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(G*) Time Resolved Characterization of a Plasma Immersion Ion Implantation System

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Plasma immersion ion implantation (PIII) is a versatile tool in the field of materials processing, surface modification, and semiconductor manufacturing[1]. By immersing the target directly in the plasma, PIII boasts many advantages over its predecessor, conventional ion implantation, including a simpler design, faster throughput and more uniform implantation over irregular objects[4]. When a negative polarity high voltage (NPHV) pulse is applied to the target, ions are implanted through this plasma sheath and into the target[5]. However, plasma immersion also introduces several complicating factors that challenge optimization. Foremost among them is maintaining constant bulk plasma parameters, specifically ion density and temperature, and appropriately correcting for inevitable fluctuations that occur[2][3].
Experiments were performed at the University of Saskatchewan plasma physics laboratory on a PIII system with an Inductively Coupled Plasma (ICP) device. This experiment utilized two identical RF-compensated Langmuir probes at two different vertical positions above the biased target to study the perturbations both near the target and further away. The results indicate that electron density and plasma potential are very sensitive to the NPHV pulse, and the amplitudes of the perturbation increase with increasing pulse magnitude above 2 kV. Perturbation amplitudes relative to steady state values trend consistently for all pressures at the same power. However, perturbations are quelled significantly when power is increased, regardless of the pressure. Additionally, the electron temperature undergoes fluctuations whose relative amplitudes are generally smaller than those of density and plasma potential, but are consistent across pulse amplitude, power and pressure. Furthermore, the sheath recovery time was measured. It was shown that it predominantly depends on NPHV amplitude, rather than power or pressure. Finally, the velocity of a rarefaction wave that propagates away from the pulser is measured based on the time delay of the peak of these perturbations. These results will contribute to optimizing the process of PIII by quantifying corrections needed to current models used to calculate implantation doses that assume constant plasma parameters. In future studies they will serve as a basis for comparison against future laser-induced fluorescence diagnostic data.

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