Thermal Expansion property and Surface Finish capability of CLEARCERAM®-Z series for EUVL Photomask Substrate Application

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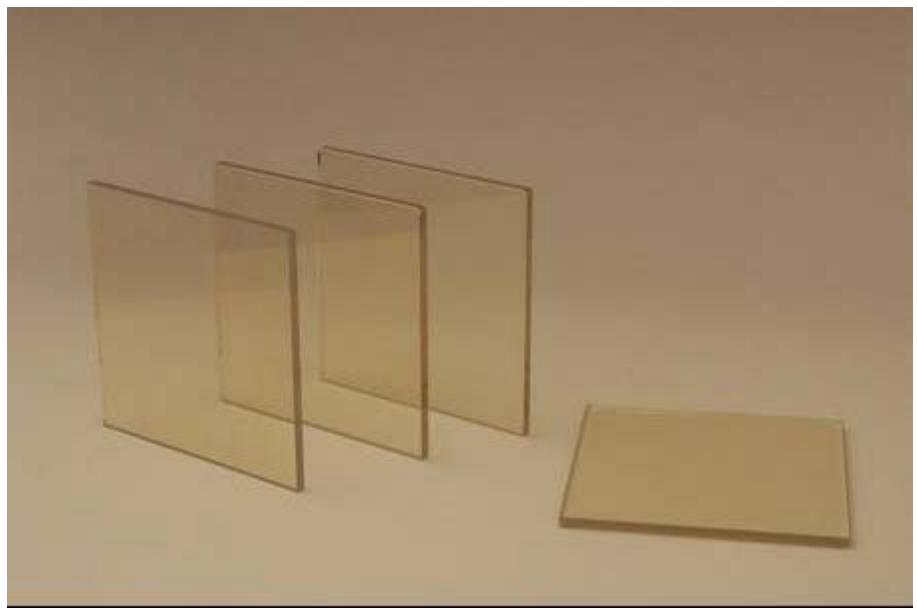

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- Agenda -

1) Introduction of CLEARCERAM®-Z HS (General property)

2) Updates and further investigations on the capability of CLEARCERAM®-Z HS for EUVL Mask Substrates

2-i) CTE characteristics of CLEARCERAM®-Z HS

2-ii) CTE Metrology

2-iii) Surface Finish of CLEARCERAM®-Z HS

2-iv) Research & Development

3) Summary & Conclusion

- Introduction -

Extreme Ultra Violet Lithography (EUVL) :

-> A strong candidate for next generation lithography for mass quantity with small variety chips in 45 - 32nm node.

->> EUVL to apply Extreme Ultraviolet light with 13nm wavelength and reflection optical systems.

->>> Exposure quality is sensitive to the thermal deformation of the substrate for photomask and optics components.

->>>> Low (Zero) thermal expansion material is required for EUVL component substrates.

- Introduction -

Low Thermal Expansion Glass-ceramics Material CLEARCERAM®-Z series

CLEARCERAM®-Z
(CTE 0.0±1.0x10^{-7}/degree C, 0 - +50degree C)

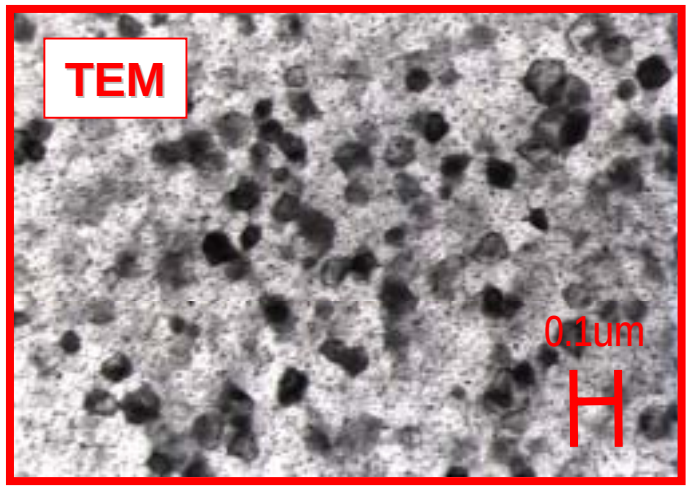
CLEARCERAM®-Z HS
(CTE 0.0±0.2x10^{-7}/degree C, 0 - +50degree C)

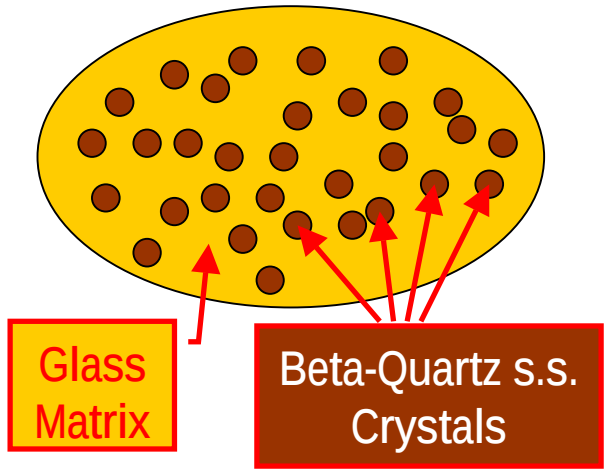
“A candidate for EUVL Photomask substrate material” in the previous report*

*K.Nakajima, “Low-thermal expansion material for EUV applications”, 23rd Annual BACUS Symposium on Photomask Technology, Proceeding of SPIE, Vol. 5256, p.1271, 2003

1) Introduction of CLEARCERAM®-Z HS (General property)

Glass-ceramics Material ->





Property		Unit		CLEARCERAM-Z HS
Thermal Property	Product Tolerance of CTE (0 to +50degree C)	$x10^{-7}$/degree C		0.0 ± 0.2
	Thermal Conductivity	W/(m*degree C)		1.52
Mechanical Property	Specific Gravity (s.g.)	-		2.55
	Young's Modulus (E)	GPa		90
	Poisson Ratio	-		0.25
	Knoop Hardness (Hk)	-		640
Optical Property	Refractive Index (nd)	-		1.53
	Abbe Number (vd)	-		55
	Transmission (10mm Thick)	%	600nm	> 80
			1,000nm	> 90

2-i) CTE characteristics of CLEARCERAM®-Z HS

SEMI P37-1102 specification for EUVL Mask substrate

-CTE specification –

< Class A >
Mean CTE: 0 ± 5ppb/degree C,
Total spatial variation of CTE: 6ppb/degree C

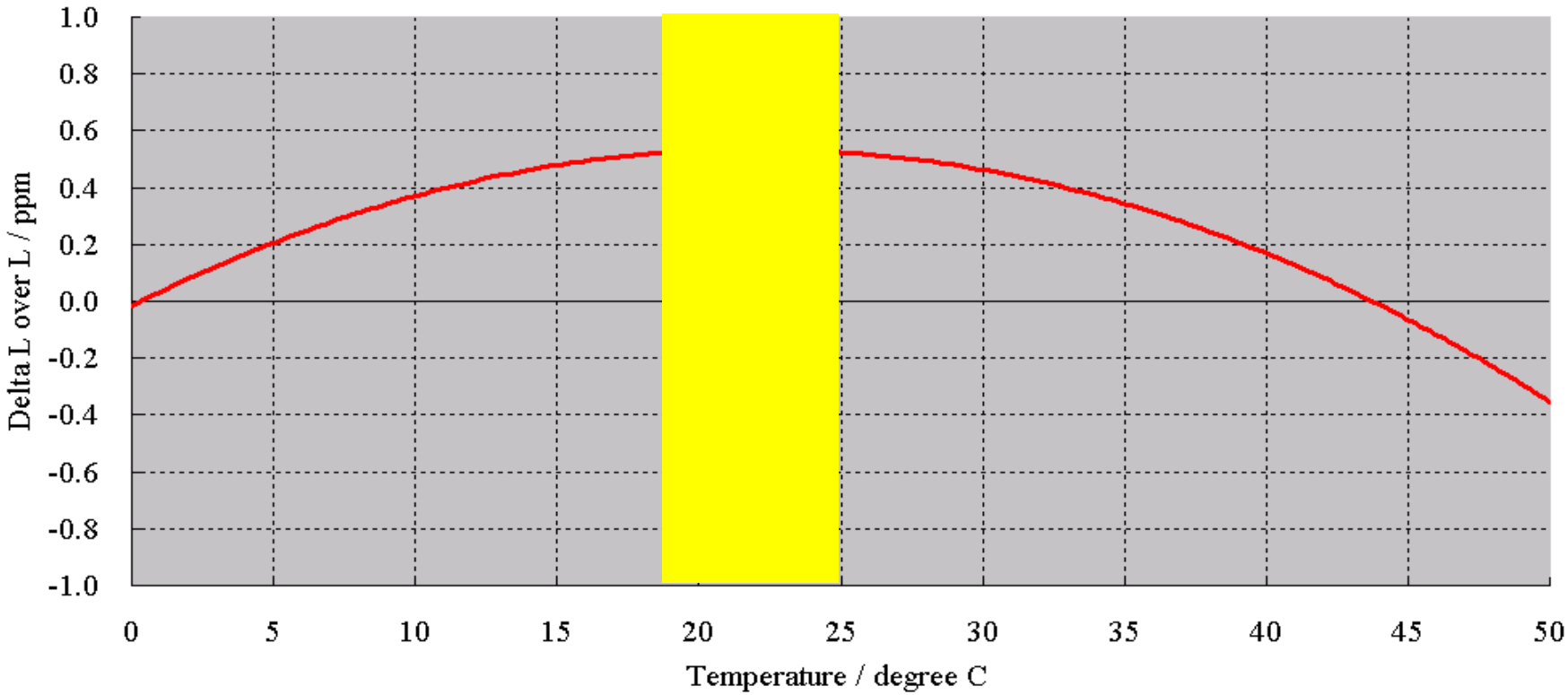
< Class B >
Mean CTE: 0 ± 10ppb/degree C,
Total spatial variation of CTE: 10ppb/degree C

< Class C >
Mean CTE: 0 ± 20ppb/degree C,
Total spatial variation of CTE: 10ppb/degree C

< Class D >
Mean CTE: 0 ± 30ppb/degree C,
Total spatial variation of CTE: 10ppb/degree C

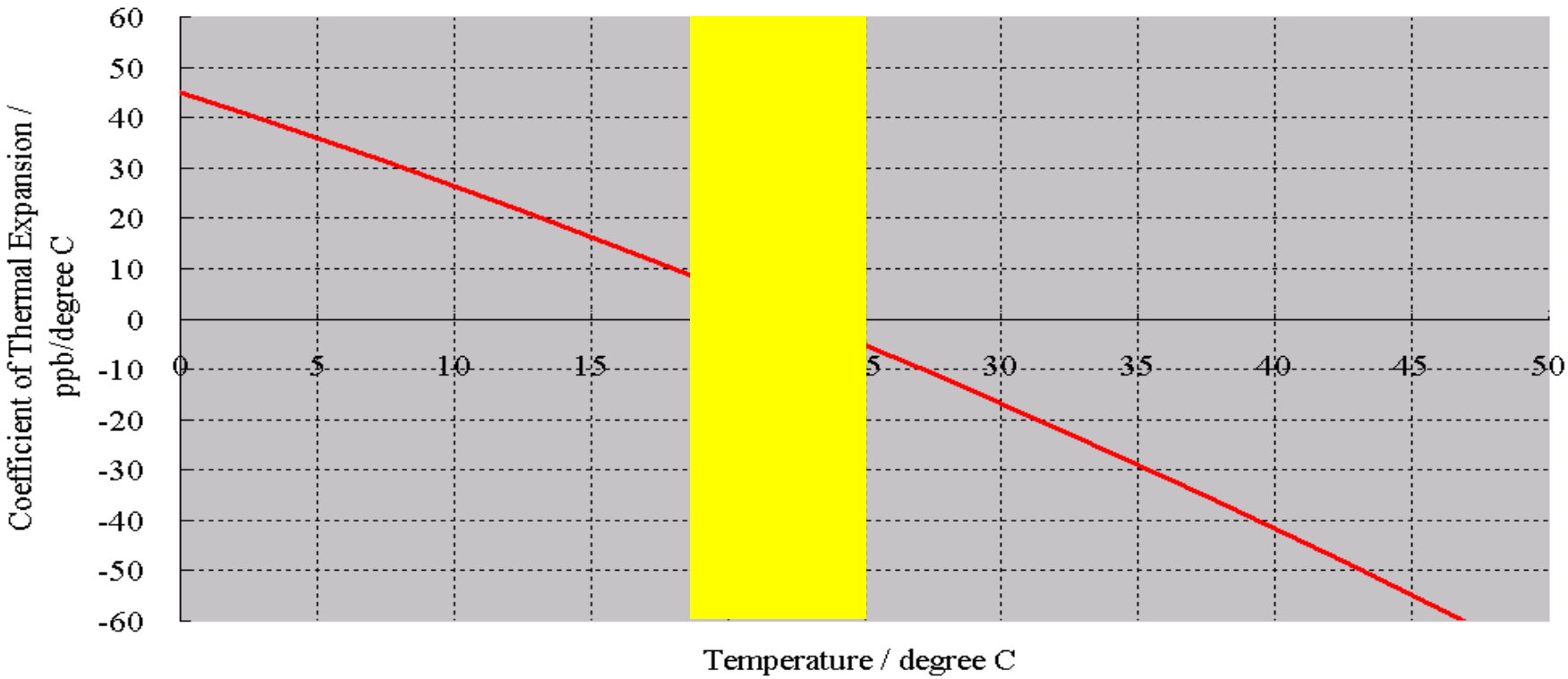
**** Temperature Range : +19 - +25degree C***

2-i) CTE characteristics of CLEARCERAM®-Z HS



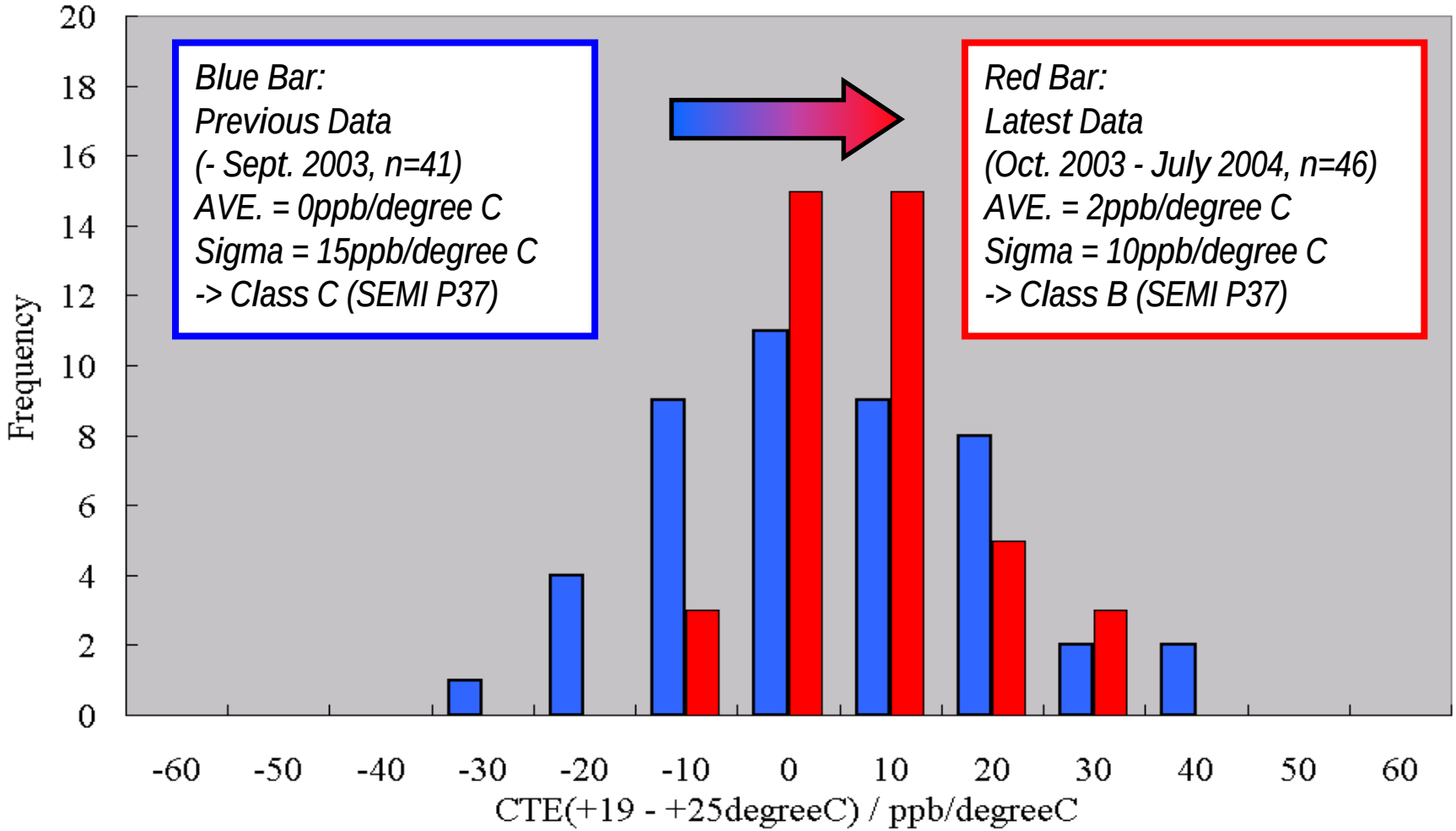
dL/L vs Temp. profile
-> Parabolic centered by the Temperature Range (+19 - +25degree C) designated in the SEMI P37 spec.

2-i) CTE characteristics of CLEARCERAM®-Z HS



CTE vs Temp. profile
-> Zero-CTE point is located in the Temperature Range (+19 - +25degree C) designated in the SEMI P37 spec.

2-i) CTE characteristics of CLEARCERAM®-Z HS



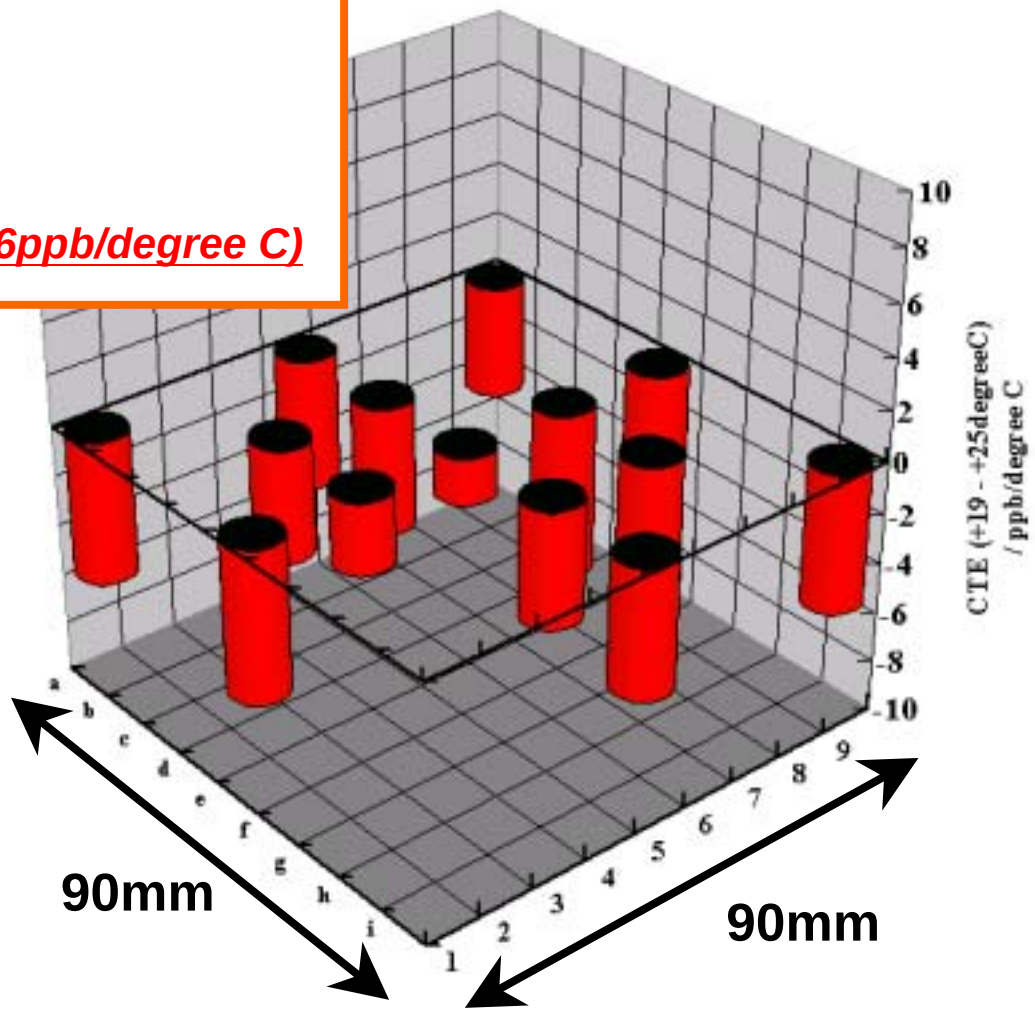
2-i) CTE characteristics of CLEARCERAM®-Z HS

AVE. CTE: -4.9ppb/degree C

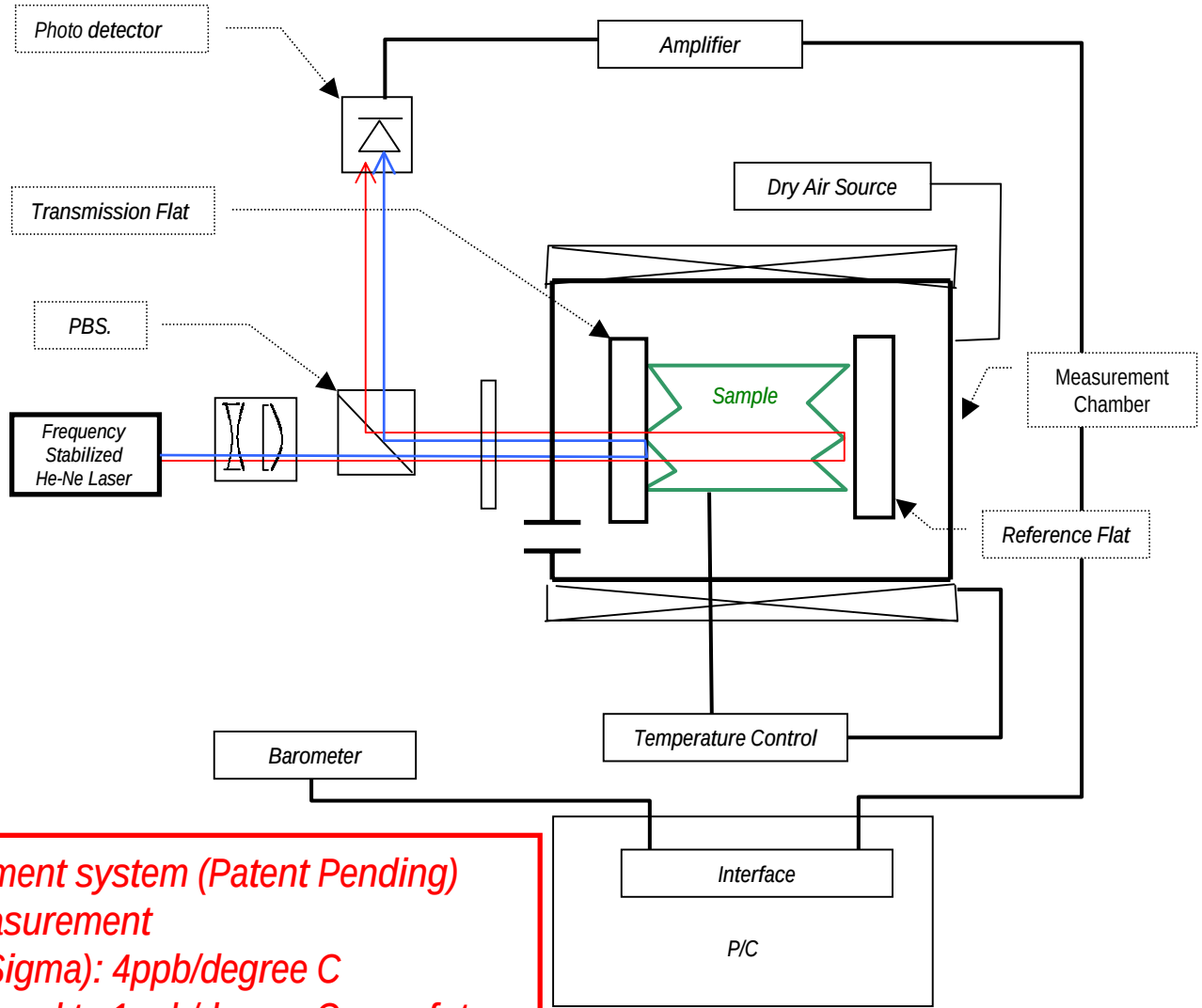
Sigma: 1.3ppb/degree C

Delta CTE: 4.8ppb/degree C

-> Class A SEMI P37 spec. (< 6ppb/degree C)



2-ii) CTE Metrology



> OHARA original CTE measurement system (Patent Pending)
> Fizeau Interferometry CTE measurement
> Measurement Repeatability (2Sigma): 4ppb/degree C
> The repeatability is to be improved to 1ppb/degree C near future

2-ii) CTE Metrology

- CTE data acquisition flow -

The Intensity of the Interference data from the Fizeau interferometric measurement.

Total Optical Path Difference (OPD) info from the Intensity data.

The OPD (sample expansion) calculation by utilizing the known 2 OPD components.

>> Total OPD = OPD (sample expansion) + OPD (the refractive index difference of the air in the chamber)

Known value from measurement

Known value from calculation using Edlen's equation

dL info is derived from the OPD (sample expansion) info.

dL / L_0 vs Temperature plot. -> (Linear) Coefficient of Thermal Expansion.

2-iii) Surface Finish of CLEARCERAM®-Z HS

SEMI P37-1102 specification for EUVL Mask substrate

- Flatness & Roughness specification -

Flatness
(within the 142 x 142mm flatness quality area)

< Class A >
Peak to Valley: 100nm

< Class B >
Peak to Valley: 75nm

< Class C >
Peak to Valley: 50nm

< Class D >
Peak to Valley: 30nm

**For Front & Back side*

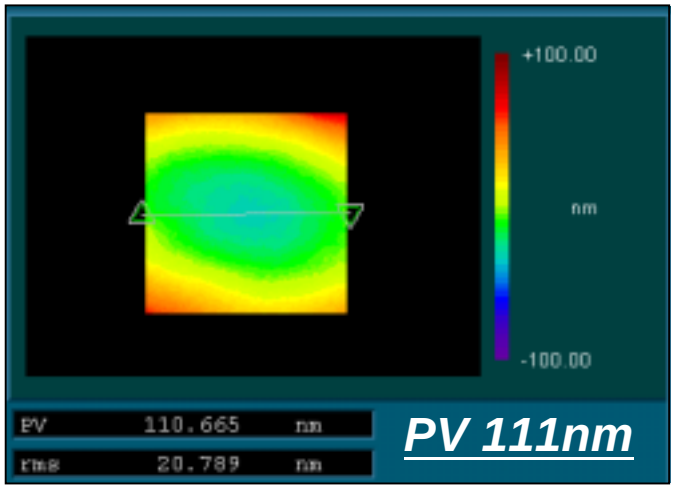
Surface Roughness
(within the quality area)

< Front Side >
Rms ≤ 0.15nm

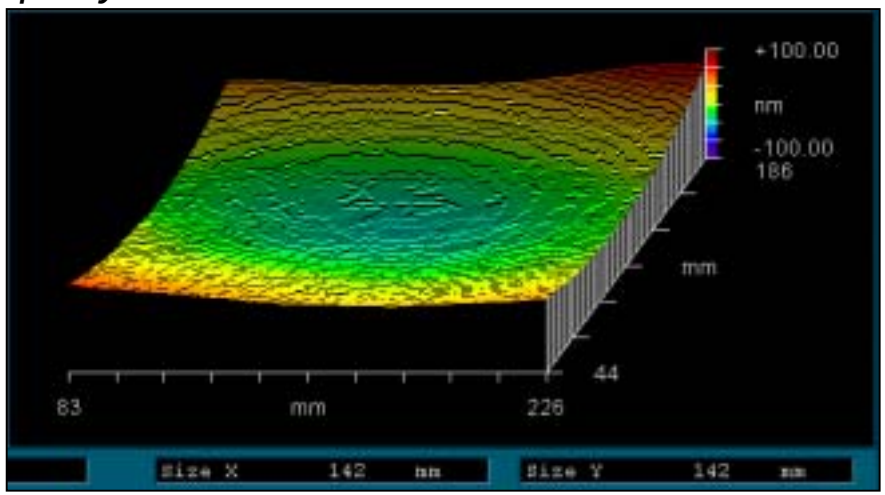
< Back Side >
Rms ≤ 0.50nm

2-iii) Surface Finish of CLEARCERAM®-Z HS

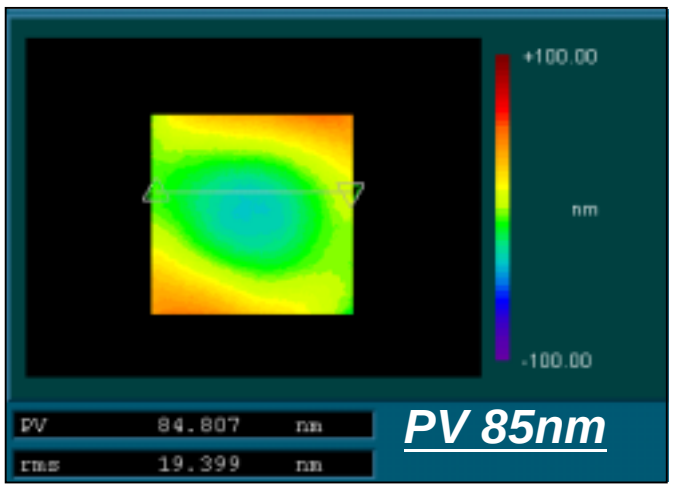
Top Side Flatness Profile for the 142x142mm quality area



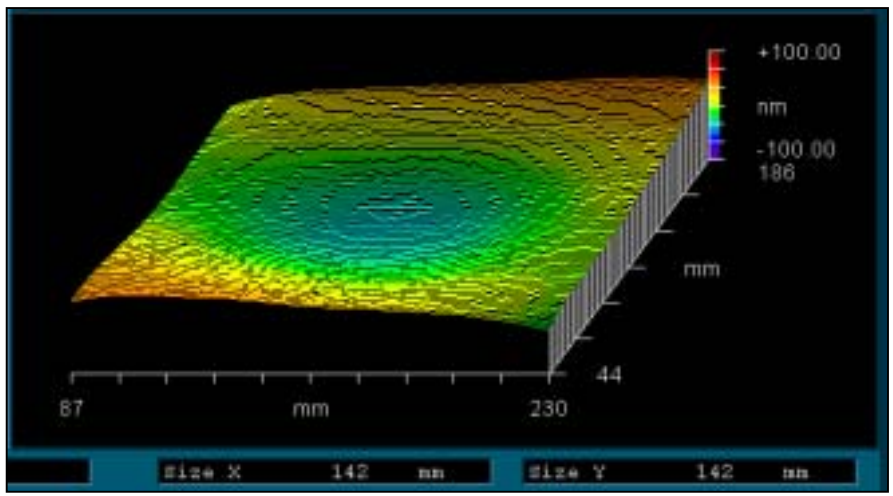
PV 111nm



Bottom Side Flatness Profile for the 142x142mm quality area

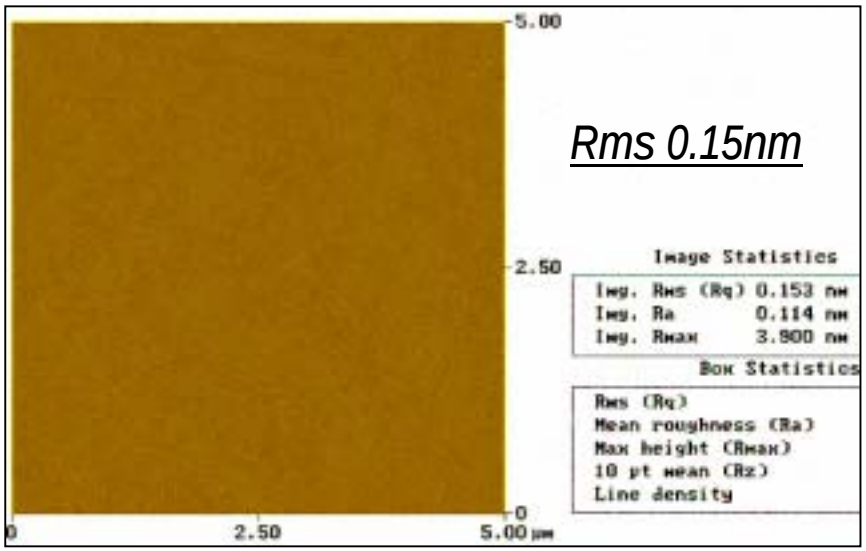


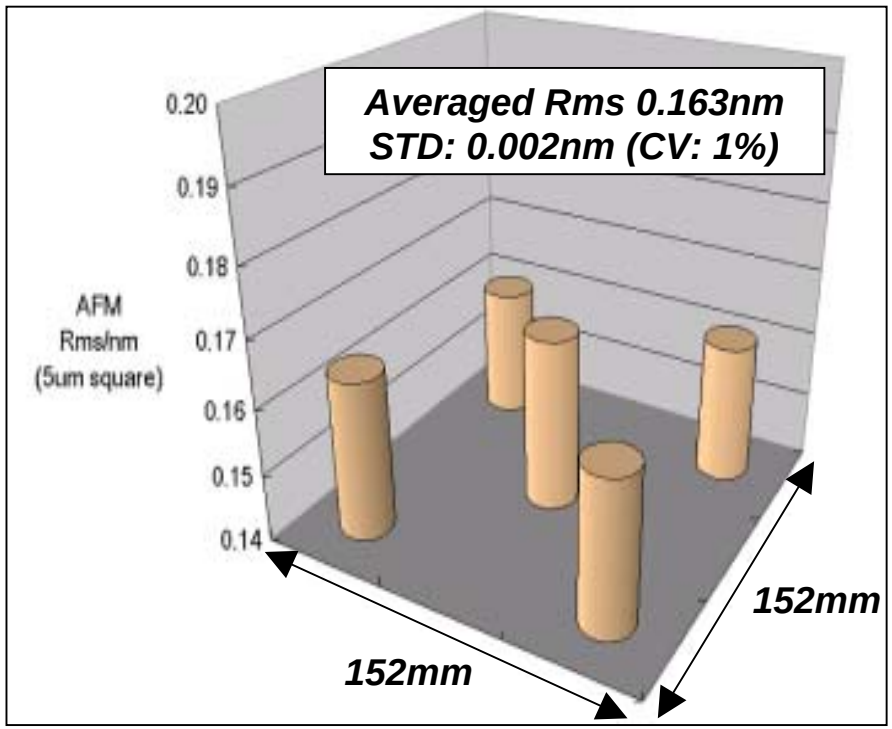
PV 85nm



2-iii) Surface Finish of CLEARCERAM®-Z HS

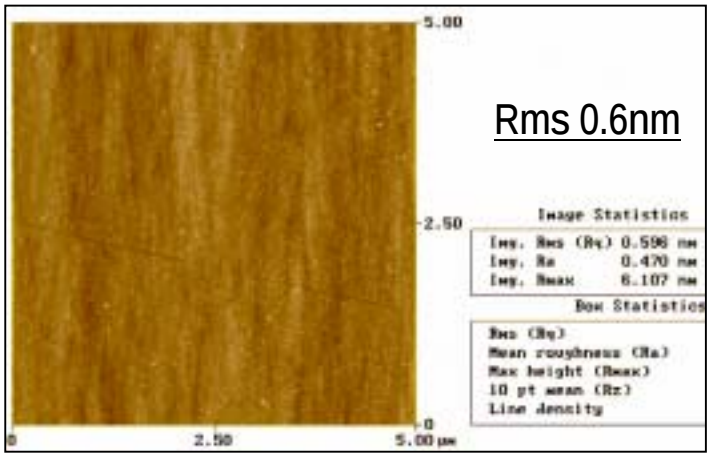
Surface Roughness Uniformity & Profile for the 142x142mm quality area

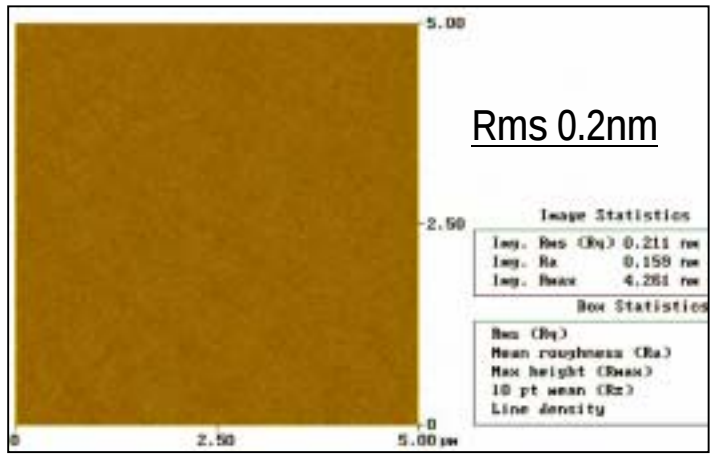




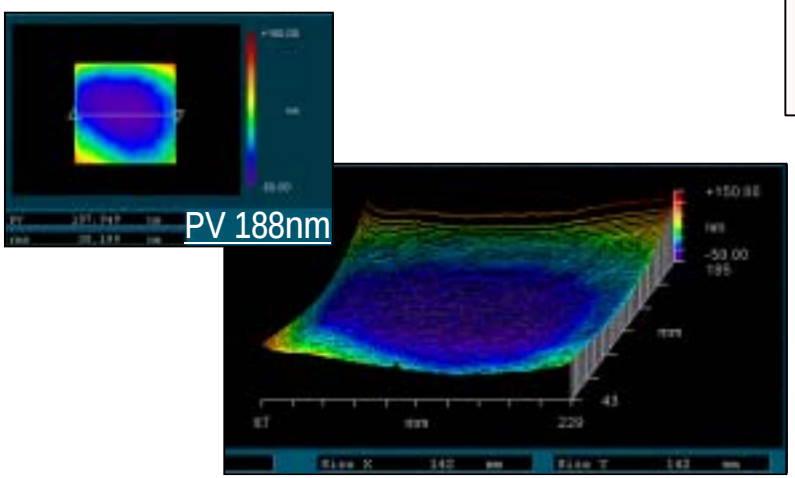
2-iii) Surface Finish of CLEARCERAM®-Z HS

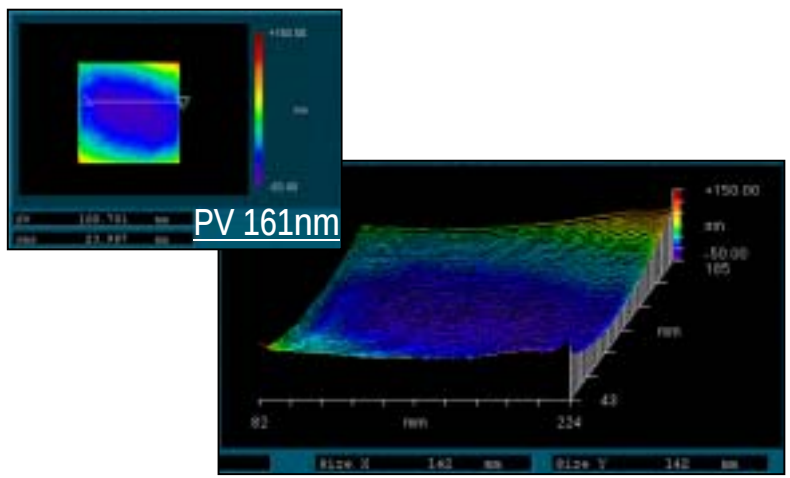
Trial for simultaneous Realization of Smoothness & Flatness on the same substrate





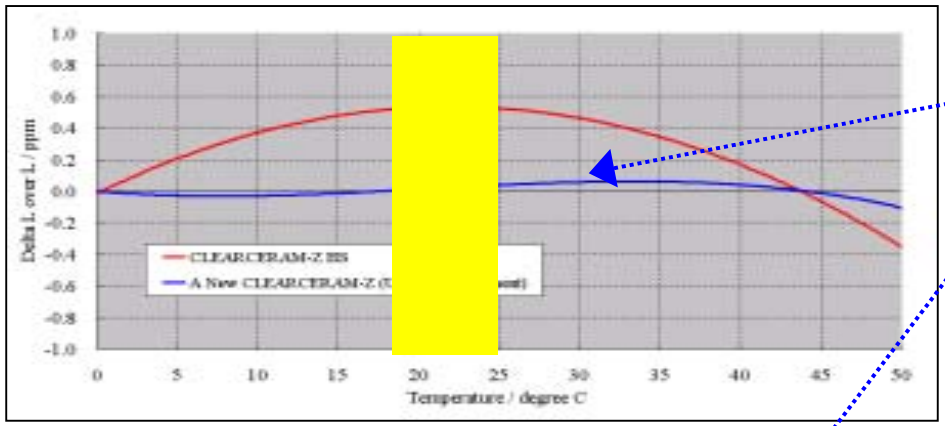
Optimized Smoothing Treatment



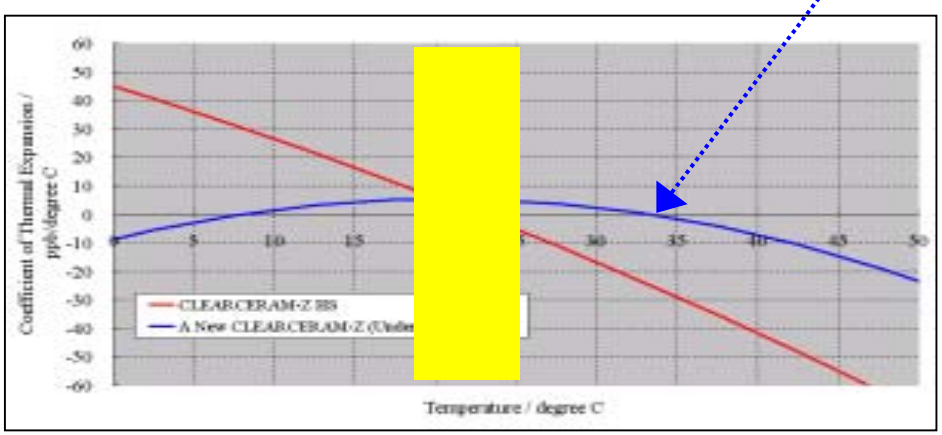


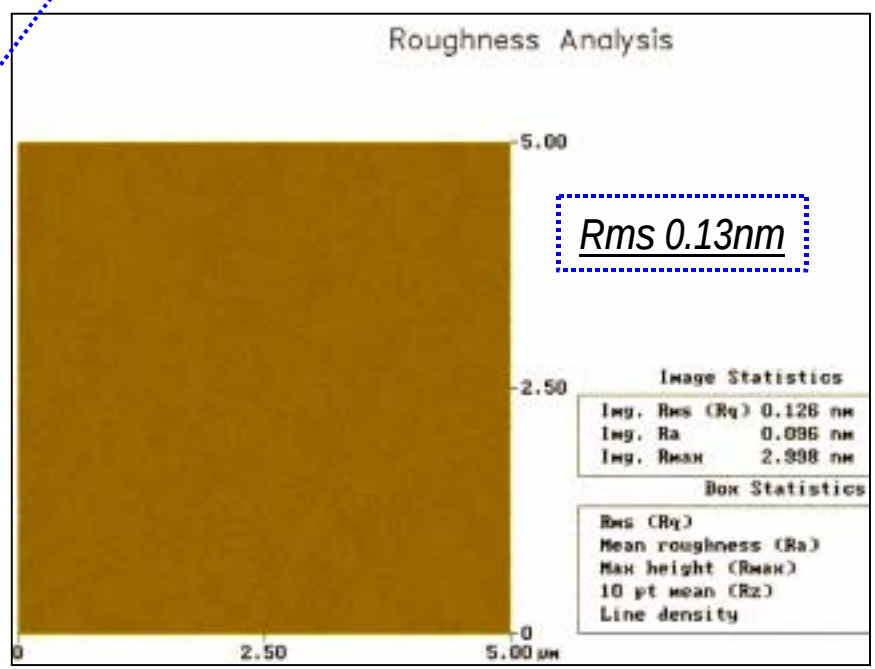
2-iv) Research & Development

-> First results from the Improvements of CTE property and Surface Finish for a new CLEARCERAM®-Z



Flatter Delta dL/L, CTE vs Temp. profile





Rms 0.13nm

3) Summary

1) The inter lot CTE uniformity of CLEARCERAM®-Z HS product has been improved to meet the Class B in the SEMI P37 with statistical confidence, from the Class C level previously reported.

2) The CTE intra block uniformity was found to be within the Class A in the SEMI P37.

3) The most precise repeatability of the CTE measurement system at OHARA Inc. is 4ppb/degree C and to be improved to 1ppb/degree C near future.

4) The surface finish capabilities of CLEARCERAM®-Z HS relative to SEMI P37 were presented by the surface figures from demonstrative tests.
Further investigations are undergoing for simultaneous realization of both specs.

5) A New CLEARCERAM®-Z material is being under developing at OHARA Inc. and the first results on the CTE profile and the surface roughness look promising.

3) Conclusion

-> OHARA is implementing systematic preparations to introduce CLEARCERAM®-Z series for EUVL Photomask Substrate material application.

*-> The data of CTE property and surface finish for CLEARCERAM®-**Z** series indicated its capability & suitability for EUVL Photomask Substrate application.*

-> Further investigations will continue at OHARA for more fit for the application and benefit for users.