APPLICATION NOTE [LP09]

Impedans PLASMA MEASUREMENT

Langmuir Single Probe used in determining the temporal evolution of negative ion density in the afterglow of reactive HiPIMS of titanium in an argon/oxygen gas mixture.*

STUDY

High power impulse magnetron sputtering (HiPIMS) has gained significant interest in recent years as an effective physical vapour deposition technology. But in reactive HiPIMS of a metallic target in the presence of electronegative gases, significant amounts of negative ions are created, which can have detrimental effects on the structure, crystallinity and electrical properties of the thin film. These negative ions can also significantly influence the positive ion flux impinging upon plasma-facing surfaces. This study used a Langmuir Single Probe to determine the temporal evolution of the oxygen negative ion, n_- and electron, n_e densities during the offtime of a reactive HiPIMS discharge operating in argon–oxygen gas mixtures. The aim of the study was to add to the knowledge base information about oxygen negative ion dynamics that will help many plasma processing methods.

METHOD

The experiment was set up according to the diagram below. The Langmuir probe was put on the discharge axis at an axial distance of 100mm from the target, in a place of low magnetic flux density, and controlled by the Impedans Langmuir Probe acquisition system.

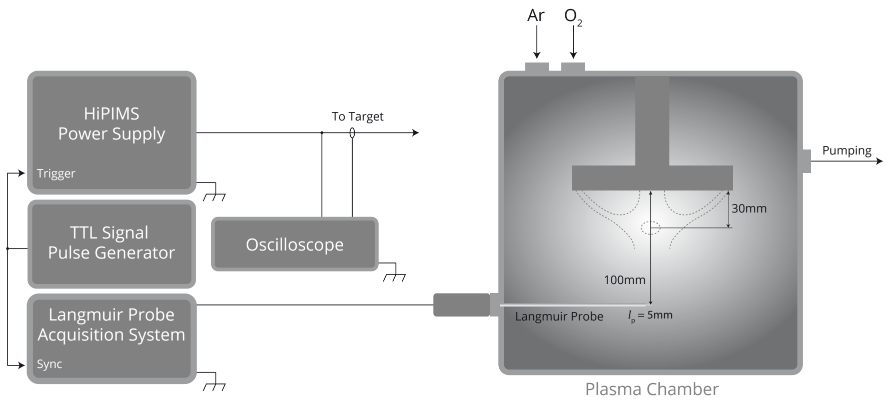

Figure 1: Experimental set-up. The Langmuir probe was placed on the discharge axis at an axial distance of 100mm from the target and controlled by the Langmuir Probe acquisition system. The position of the magnetic null is also displayed at an axial distance of 30mm from the target surface.

Data was gathered from two different time steps, Δt = 10 and 100 μs, and from two different time ranges, t = 0–500 μs and t = 500–3000 μs. The probe bias, Vb , went from −150 V to +30 V in steps of 0.05 V and the current resolution of the acquisition system was set at 100 pA. Each data point was measured 50 times and averaged out for the result.

FINDINGS AND CONCLUSIONS:

The study estimated average oxygen negative ion densities to be about 10^{16} m^{-3}, with values slightly higher for when oxygen is increased. But for all oxygen partial pressures, n_ decreased in the afterglow with long decay times.

The temporal evolution of the electron-to-ion saturation current ratio normalised to an electropositive (argon only) discharge is illustrated below:

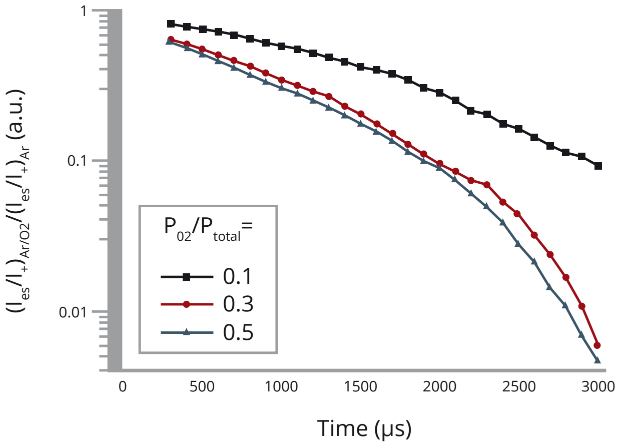

Figure 2: A semi-log plot of the temporal evolution of the electron-to-ion saturation current ratio normalized to a nominally identical, electropositive (argon only) discharge.

Electronegativity was also observed to increase monotonically in the afterglow, as illustrated below:

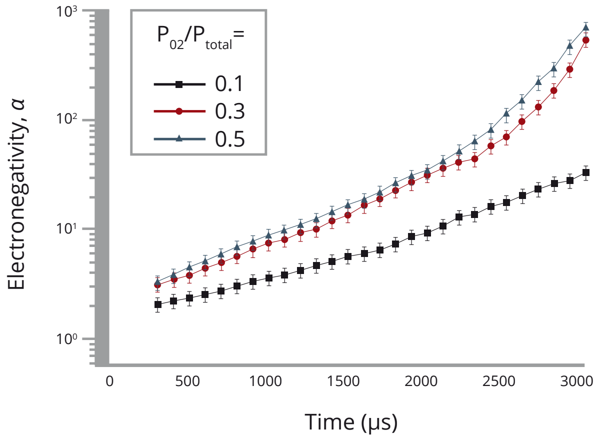

Figure 3: The temporal evolution of the electronegativity, $\alpha = n_-/n_e$ as measured for the three different oxygen partial pressures. Error bars represent an uncertainty of approximately ±15%.

Negative ion fluxes of the order of 10^{18} m^{-2} s^{-1} could also occur at the chamber walls and substrate surface as the plasma evolves into an ion–ion state. This particular finding is especially important for many plasma processing methods.

USES OF THE STUDY

This study sheds more light on oxygen negative ion dynamics, which is important for plasma processing technologies.

REFERENCES

* M Bowes and J W Bradley.
"The behaviour of negative oxygen ions in the afterglow of a reactive HiPIMS discharge".
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