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LIF measurements of the ion distribution function in the sheath and pre-sheath of a biased capacitively coupled plasma reactor[1]

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The time-dependent argon ion energy distribution function (IEDF) above and within the plasma sheath of a radio frequency (rf) biased substrate has been measured using laser induced fluorescence (LIF) in a commercial plasma processing tool. The measurements were acquired at eight different phases of the 2.2 MHz rf waveform and show the ion dynamics to vary dramatically throughout a cycle. Discharge parameters were such that the rf bias period was on the order of the ion transit time through the sheath ($t_{ion}/t_{rf} = 0.435$). The first experiments measured the IEDF along a line parallel to the normal of the wafer with spatial resolution (dy=88 um). These measurements have been extended to an x-y plane (y is the height above the wafer) which includes the wafer edge so that f(r,v,t) can be measured within a sheet of light. These measurements include the option for multiple bias voltages (2.2, 60 MHz). A patented technology, which enables rapidly switching either bias or ICP source without a match circuit allows for time sequencing in any combination with (t_{pulse} >50 usec). The heat flux and plasma flow is derived from the ion distribution function. This work embodies the first time resolved measurement of ion velocity distribution functions (IVDFs) within an rf biased sheath over a large area (30 cm diameter) substrate. Additional probe measurements of the plasma parameters above the wafer will be presented as well. Comparisons will be made to ion energy and velocity distributions obtained from computer modeling.

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