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2D ion velocity distribution function measurements by laser-induced fluorescence above a radio-frequency biased silicon wafer[1]

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Ion dynamics have been measured in the sheath above a 30 cm diameter, 2.2 MHz-biased silicon wafer in a plasma processing etch tool using laser-induced fluorescence (LIF). The velocity distribution function of argon ions was measured at thousands of positions above and radially along the edge of the wafer by sending a planar laser sheet from a pulsed, tunable dye laser into the tool. The RF sheath is clearly resolved. The laser sheet entered the machine both parallel and perpendicular to the wafer in order to measure the distribution function for both parallel and perpendicular velocities/energies (0.4 eV $< E_{max} <$ 600 eV). The resulting fluorescence was recorded using a fast CCD camera, which provided spatial (0.4 mm) and temporal (30 ns) resolution. Data was taken at eight different phases of the 2.2 MHz cycle. The distribution functions were found to be spatially non-uniform near the edge of the wafer and the distribution of energies extremely phase-dependent. Several cm above the wafer the distribution is Maxwellian and independent of phase. Results are compared with simulations; for example, the experimental time-averaged ion energy distribution function compares favorably with a computer model carefully constructed to emulate the device.

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