Ion energy distribution measurements in RF and pulsed DC plasma discharges

THE STUDY

The energy and flux of bombarding ions play a vital role in the etching and deposition of layers on the substrate surface. Asymmetric radio-frequency (RF) capacitively coupled plasma (CCP) reactors are commonly used for plasma etching. Monitoring of the flux and energy of ions arriving at the substrate in these reactors is essential for process optimization and the control of films' microstructure.

This study used a commercial retarding field energy analyser (RFEA), the Semion System from Impedans Ltd, to measure the ion energy distribution functions (IEDFs) of impacting ions at the powered electrode in a 13.56MHz driven, capacitively coupled, parallel plate discharge operated at low pressure.

METHOD

The study was carried out in argon discharges at 10mTorr where the sheaths are assumed to be collisionless. The RFEA was mounted flush with the powered electrode surface where the impacting ion and electron energy distributions were measured for a range of discharge powers. A circuit model of the discharge, along with analytical solutions for the ion energy distribution in radio-frequency sheaths, was used to calculate other important plasma parameters from the measured energy distributions.

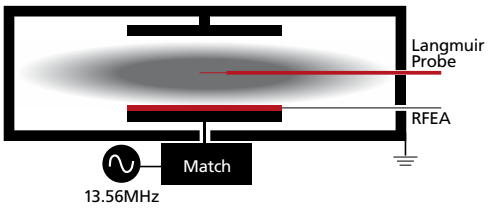

Figure 1a: CCP Reactor with RFEA and Langmuir Probe

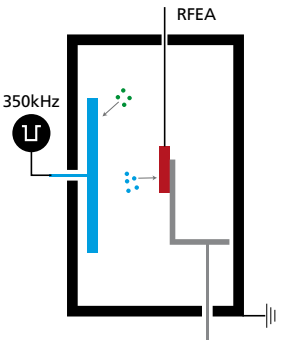

Figure 1b: Magnetron Sputtering Reactor showing pulsed biased target and location of RFEA. Argon ions (green) from the discharge sputter the titanium ions (blue) from the target which in turn become deposited on the substrate.

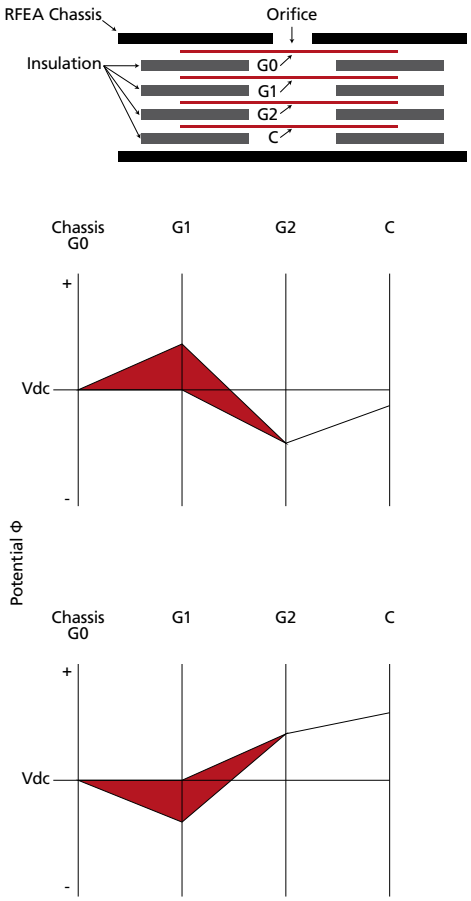

Figure 2a: Schematic of RFEA construction
Figure 2b: RFEA potential configuration for ion discrimination
Figure 2c: RFEA potential configuration for electron discrimination

Radio-frequency compensated Langmuir probe measurements were compared with the data from the RFEA. The time-resolved capability of the RFEA was also shown in a separate pulsed DC magnetron reactor. The analyser is put on the floating substrate holder, and ion energy distributions of the impinging ions on a growing film, with 100ns time resolution, are measured through a pulse period of applied magnetron power.

RESULTS AND FINDINGS:

The Semion System RFEA used in this study, incorporates a novel filter design that enables 100ns time resolution. The capabilities of this design were demonstrated in a pulsed magnetron discharge. The 100ns time steps clearly show the transitions between phases of the bias waveforms through the ion energy distribution measurements.

References

* *Ion energy distribution measurements in rf and pulsed dc plasma discharges*
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