Design and Preliminary Results of an Atmospheric Chamber to Evaluate Nanoparticle Protection Schemes for EUVL Carrier System

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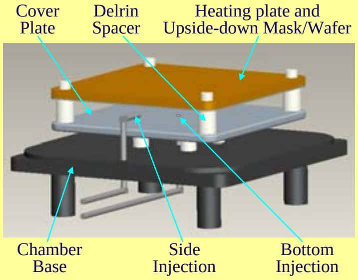
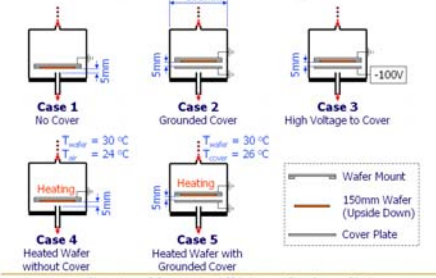
Motivation and Objectives

It is important to understand particle transport and deposition mechanisms during handling or shipping of masks. Because of the strong material absorption at EUV wavelength, pellicles cannot be used effectively to protect the critical mask surface in EUVL systems. An atmospheric chamber was built for nanoparticle deposition studies. In the chamber, the critical mask/wafer surface was placed upside down to reduce particle deposition due to gravitational settling. Here we use a cover plate to protect the masks from nanoparticle deposition, and evaluate the effectiveness of electrophoresis and thermophoresis in preventing nanoparticle deposition.

Chamber Design

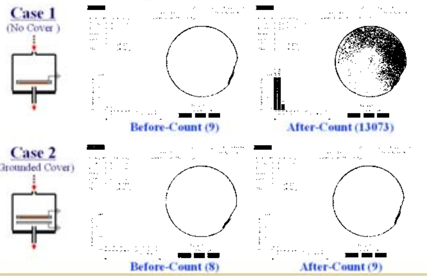


Particle Injection from Top



Note: Aerosol flowrate Q = 0.5L/min, sampling time t = 20min.

Results of Top Injection (D_p = 125nm)



1 particle was added in Case 2.

Comparison of Protection Factors

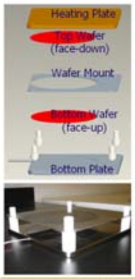
$$PF = \frac{\text{Total number of particles injected into the chamber}}{\text{Number of particles added on the wafer}}$$

If PF → ∞ : Good protection (no particles added)
If PF → 1 : Bad protection (many particles added)

Case	Particle Size (nm)	Total Number of particles	Before Sampling	After Sampling	Particles Added	Protection Factor
1	125	8.0×10^6	9	13073	13064	612
	400	2.7×10^6	9	7389	7380	366
2	125	8.0×10^6	8	9	1	8.0×10^6
	400	2.7×10^6	5	9	4	6.8×10^5
3	125	8.0×10^6	9	8	0	∞
	400	2.7×10^6	5	5	0	∞
4	125	5.0×10^6	20	4857	4837	1033
	400	3.0×10^6	9	6657	6648	451
5	125	5.0×10^6	28	20	0	∞
	400	3.0×10^6	9	9	0	∞

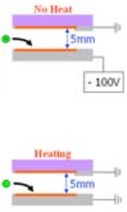
Note: 1. Wafer scanning repeatability: ±4 particles, if total particle number < 50.
2. Particles with Boltzmann's charge distribution.

Particle Injection from Side



Electrophoresis

- Singly charged particles
- Electric field: 200V/cm
- Injection speed: 30.1cm/s
- Total particle number: 1.5×10^6
- Sampling time: 5min

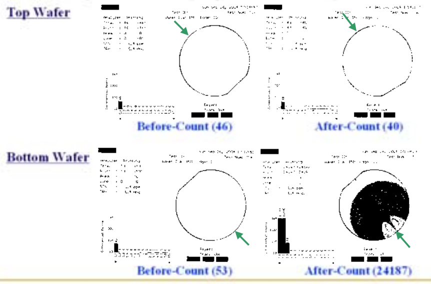


Thermophoresis

- Zero charge particles
- Temp. difference: 5K
- Injection speed: 30.1cm/s
- Total particle number: 3.0×10^6
- Sampling time: 20min

Note: Inner diameter of the side injection tube is 4.6mm.

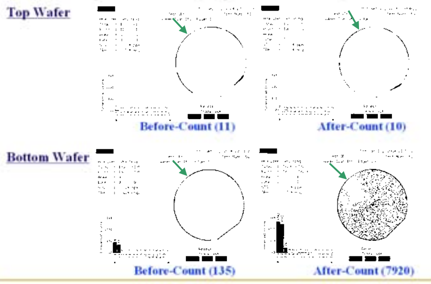
Electrophoresis (D_p = 125nm)



No particles were added to the top wafer.

Note: → Direction of particle injection

Thermophoresis (D_p = 125nm)



No particles were added to the top wafer.

Note: → Direction of particle injection

Conclusions

- The atmospheric chamber was constructed to evaluate thermophoretic and electrophoretic protection schemes for EUVL carrier system.
- Polystyrene Latex (PSL) particles were injected from the top and the side injection ports into the chamber.
- The effectiveness of the cover plate was studied experimentally.
  - The cover plate was very effective in protecting the wafer surface.
  - Electrophoresis and thermophoresis can provide further protection.

Researchers

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Related Presentations

Oral Presentation (Nov. 3, Ha01):
Vacuum Chamber Study

Other Poster (HaP03):
Modeling Studies

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