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PLASMA MEASUREMENT

A study of plasma parameters in a BAI 730 M triode ion plating system by means of a Langmuir probe and plasma mass and energy spectroscopy*

STUDY

Plasma-assisted processes are widely used in various areas of modern manufacturing, including physical vapour deposited (PVD) hard coatings, and there is an ongoing need for characterisation of plasma parameters. Beside the conventional Langmuir probe technique, plasma spectroscopy is being more and more widely used. This paper compares the results obtained by the Langmuir plasma probe with the results of energy and mass resolved plasma spectroscopy during three modes of operation (heating, etching, deposition) in a commercial triode ion plating system (Blazers BAI 730 M) used to deposit hard coatings like TiN, CrN and Ti(C,N).

METHOD

Energy distributions of positive ions were measured in the commercial Balzers BAI 730 M triode ion plating systems. This system uses a filament-based ionisation source, which forms a low voltage (LV) arc expanding into the reaction chamber. The power supply for the LV arc is electrically floating with respect to the chamber walls. Its negative pole is connected to the arc cathode, while the positive one can be connected to different anodes, depending on the operation mode (heating, etching and evaporation).

A cylindrical molybdenum Langmuir probe (length 1.5 mm, diameter 1 mm) with an area Ap is located horizontally in the middle of the vessel height, similarly to the spectrometer. The radial position of the probe tip varies from 10 to 35 cm from the vessel axis. If not mentioned specifically, the radial position of the probe tip was 20 cm from the centre, and was aligned with the inner surface of the dummy substrates.

I-V plots are measured in the range of at least 50 V below the floating potential and up to 50 V above the plasma potential.

The plasma parameters are derived from the measured I-V characteristic assuming a Maxwellian distribution of electrons.

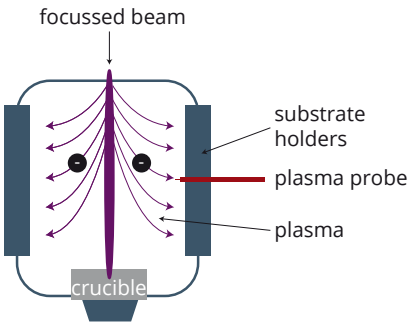

Figure 1 Heating

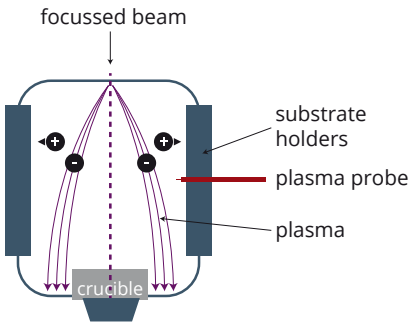

Figure 2 Etching

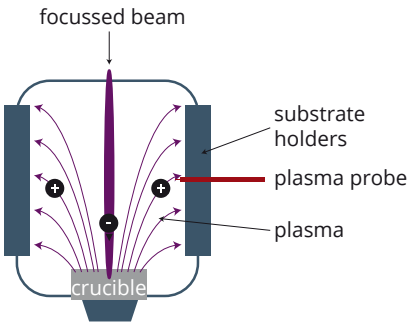

Figure 3 Deposition

Mode	P_{Ar} mbar	P_{N2} mbar	I_{arc} A	I_{coil} A	B mtorr	U_{substr} V	U_{arc} V	U_{anode} V	U_{cruc} V
Heating	2.5 E-03		150	8 8	3.7	12-17	49	0.6	12.5
Etching	1.5 E-03		130	8 8	3.7	130	55	8.3	20.6
Depostion	1.5 E-02	5.0 E-03	200	15 15	7.0	125	56	50	53

FINDINGS:

On the basis of plasma probe measurements and of energy and mass spectroscopy the authors concluded that the plasma during the heating and etching modes behaves like a classical cold plasma with electrons in thermal equilibrium with a mean energy below 1.5eV for the standard operating conditions. The flux of ions is low compared with the flux of gas neutrals. The plasma potential is very uniform over the vessel radius, corresponding to the highest potential in the chamber.

During the deposition of TiN, as well as other metals like Cr, the plasma is very intense. The ratio between fluxes of ions and neutrals (gas and metal) is high compared with heating and etching, ji/jn =25% at the standard conditions. Mass spectroscopy shows that the majority of the Ti ions are doubly charged ones. The apparent energy of electrons under the standard deposition conditions with a strong magnetic field, B=7mT, is very high. Assuming thermal equilibrium and a quiescent plasma, the electron temperature kTe should be approximately 6eV. The study found that the energy distribution of the electrons is better described by the Druyvesteyn function than by the Maxwellian one.

In addition, a large plasma instability was observed, especially during TiN deposition. This affects the apparent Langmuir probe characteristics, as well as the ion energy distribution.

REFERENCES

* "A study of plasma parameters in a BAI 730 M triode ion plating system by means of a Langmuir probe and plasma mass and energy spectroscopy." Marijan Maček, Boris Navinšek, Peter Panjan, Stanislav Kadlec. Surface and Coatings Technology (Impact Factor: 1.94). 01/2001; 135(2). DOI: 10.1016/S0257-8972(00)00998-1

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