Study of Impact of Particles between EUV Reticle and Electrostatic Chuck

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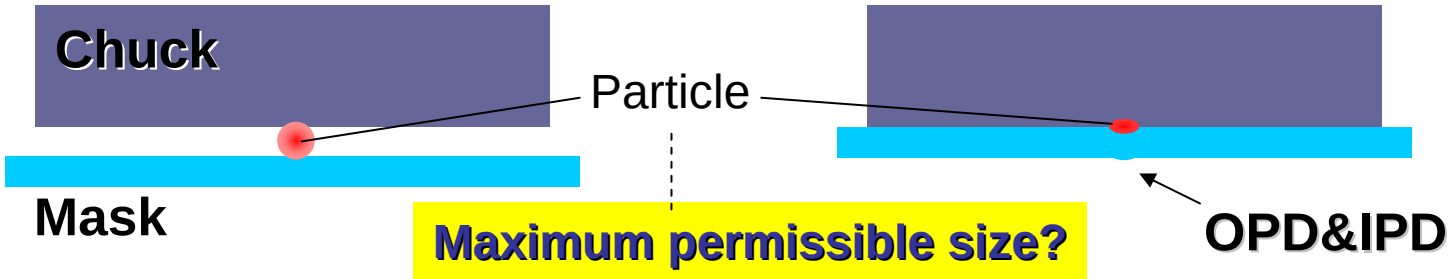
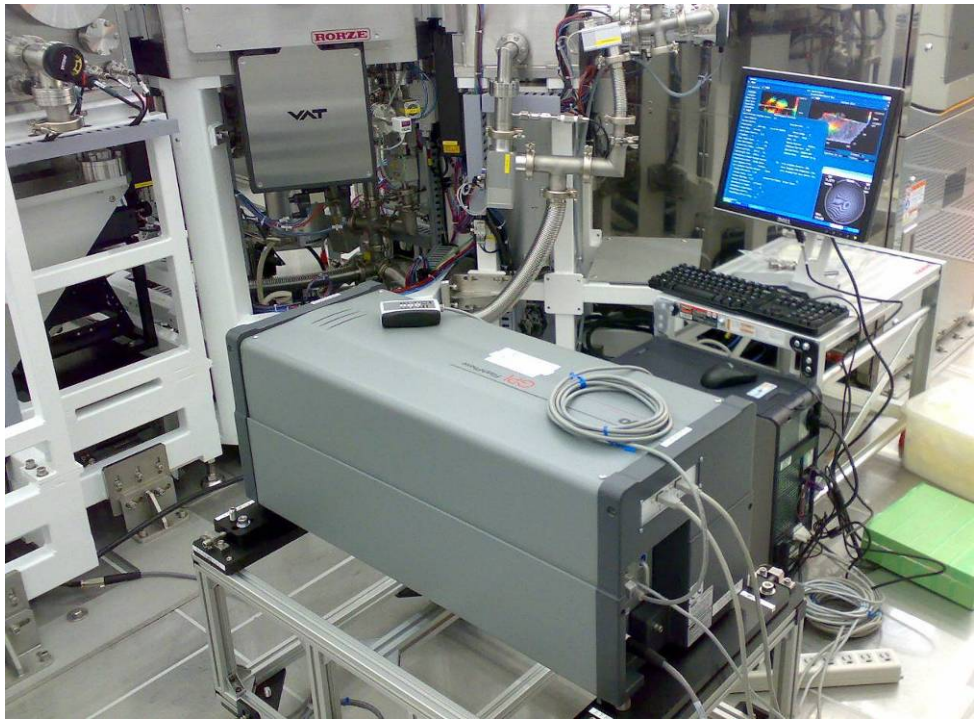
Our Goal

- To know the maximum permissible size of particles between the chuck and the reticle.
  - Criteria
    - OPD (Out-of-Plane Distortion) < 50nm
    - IPD (In Plane Distortion) < 5nm
  - Conditions
    - Chucking pressure > 15kPa
    - Reticle substrate: ULTEM ~ Ti-doped Qz
    - Chuck substrate: ex. Ceramics
    - Material of particle: TBD

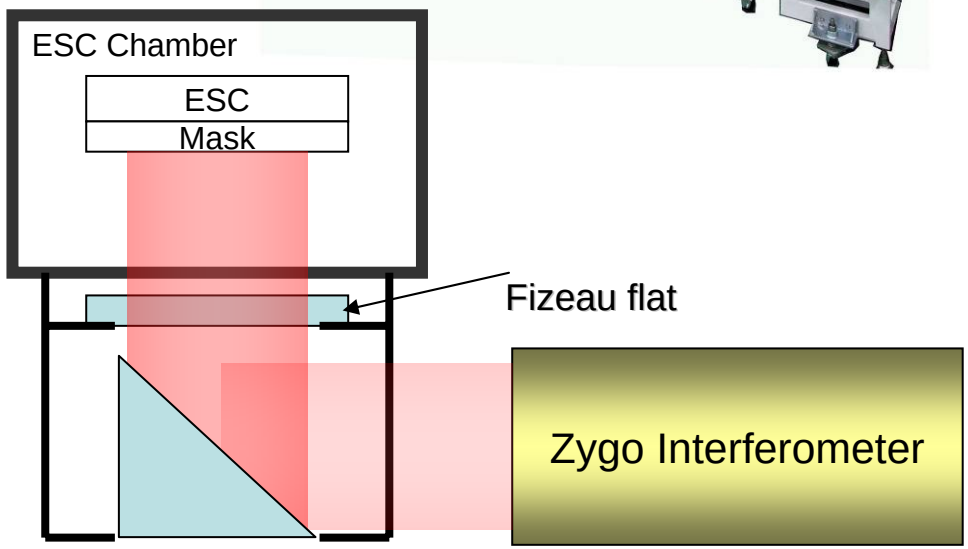


Flatness Measurement Setup

Zygo interferometer has been installed in MPE Tool.



Zygo Interferometer

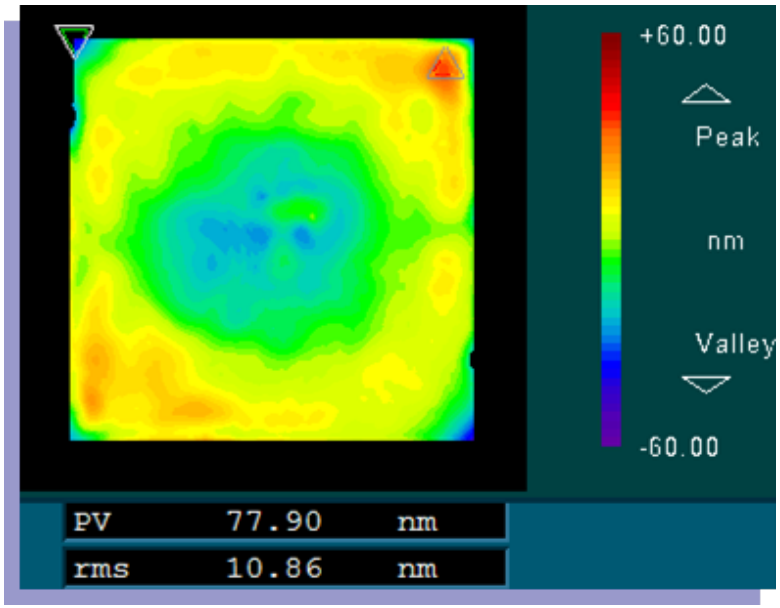


Electrostatic Chucks for MPE Tool

- Two chucks fabricated.

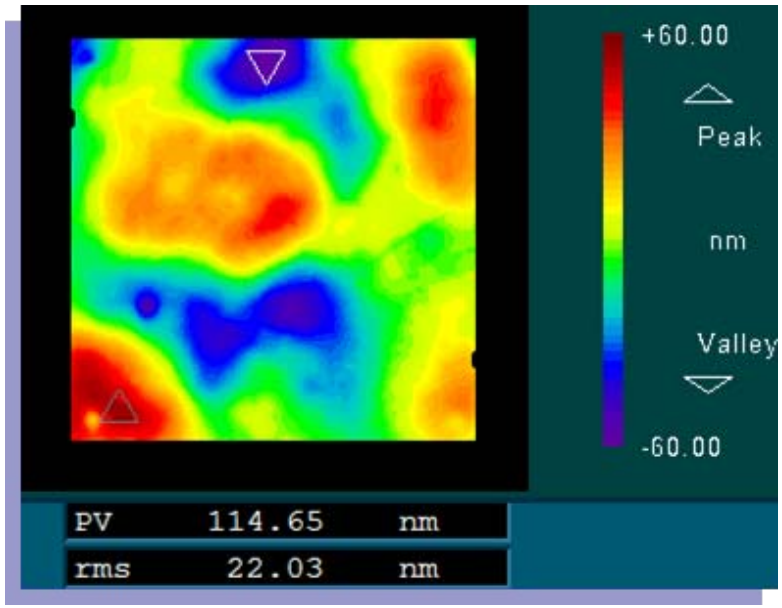
Chuck-1 (by Hitachi Chemical Co. Ltd.)

- Chucking pressure: >15kPa@70V
- Chucking pressure variation: < +/-10%
- Flatness: 78nm @ 142x142mm^2
- Thickness: 40mm
- Material: SiC



Chuck-2 (by Nihon Ceratec Co.,Ltd.)

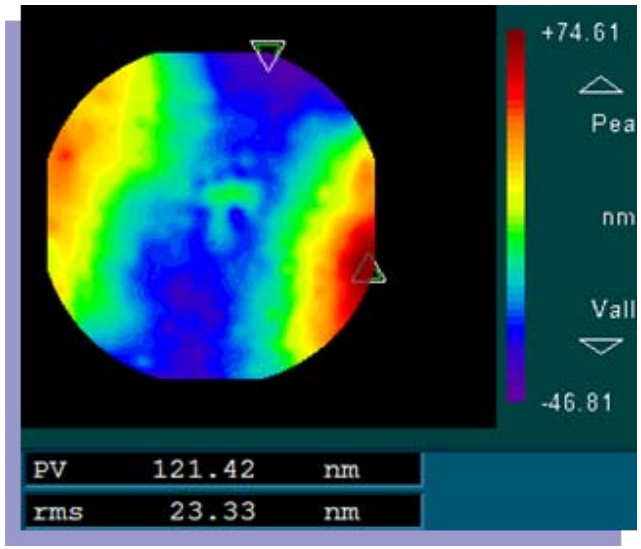
- Chucking pressure: >15kPa@100V
- Chucking pressure variation: +/-45%
- Flatness: 115nm @ 142x142mm^2
- Thickness: 30mm
- Material: Ultra Low Expansion Ceramics



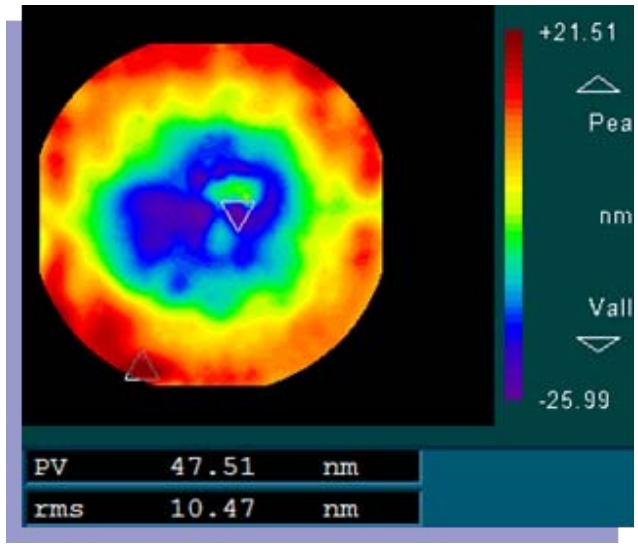
Measured by the flatness interferometer “FUJI”, accuracy ~ 10nm@P-V
(Courtesy of National Metrology Institute of Japan, AIST)

Chuck Flatness Measurement in Selete

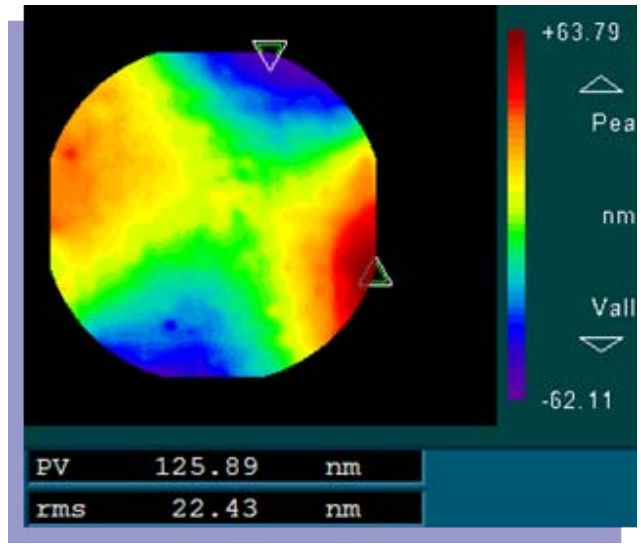
- Chuck-1 was installed in MPE Tool and measured with Zygo interferometer.



Selete Data



AIST Data



(Selete) – (AIST)

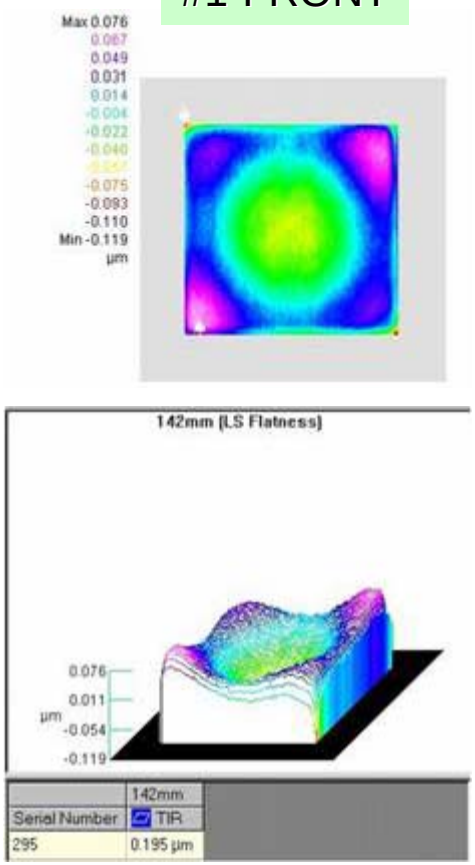
* Data plot area: (ϕ142mm) ∩ (□135mm)

↑ Errors
- Chuck mounting distortion
- Optical distortion of the view port
- Interferometer errors

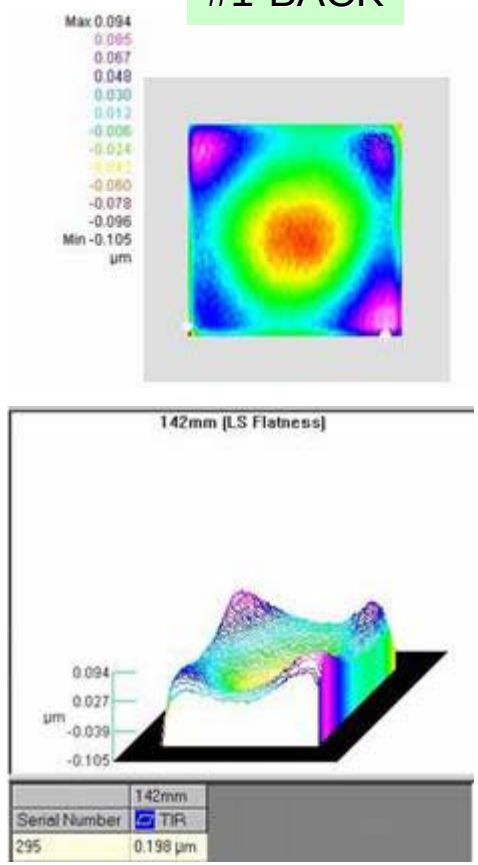
Substrate Flatness/Thickness

- Two substrates were used. Both substrates have about 300nm@P-V thickness variation like a concave lens.

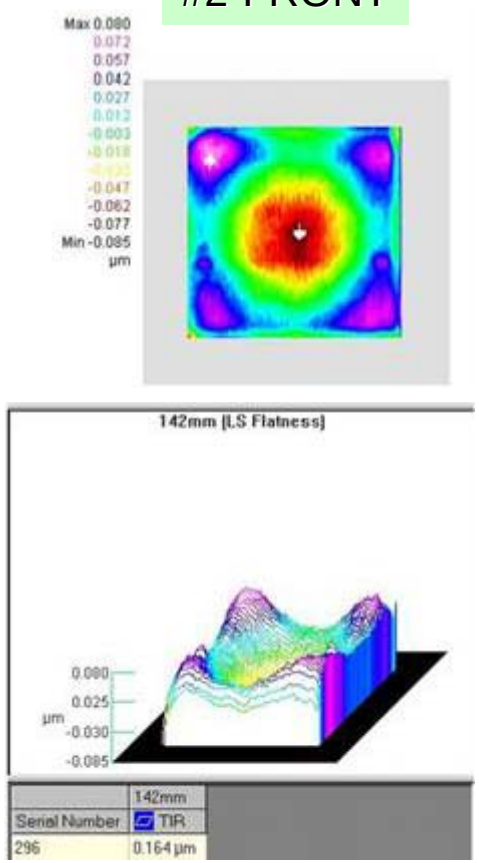
#1-FRONT



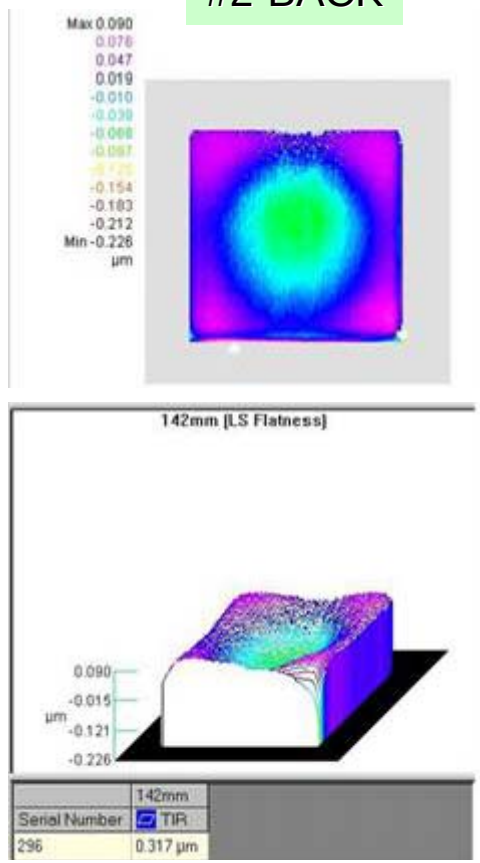
#1-BACK



#2-FRONT



#2-BACK

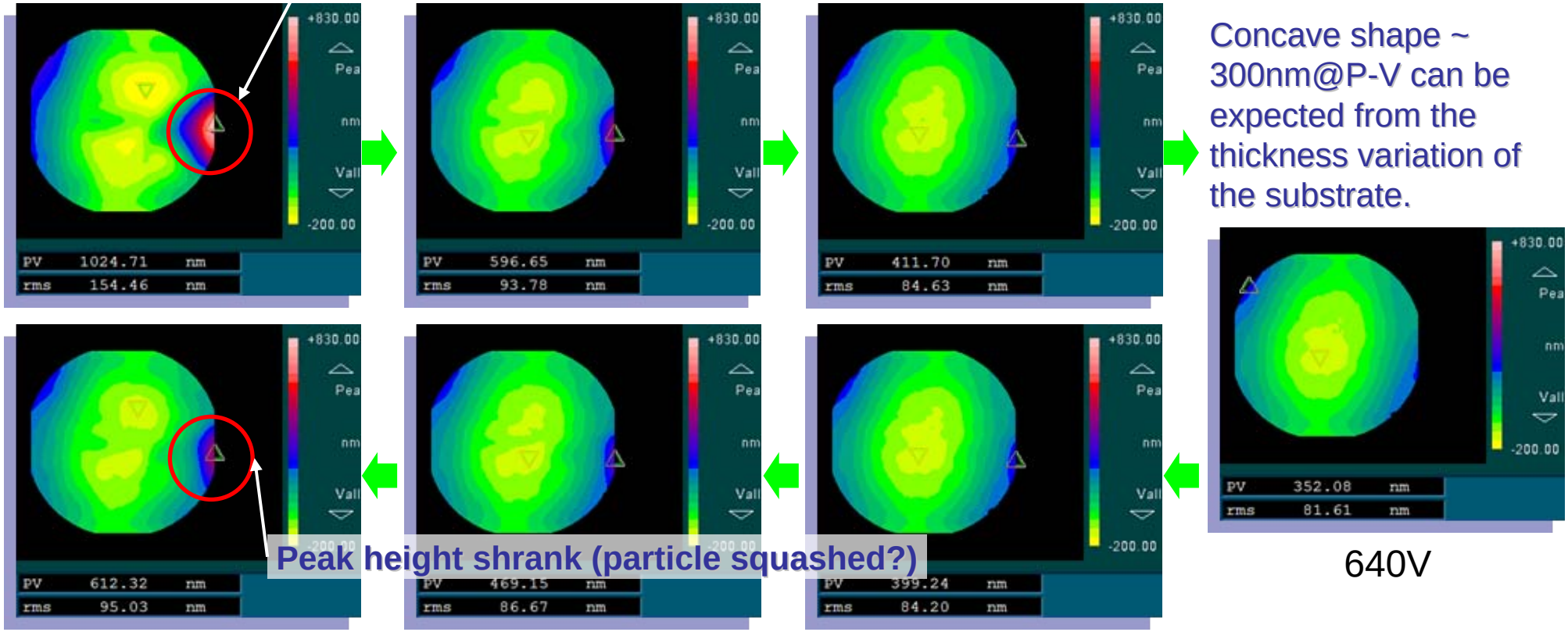


Supplier's data

Chucked Substrate #1 Flatness

- Conditions
  - ESC impressed voltage (V): 80→160→320→640→320→160→80

Distinctive peak (particle jammed?)



Concave shape ~ 300nm@P-V can be expected from the thickness variation of the substrate.

Peak height shrank (particle squashed?)

640V

80V 160V 320V

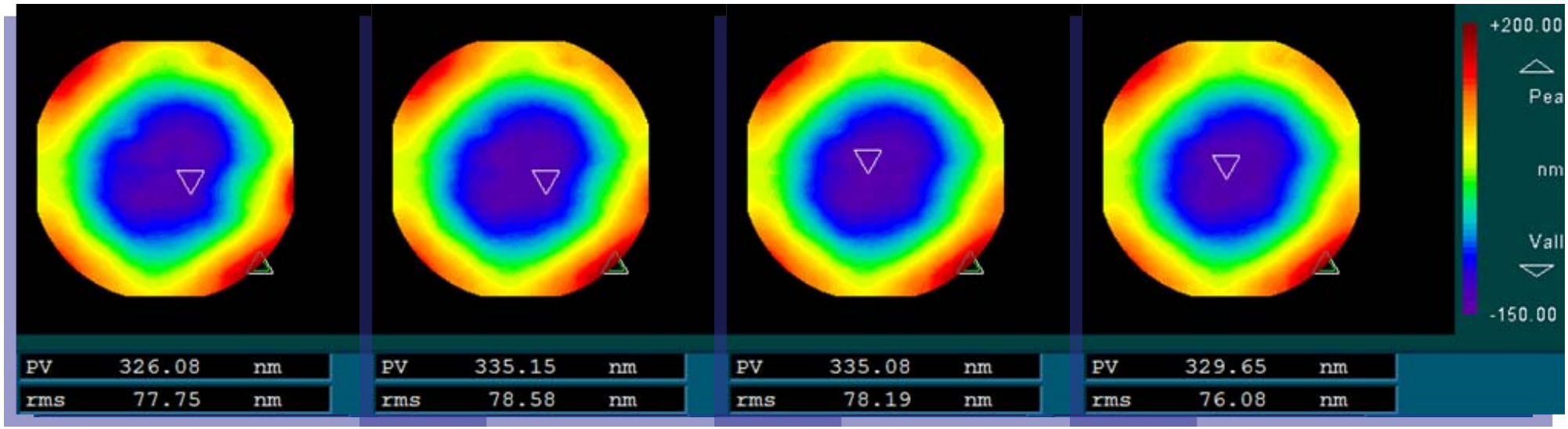
*Plot color: Neons

* Plot area: (ϕ142mm) ∩ (□135mm)

Chucked Substrate #2 Flatness

- Conditions
  - ESC impressed voltage (V): 80, 160, 320, 640

Concave shape ~ 300nm@P-V can be expected from the thickness variation of the substrate.



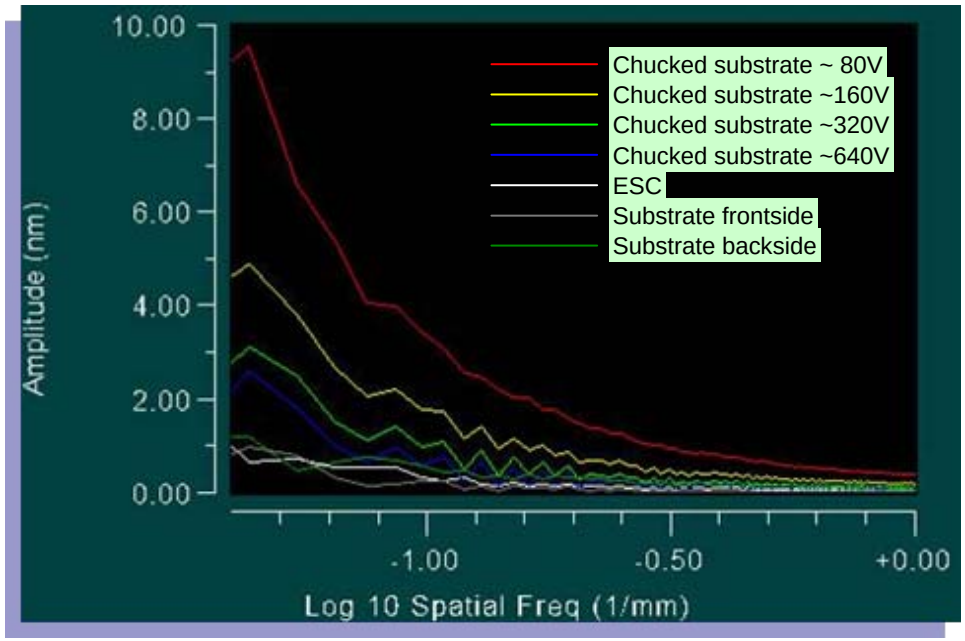
80V 160V 320V 640V

P-V values not changed!
(no particle jammed?)

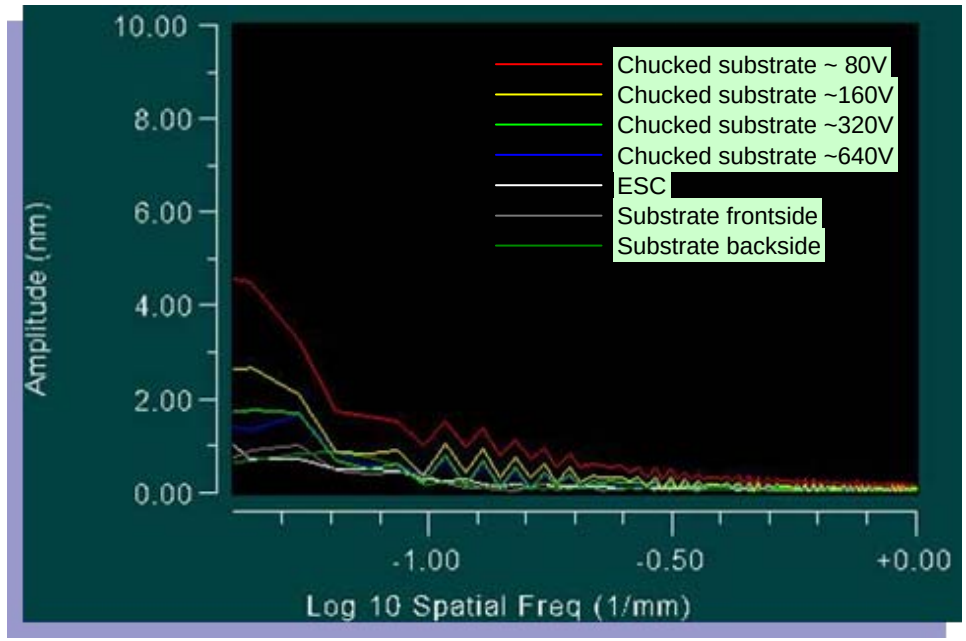
*Plot color: Spectrum
* Plot area: (ϕ142mm) ∩ (□135mm)

Chucking Pressure vs. Flatness Frequency Response

- Higher chucking pressure can compensate higher spatial frequency non-flatness.



Substrate-#1 Amplitude Spectra

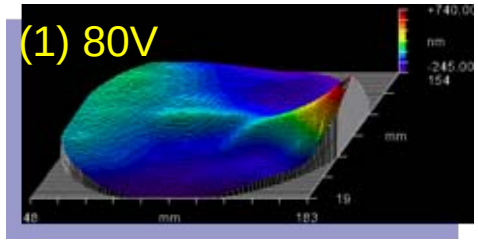


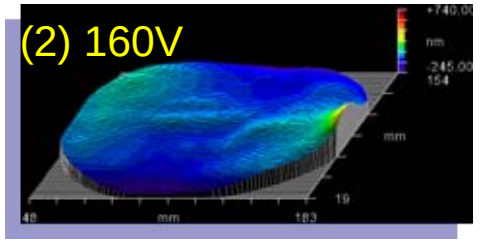
Substrate-#2 Amplitude Spectra

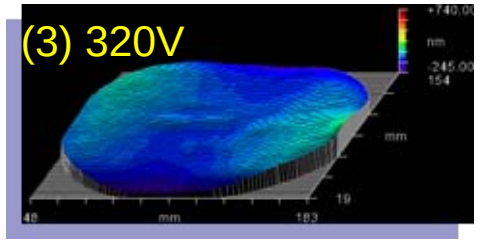
Calculated area: ϕ100mm
Power component removed before the spectrum calculation.

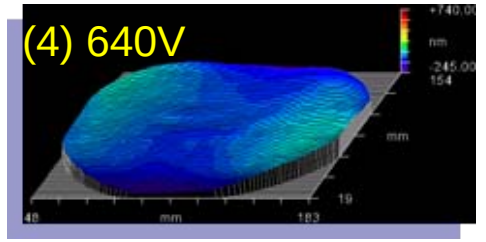
Propagation Length of Particle Induced OPD

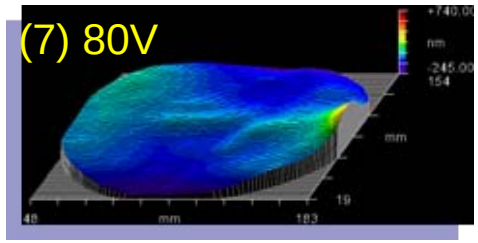
- We can estimate the propagation length of particle induce OPD from the flatness data of the substrate #1.

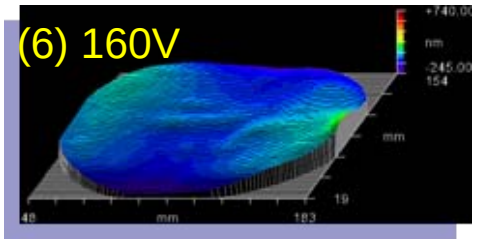


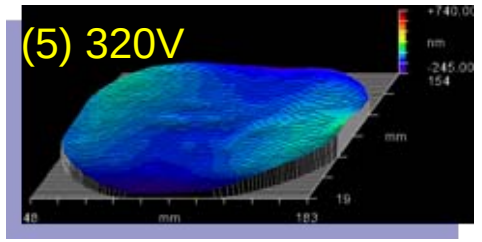




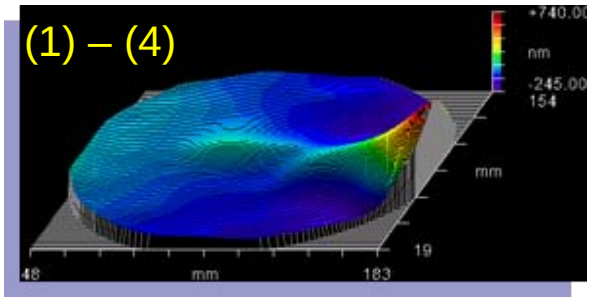


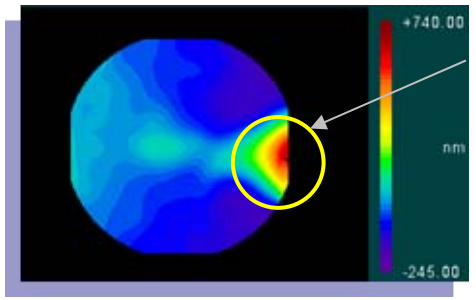






Zmax = 740nm
Zmin = -245nm
Power component removed.





r = 28mm

The peak height was about 1 micron at the beginning.
The OPD spread about 28mm.

Summary

- MIRAI-Selete has started the flatness evaluation of ESC and mask substrates using MPE Tool.
- We confirmed that higher chucking pressure can compensate higher spatial frequency non-flatness of substrates.
- We confirmed that higher chucking pressure can reduce the particle induced OPD.

*** This work is supported by NEDO.**