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CALCULATION OF ELECTROMAGNETIC FIELD AND CONCENTRATION OF CHARGED PARTICLES IN A MAGNETRON DISCHARGE *)

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Magnetron sputtering is widely used for applying thin coatings. A serious disadvantage of this spraying method is the low utilization rate of the target material [1]. The film quality is very sensitive to the effects of plasma particles. Therefore, it is important to control the structure of the magnetron discharge not only near the cathode, but also in front of the substrate. Numerical modeling is an effective tool for achieving this goal. To obtain adequate results, the model must be self-consistent and take into account the entire release with as few assumptions and simplifications as possible. The means of developing such a model can be, in particular, the Comsol Multiphysics software [2].

A DC discharge in intersecting fields was considered between flat electrodes in a cylindrical coordinate system with permanent magnets placed under the cathode. The interelectrode distance is 9.4 cm, the radius of the electrodes is 3.75 cm, the cathode voltage is 125 V, the magnetic field induction is 0.8 mt. The plasma-forming gas is argon. The calculated pressure ranged from 66.7 pa to 0.02 Pa.

The modules “Plasma” and “Magnetic field” [2] were used to simulate the discharge. The Plasma module describes the plasma state using the equations of balance of electrons, ions and metastable atoms, conservation of electron energy, electron momentum and the Poisson equation. The “Magnetic field” module is used to calculate the distribution of a constant magnetic field from Maxwell's equations.

Comparative calculations of discharge characteristics were performed with a magnetic field and in the absence of a magnetic field. Spatial distributions of the concentration of electrons, ions, metastable atoms, electron temperature, and electric field potential were obtained at various pressures of the plasma-forming gas.

The results of calculations showed that magnetic field leads to a more uniform plasma distribution plasma over the volume of the device, an increase in the concentration of electrons and a decrease in the electron temperature. The calculation algorithm with a magnetic field requires almost 2 times more steps to reach a steady state. At a pressure less than 0.1 Pa, the calculation diverges, which may be due both to the fact that the hydrodynamic model used in the Plasma module does not correspond to the nature of processes in the discharge at low pressures, and to the instability of the numerical method.

References

[1]. Swann S. Magnetron sputtering //Physics in technology. – 1988. – T. 19. – №. 2. – C. 67

[2]. Comsol Multiphysics Simulation Software URL:https://www.comsol.com/comsol-multiphysics

*) abstracts of this report in Russian