5.1 Modelling of Magnetron Sputter Device

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Magnetron sputtering is widely used in industry and research for sputter etching and thin film deposition [1, 2]. In all types of magnetrons, a specific configuration of an external magnetic field, applied to trap electrons in the region close to the cathode, allows the magnetron operation at lower pressures and voltages than within the other devices.

Investigation of the spatial structure of the magnetron discharge is a way to understanding discharge dynamics and has important implications for controlling nonuniformity of the target sputtering. Since a principal virtue of the magnetron is its ability to operate effectively at low neutral pressures and voltages, it is worthwhile to study mutual relations of discharge phenomena and plasma transport.

A one-dimensional three-fluid model has been developed for the modeling of plasma behavior in the in magnetron [3]. The model includes continuity, momentum transfer, energy balance for electrons and ions as well as the Poisson equation for potential. A conception of taking into account two-temperature electrons has also been worked out.

[1] J.A.Thornton, J.Vac.Sci.Technol. 15 (1978) 171

[2] B.Window G.L.Harding, J.Vac.Sci.Technol. A8 (1990) 1277

[1] M.Rabiński, 1998 ICPP, ECA 22C (1998) 2165

5.2 Investigation of Discharge Phenomena in IPD Accelerator

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A coaxial impulse plasma accelerator is used in surface engineering, e.g. the Impulse Plasma Deposition [1], as an efficient source of mass and energy in the synthesis and deposition of various materials in the form of layers. A pulse plasma is generated within the working gas by a high-voltage high-current discharge ignited in the inter-electrode space. Electro-erosion during the discharge enriches the plasma with the electrode material.

On the basis of earlier observations and a snow plow model of the current sheet motion, a physical model of phenomena in such devices has been proposed [2]. The selfconsistent model combines the dynamics of the current carrying sheet driven by the Lorentz force, with the balance of magnetic and fluid pressures at the contact interface, as well as the discharge of a condenser bank. The even phases of current flow in the accelerator (the second and fourth half-period) occur with the change of electrode polarization. Because of a significant difference in the discharge pattern caused by the polarity change as well as lowering current consecutive amplitudes, the plasma approaches nearer and nearer the range along the electrodes. At the end of each phase a weakening magnetic piston slows the current sheet motion, stops it or even causes its reverse movement. This leads to massive electro-erosion at the sheet foot and after many discharges one can observe a characteristic form of the eroded central rod.

A detailed analysis of the current sheet dynamics has been carried out for different discharge conditions (see Fig.1) [3]. Conditions favourable for evaluation of the Rayleigh-Taylor instability on the current sheet surface have been found. The plasma configuration following this instability explains formation of a toroidal ring of dense plasma observed in front of the central electrode, as well as the nonuniformity of coating phase composition and morfology. By proper modification of the plasma accelerator design, for the first time we succeeded in reducing substantially the R-T instability and in obtaining α-Al_2O_3 coatings instead of common γ- Al_2O_3 [4].

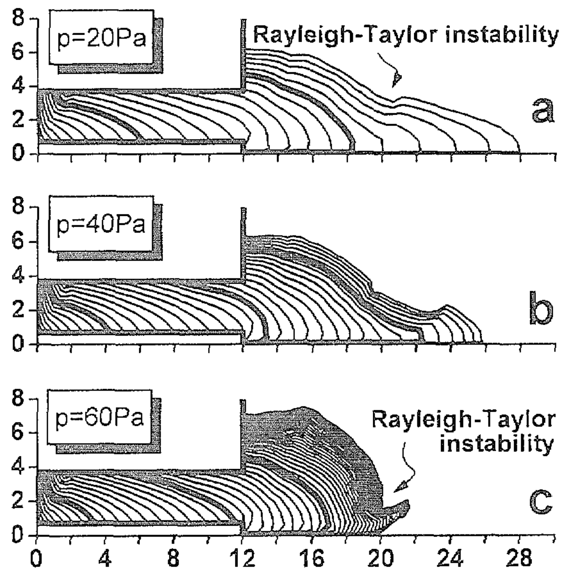

Fig.1. Time evolution of the current sheet shape (plotted with 1 μsec interval) for several discharge conditions (C=100:F, U=6kV, argone pressure p= 20/40/60 Pa). Radial and axial coordinates in cm.