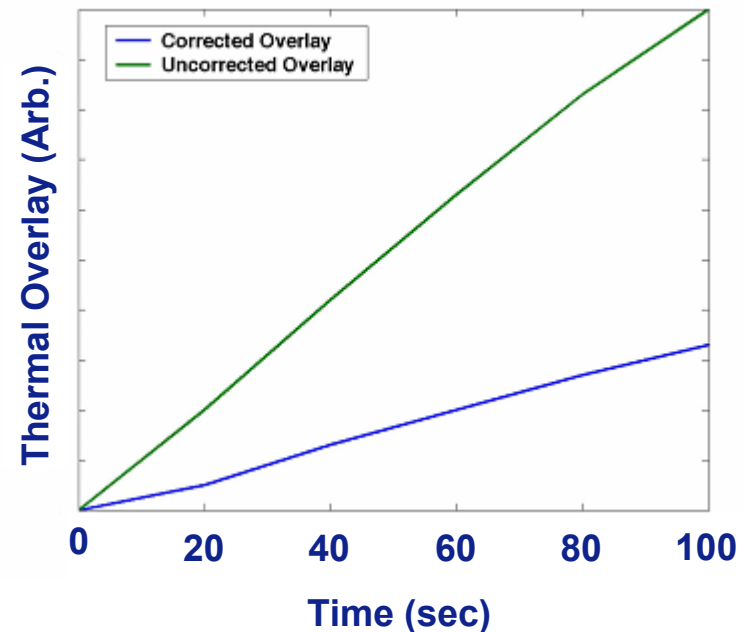
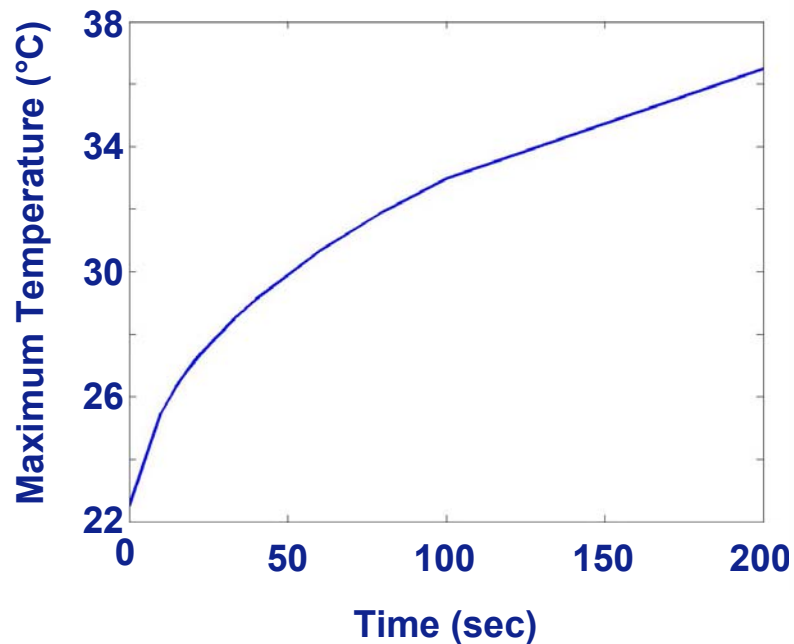
Current mask CTE is acceptable for ASML overlay of 4nm at 100 wph

- Using a complete thermal model, the predicted max reticle temperature is $\sim 30^{\circ}\text{C}$ / 38°C for 60/100 wph
- Using the non-linear CTE in the model, the simulated overlay performance stays in spec at this temperature for 100 wph



About 2/3 of the thermal induced overlay error can be compensated with normal scanner corrections

- Thermal time constant ~120 seconds
- Heat load is constant in these simulations



CTE solution is needed by 2012 in order to have reticle thermal management design ready for the next generation

Resolution (half pitch) = k_1 wavelength / NA

Physical limit for single exposure: $k_1 = 0.25$

half pitch (nm)		100	65	45	32	22	16	11
year		2005	2007	2009	2011	2013	2015	
λ [nm]	NA							
13.5	0.25				0.59	0.41		
	0.35					0.57	0.41	
	0.45						0.53	0.37



CTE solution needed by 2011

- most likely
- opportunity



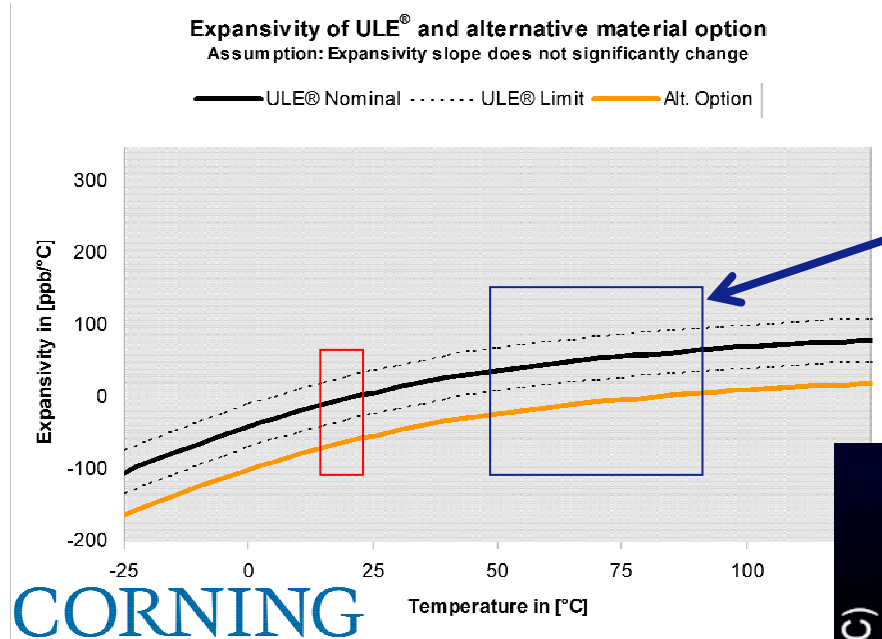
Backup

CTE spec does not match the operating temperature range for high-volume tools

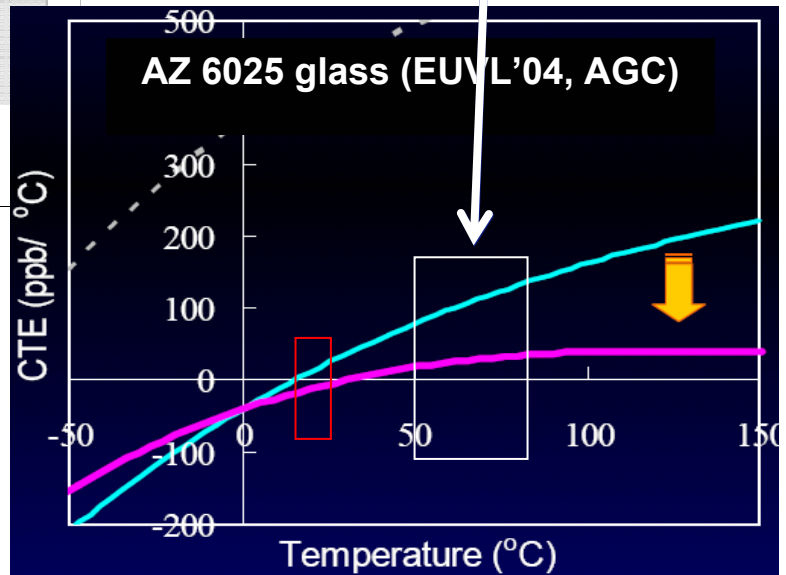
<i>Property</i>	<i>Symbol</i>	<i>Characteristic</i>
Temperature range for CTE requirement		19 to 25°C
Coefficient of Thermal Expansion	CTE (ppb/°C)	Class A: mean: 0 ± 5 ppb/°C 6 ppb/°C total spatial variation Class B: mean: 0 ± 10 ppb/°C 10 ppb/°C total spatial variation Class C: mean: 0 ± 20 ppb/°C 10 ppb/°C total spatial variation Class D: mean: 0 ± 30 ppb/°C 10 ppb/°C total spatial variation

- For High T-put tools the reticle operating temperature will be substantially higher than 25°
 - Current estimates with 67% reticle reflection, heat conductivity of 1.5 W/m·K, reticle thickness 6.35 mm, show operating temperatures of 50...80°C
- At operating temperatures 50...80°C, CTE of current LTEM materials will largely exceed allowed values
- Thermal expansion specification needs to be reviewed

LTEM materials can be tailored for a specific cross over temperature



Expected reticle operating temperature range for High T-put HVM



Task force should review the CTE issue and potential solutions

- Industry must understand the situation
 - Reticle use and impact on temp
 - Power
 - Effective reflectivity
 - Heat conductivity
- Possible solutions for compensating the expected operating conditions for high throughput
 - Cross over temperature modifications
 - Higher thermal conductivity materials
 - Thinner reticles