

Shin-Etsu's Synthetic Quartz Photomask Substrate



Shin-Etsu's Synthetic Quartz Photomask Substrate

“KNFS6025”

for Polarized ArF Lithography

～ Optimum Substrate for High-NA and Immersion Lithography ～

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ShinEtsu

“KNFS6025” for ArF High-NA and Immersion Lithography

[Summarized typical data]

Laser source	Wavelength	Optics		Substrate grade	Transmission at 193nm (Distribution in a surface: Δ T)	Durability to ArF (10mJ/cm ² · pulse, 2×10 ⁶ pulses)	Birefringence (nm / 6.35mm at 193nm)	Flatness
ArF	193.4nm	Non-polarized system	Dry	KNFS6025	90.7% (Δ T=0.20%)	-0.2% (Transmission loss)	>2nm	0.5μm
		Polarized system						2nm、1nm
			Immersion				1nm or less	
				Special use		XNFS6025	90.7% (Δ T=0.05%)	-0.05%

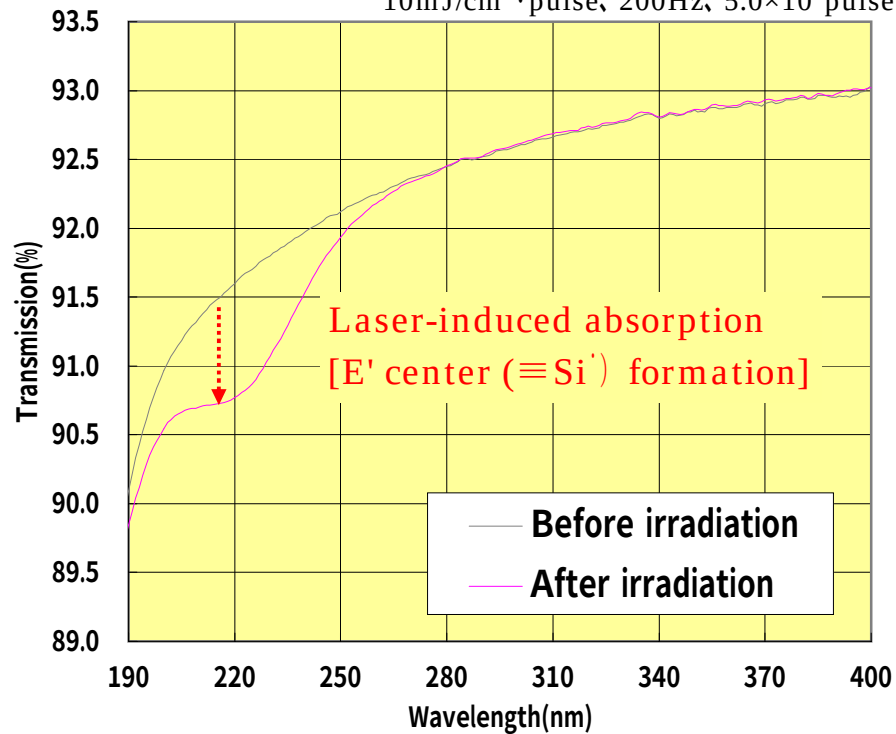
Laser Durability against ArF Excimer Laser (1)

Shin-Etsu's photomask substrate for ArF lithography keeps high transmission property even after practically high level dose of ArF excimer laser.

◎Result of accelerated test

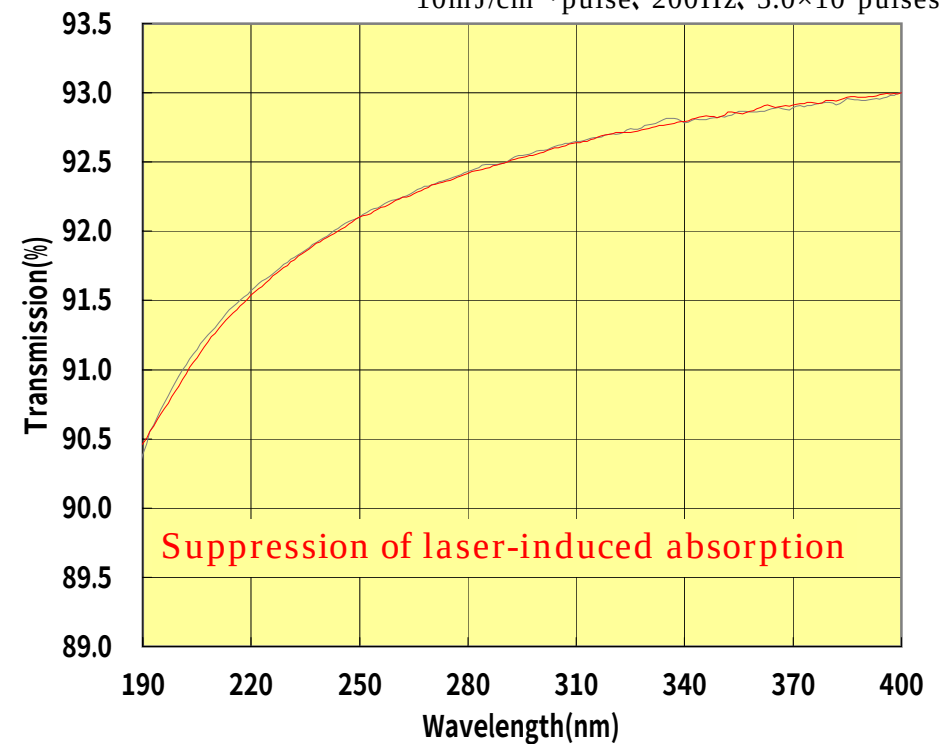
[SZS6025~conventional grade for KrF]

10mJ/cm²·pulse, 200Hz, 5.0×10⁴pulses



[KNFS6025~ArF grade]

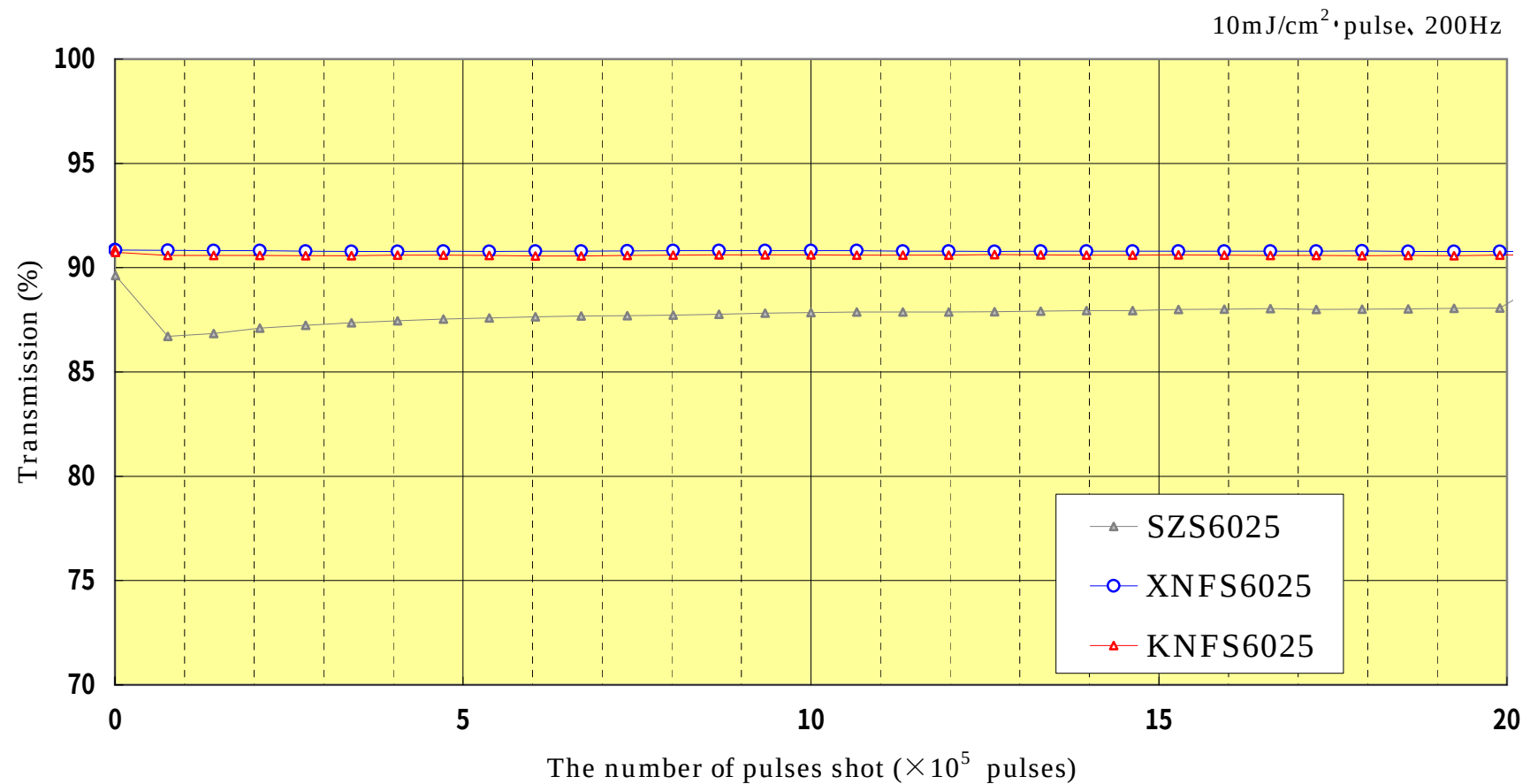
10mJ/cm²·pulse, 200Hz, 5.0×10⁴pulses



Laser Durability against ArF Excimer Laser (2)

Shin-Etsu's photomask substrate for ArF lithography keeps high transmission property even after practically high level dose of ArF excimer laser.

◎Result of accelerated test



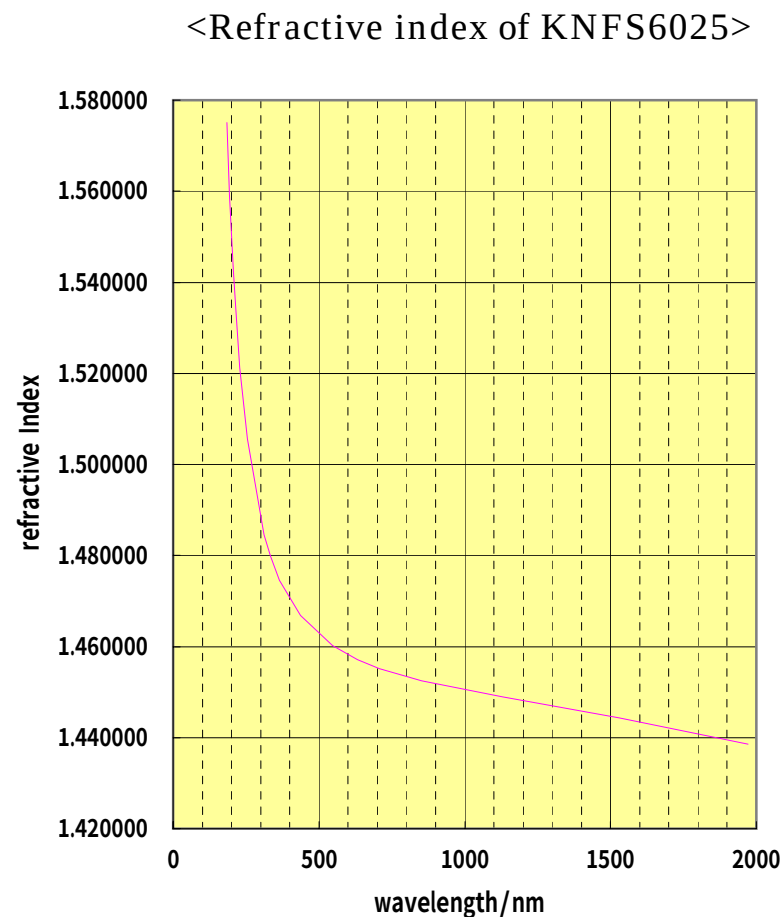
Miscellaneous Properties

Optical properties, mechanical properties and thermal properties of Shin-Etsu's photomask substrate for ArF lithography are shown below. Refractive index will be important for Levenson masks, CPL masks, etc.

[Optical Properties]		Substrates for ArF		for KrF
		KNFS6025	XNFS6025	SZS6025
Refractive Index	248.3nm	1.508552	1.508543	1.508528
	193.4nm	1.560350	1.560338	1.560331

[Mechanical Properties]		Substrates for ArF		for KrF
		KNFS6025	XNFS6025	SZS6025
Young's modulus	kg/mm ²	7450	7450	7450
Shear modulus	kg/mm ²	3160	3160	3160
Poisson's ratio		0.17	0.17	0.17
Specific gravity	g/cm ³	2.20	2.20	2.20

[Thermal Properties]		Substrates for ArF		for KrF
		KNFS6025	XNFS6025	SZS6025
Coefficient of thermal expansion	K ⁻¹	5×10^{-7} (0~200°C)	5×10^{-7} (0~200°C)	5×10^{-7} (0~200°C)
Strain point	°C	985	1095	985
Annealing point	°C	1090	1190	1090



Low Birefringence Grade for ArF High-NA Lithography

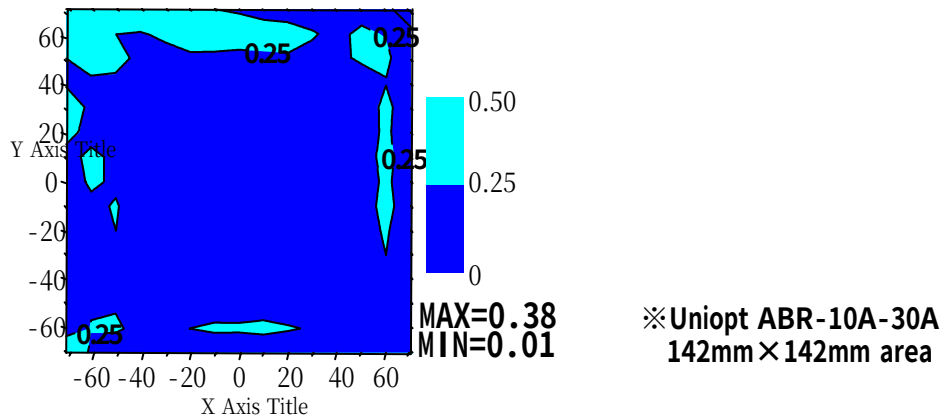
Shin-Etsu can add the property of low birefringence to the next generation photomask substrate for ArF High-NA and immersion lithography.

[Tentative specification]

Birefringence $\leq 1\text{nm}/6.35\text{mm}$ at wavelength of 193.4nm

Birefringence $\leq 2\text{nm}/6.35\text{mm}$ at wavelength of 193.4nm

[An example map of low birefringence KNFS6025]



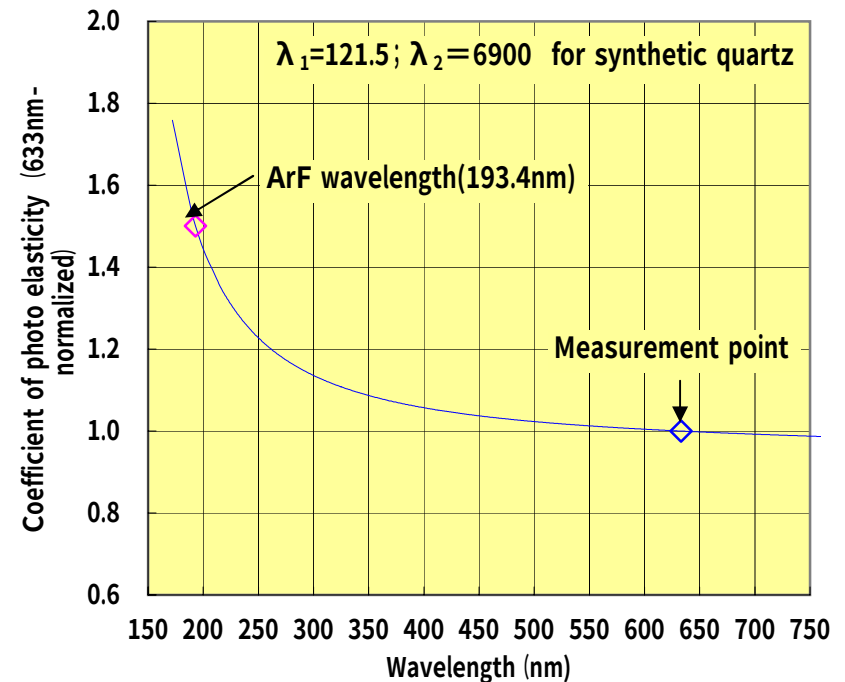
6.35mm-thick-Birefringence 0.38nm at wavelength of 633nm

→corresponds to 0.57nm at 193.4nm

[Conversion of birefringence, $\text{Re}(\lambda)$] λ : wavelength; $n(\lambda)$: index

$$\frac{\text{Re}(193.4\text{nm})}{\text{Re}(633\text{nm})} = \frac{C(193.4\text{nm})}{C(633\text{nm})} = 1.50$$

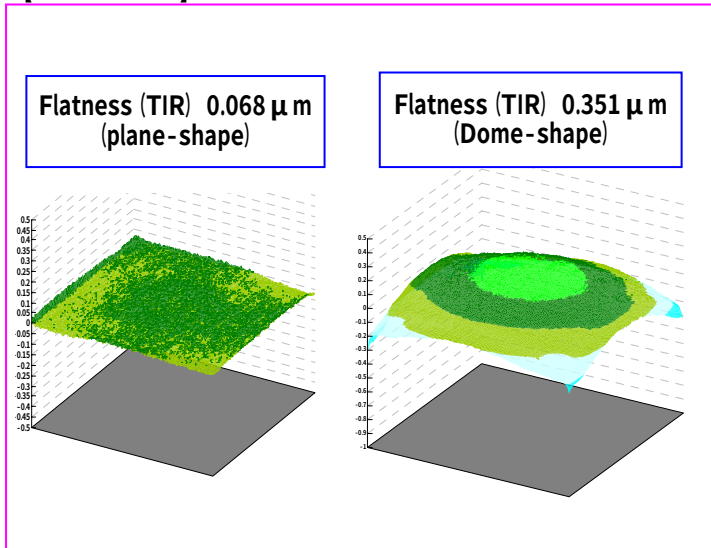
$$C(\lambda) = C(\lambda_0) \cdot \frac{n(\lambda_0)}{n(\lambda)} \cdot \frac{\lambda^2}{\lambda_0^2} \cdot \frac{\lambda_0^2 - \lambda_1^2}{\lambda^2 - \lambda_1^2} \cdot \frac{\lambda^2 - \lambda_2^2}{\lambda_0^2 - \lambda_2^2}$$



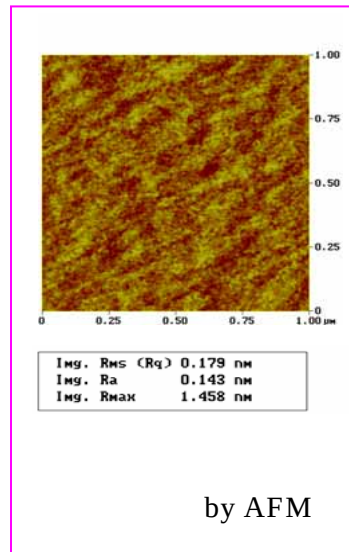
Shin-Etsu's Surface Technologies

Shin-Etsu supplies smooth, low-defect-density and highly flat surface for the photomask substrate for ArF lithography. Shin-Etsu manufactures a 0.5 μm -flatness substrate as a standard flatness grade for the photomask substrate for ArF lithography.

[Flatness]



[Roughness]



[Defect]



Flatness grades

Grade	Flatness	Comments
E05	0.5 μm	
E05S	0.5 μm	A certain shape to your option
E025	0.25 μm	Special use
E01	0.1 μm	

Low Surface Roughness

Rms(1 μm) $\leq$ 0.2nm

Low-Defect-Density Surface (called LD-SZS)

The number of $\leq 0.5\mu\text{m}$ -defects counts ≤ 20

(Standard grade with sampling inspection by MAGICS)