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Dissertation Announcement

A Novel Resist Removal Tool Based on a Surface Wave Plasma Applicator

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We have developed a plasma system for removing photoresist from silicon wafers where reactant gas flowing in a quartz tube is activated by a high power, 2.45 GHz surface wave discharge at pressures near 80 Torr. The plasma applicator is based on Moisan's 'surfaguide' design where the discharge tube passes through a thin-walled coupling aperture in a reduced-height wave-guide section. The directional flow of process gas in the tube suppresses the discharge on the upstream side of the waveguide. This same flow, in conjunction with the downstream surface wave, produces a plasma jet that emerges from the end of the discharge tube and carries hot, activated gases to a wafer clamped to a heat 200 mm chuck scanning with speed and acceleration up to 1.1 m/s and 2g, respectively. The discharge tube is cooled by a counter-flow of clean, dry air confined in a coaxial outer tube; this enables extended operation at 2.5 kW for O_2/N_2 discharges. The efficiency of converting microwave power to thermal jet power is 21% for a substrate-to-source distance of 0.9 cm. The jet, about 1 cm in diameter, carries a thermal power of 500 W. The time-to-clear 1.2 µm thick, unimplanted photoresist is about 10 seconds for a 70 cm/s scan speed and 200 ^{o}C chuck temperature. This corresponds to an instantaneous etch rate of about 4000 µm/min.

The jet is applied for high dose ion implanted (HDI) resist ash where it delivers hot, reactive species to the resist surface while the wafer temperature is held below the hard-bake temperature to prevent popping. Remarkably, it is then possible to selectively remove the crust from the unimplanted layer. Once the crust is removed, the base resist is rapidly ashed with a high temperature (low speed) scan resulting in residue-free wafer. The projected time to clear 1.2 µm thick, HDI photoresist (As+, 40 keV, 1e16) from a 300 mm wafer by dual jet is ~ 80 seconds. Finally, we explored different metrology techniques for measuring silicon loss during low temperature plasma processing and we found that $2.7\underline{+}1$ Å of silicon, corresponding to two lattice planes, is consumed.

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