FEATURES OF SELF-SUSTAINED MAGNETRON SPUTTERING OF EVAPORATING METAL TARGET

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Studies of the mechanisms and regularities of the discharge operation were performed when the magnetron sputtering system (MSS) was operating in the self-sputtering mode of an evaporating metal target under conditions of extremely low pressure in the vacuum chamber (less than 0.1 Pa) due to the termination of the inlet of the sputtering gas argon. It has been established that the magnetron is able to work in gasless mode if, due to evaporation of the target, the concentration of metal atoms near the surface of the target is necessary to maintain the discharge. Using the example of an MSS with a copper target, the minimum required power has been determined, starting from which the discharge can function without the inlet of the sputtering gas. The threshold power value depends on the crucible substance and the type of power source (mid-frequency, high-current). Thus, in the case of using a copper target in a molybdenum crucible and a mid-frequency power source, the minimum power density required for stable self-sputtering without supplying the sputtering gas is 19.4 W/cm^2, and in the case of a high-current power source - 33 W/cm^2. It has been revealed that thermo-electronic emission is not a necessary factor in maintaining the discharge of a magnetron operating on vapor of a target substance.

It has been found that the erosion yields of metal targets at evaporation reach several tens of atoms per ion, which is an order of magnitude higher than the sputtering yields. Due to this, the coatings deposition under self-sputtering conditions takes place without reducing a deposition rate as compared to the case with sputtering gas.

The evolution of the intensity of the spectral lines of the plasma optical radiation during the transition of a magnetron with an evaporating copper target into the self-sputtering mode and switching off the sputtering gas was studied. A correlation was found between the intensity of the spectral lines of copper atoms and ions with the evolution of evaporation. As the intensity of evaporation increases, argon atoms are displaced from the burning region of the discharge in front of the target.

The flux densities of deposited particles and energy under conditions of intense evaporation of a copper target were studied. It was found that in the considered MSS power range, due to evaporation, the flux density of the deposited particles increases by about an order of magnitude. The main source of energy entering the substrate is heat radiation from the target. The magnitude of the total energy flux is about the same as when the target is sputtered in an argon atmosphere, and in the self-sputtering mode.

Experiments were carried out on the deposition of copper coatings with argon at a pressure of 0.2 Pa and in the full self-sputtering mode at a pressure of 0.01 Pa. Different power sources were used (mid-frequency and high-current). The microstructure, crystal structure and roughness of coatings obtained at different evaporation rates were studied. It turned out that under conditions of intensive evaporation, there is no noticeable pronounced influence of the self-sputtering factor and the type of power source on the studied characteristics of copper coatings. At low evaporation rates, the structural characteristics of the coatings turn out to be better in the gasless mode.

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