Experimental Evaluation of Out-of-Plane Distortion of Electrostatically Chucked EUV Reticle

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Motivation

• 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

![Diagram of chuck, mask, particle, and OPD&IPD]
Flatness Measurement Setup

Zygo interferometer has been installed in MPE Tool.
Chuck Flatness Measurement in Selete

- An electrostatic chuck made of SiC was installed in MPE Tool and the surface flatness was measured using Zygo interferometer.

Data plot area: (φ142mm) ∩ (135mm)

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

1. To place programmed particles on substrates.
   - Carbon particles deposited using FIB.
   - Qz glass particles quarried out from the substrate itself using FIB.

2. To chuck the substrates and measure the flatness of the front surfaces.

3. To observe the programmed particles after chucked.
Programmed Particles (1)

(1) Carbon particles deposited using FIB

Substrate(1)

50mm
Programmed Particles (2)

(2) Quartz glass particles quarried out from the substrate itself using FIB
Flatness Measurement Results (1) ~ Carbon Particles

No bump observed!

Raw Data

High pass filtered (>0.1mm⁻¹)

* Plot area: (ϕ142mm) ∩ (ϕ135mm)

ESC 80V (~20kPa)  
PV 7.9 nm  
rms 0.54 nm

ESC 160V (~78kPa)  
PV 8.0 nm  
rms 0.53 nm
Flatness Measurement Results (2) ~ Quartz Particles

No bump observed!

Raw Data

High pass filtered (>0.1mm⁻¹)

ESC 80V (~20kPa)

ESC 160V (~78kPa)

* Plot area: (φ142mm) ∩ (□135mm)
Story of Carbon Particles

- $5\mu m(W) \times 5\mu m(D) \times 5\mu m(H)$

  ![before](image1)
  ![after](image2)
  Crushed!!

- $5\mu m(W) \times 5\mu m(D) \times 1\mu m(H)$

  ![before](image3)
  ![after](image4)
  Partially subsided!!
Story of Quartz Particles

- 3µm(W) x 5µm(D) x 6µm(H)

before

after

Crushed!!

- 1µm(W) x 5µm(D) x 3µm(H)

before

after

Collapsed!!
Summary

1. We evaluated the impact of particles between the chuck and the reticle. The particles were carbon particles deposited using FIB and quartz particles quarried out from the substrate using FIB.

2. The particles bigger than 3\(\mu\)m were crushed and the particles about 1\(\mu\)m partially subsided when chucked.

3. There were no OPD change observed by the programmed particles.

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