PHYSICS

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Fig. 1

Figure 1: Fig. 1

Abstract

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ANISOTROPY OF CATHODE SPUTTERING OF SINGLE CRYSTALS

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The study of the sputtering of single crystals by ion beams is of great importance for elucidating the mechanism of cathode sputtering ([1]). However, most investigations carried out in this direction have been purely qualitative in character, and only in a few works published recently has an attempt been made to study the sputtering of single crystals quantitatively ([2]).

This paper contains the results of measuring the dependence of the sputtering coefficient of the (100) face of copper and nickel single crystals on the angle of incidence of ions on the target. The work was carried out on an apparatus described previously ([3]).

The sputtering was performed with a beam of singly charged argon ions with an energy of 27 keV. The ion-current density was 1—2 mA/cm^2, and the angular divergence of the beam did not exceed $\pm 2^{\circ}$.

The method for measuring the sputtering coefficient was the same as in the preceding work ([4]).

After polishing, the single-crystal specimens were subjected to prolonged annealing in a vacuum furnace at a temperature of about 800°C. They were then slowly cooled to room temperature, and the surface layer was removed by chemical etching. The state of the surface and the orientation of the single crystals were checked by X-ray structural analysis methods.

Fig. 1

The scheme for orienting the specimens relative to the crystallographic directions of the single crystal is shown in Fig. 1. The arrow indicates the direction of rotation of the specimen during the experiment. The measurement results are given in Fig. 2, 1 (copper single crystal) and in Fig. 3 (nickel single crystal). In these figures the angle of incidence of the ion beam is plotted along the abscissa, and the sputtering coefficient along the ordinate.

Fig. 2

Figure 2: Fig. 2

Fig. 3

Figure 3: Fig. 3

In Fig. 2, 2 an analogous dependence is given for polycrystalline copper, taken from work ([4]). Comparing curves 1 and 2, one may note that, in contrast to the polycrystal, where the sputtering coefficient increases monotonically with increasing angle of incidence of the ions on the target, the sputtering coefficient of a copper single crystal depends in a more complicated way on the angle of incidence of the ions. At certain angles (0°; $35^\circ \pm 1^\circ$; $55^\circ \pm 1^\circ$) there are minima of the sputtering coefficient. The absolute values of the coefficients at these minima increase with increasing angle of incidence of the ions on the target.

The angular dependence of the sputtering coefficient of a nickel single crystal has the same character (Fig. 3).

The angles of incidence of the ions corresponding to the minima on the sputtering curves of copper and nickel coincide within the accuracy of measurement. Copper and nickel have the same crystal lattice.

When the target is rotated by 35°, the direction of the beam coincides with the (112) direction of the single crystal; when rotated by 55°, with the (111) direction.

Thus, the sputtering coefficient is minimal when the direction of the ion beam coincides with the direction of one of the principal crystallographic axes of the target (100), (111), (112).

It is interesting to note that the dependence of the secondary-electron-emission coefficient on the angle of incidence of the ions in the case of a single crystal is also non-

Fig. 2

Fig. 3

monotonic; in particular, the secondary-emission coefficients of a copper single crystal at ion incidence angles of 36° and 48° differ by more than a factor of two.

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Note: Figure translations are in progress. See original paper for figures.