4i Protection Schemes for Extreme Ultraviolet Lithography (Euvl) Masks in Low Pressure Environments

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Protection of critical surfaces such as masks and wafers during manufacturing is an important issue for the EUVL process development. Surface contamination from nanoparticles is one of the important challenges for the future EUVL applications. Since most of the EUVL operations are under low pressure conditions, it is crucial to understand particle behavior in low pressure systems for preventing any particle contaminations.

1. Protection during vacuum pump down Particle formation during pump down is examined with temperature measurements. Particles are intentionally produced at hard pump down condition for studying protection schemes. First, a face-down approach for a critical surface is used to investigate the effectiveness of protection from particle contamination. Because of the high gravitational settling speed in the vacuum environment, the face-down approach provides a high degree of protection from particle contamination. Second, a bottom plate is introduced below the critical surface to further improve the protection efficiency. The bottom plate is effective because it prevents particle formation near the critical surface by keeping the surrounding gas temperature sufficiently high to avoid particle formation. Higher gas temperature intrinsically avoids condensation induced particles from forming during pump down. It also serves as a shield to block incoming particles toward the critical surface.

2. Protection against existing particles inside the vacuum chamber For existing particles detached from the valves and the chamber wall, thermophoresis is considered as a candidate for the protection of EUVL masks from these particles during vacuum exposures. A thermophoretic force is exerted on a particle by surrounding gas molecules within a temperature gradient. Gas molecules on the “warm side” of the particle provide more momentum than on the “cool side”, so particles move from the warm to the cool region. A temperature gradient can be set up by either heating the critical surface or by cooling the bottom plate. Thermophoretic protection of the critical surface from particles injected with known initial speeds into a quiescent gas has been investigated at pressures down to 25 mTorr. Initial particle speed is also an important parameter to investigate thermophoretic protection depending on the gap distances, particle sizes, and system pressures. A pinhole plate is designed to supply speed controlled particles with almost no accompanying gas flow. Thermophoresis is found to provide excellent protection for low-velocity particles subject to diffusional motion in the vacuum system.