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PHYSICS

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Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

Abstract

Full Text

PHYSICS

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ANGULAR DISTRIBUTION OF SPUTTERED PARTICLES UPON IRRADIATION OF A SINGLE CRYSTAL BY AN ION BEAM

(Presented by Academician L. A. Artsimovich on 4 March 1961)

In the cathode sputtering of single crystals, there occurs a preferential ejection of atoms along certain crystallographic axes of the target, and the sputtered substance forms on the collector a characteristic pattern ("Venus spots"), the appearance of which depends both on the type and orientation of the crystal and on the energy of the ions. This phenomenon was investigated by Wehner (¹, ²) and, after him, by other authors (³⁻⁵). The angular distribution of the sputtered substance was studied only in work (⁵). On the basis of indirect measurements, the authors of work (⁵) concluded that this distribution within each Venus spot obeys the cosine law. Meanwhile, in work (⁸) it was shown that another quantity characterizing sputtering—the sputtering coefficient of single crystals—exhibits a considerably stronger angular dependence. For this reason it was of interest to carry out a direct measurement of the spatial distribution of particles leaving the target upon its irradiation by an ion beam. The principal results of the work are given below.

Fig. 1

The experiments were carried out on the apparatus described in (⁷). The ion beam 1 (see Fig. 1) passed through diaphragm 2 and struck crystal 3. The collector was a substrate made of x-ray film, fastened to a copper plate—flat (4a) or curved (4b). The distance R from the crystal to the collector was different in different experiments; however, it was always about an order of magnitude greater than the size d of the irradiated surface of the crystal. The remaining experimental conditions were the same as in works (⁶, ⁸).

Fig. 3

Figure 3: Fig. 3

Fig. 4

Figure 4: Fig. 4

Fig. 2

Figure 2 shows a typical pattern of the deposit on the collector, obtained when the (100) face of a copper single crystal was irradiated by an argon beam of energy 27 keV. The four symmetric spots correspond to the crystallographic axes [110], and the spot in the middle to [100]. The arrows indicate the directions along which photometry of the deposit was carried out.

The results of photometry are given in Figs. 3 and 4. Along the x axis is plotted the angle of emission of the particles; along the y axis, the blackening S ⁽⁹⁾, proportional to the thickness of the deposited layer. The different curves correspond to different values of R , d , and of the angle of incidence α of the ion beam on the crystal. As is seen from the microphotograms presented, a considerable part of the atoms leaving the target is enclosed in narrow cones whose axes coincide with the principal crystallographic axes of the target. The angular half-width of the corresponding distributions is of the order of 20° . Unfortunately, it is impossible to determine this quantity more accurately because of the asymmetry of the background surrounding the spots.

Fig. 3. 1 $-d = 5$ mm, $R = 55$ mm, $\alpha = 28^\circ$; 2 $-d = 5$ mm, $R = 55$ mm, $\alpha = 52^\circ$; 3 $-d = 4$ mm, $R = 40$ mm, $\alpha = 20^\circ$; 4 $-$ angular dependence of the sputtering coefficient K of the (100) face of a copper single crystal (from Ref. ⁽⁸⁾)

Fig. 4. 1 $-d = 5$ mm, $R = 55$ mm, $\alpha = 54^\circ$; 2 $-d = 4$ mm, $R = 40$ mm, $\alpha = 20^\circ$; 3 $-d = 8$ mm, $R = 95$ mm, $\alpha = 35^\circ$

It should be noted that the “intensity” of the Wehner spots corresponding to equivalent crystallographic axes of the target depends substantially on the angles which these axes make with the plane of the crystal cut. In the case where the plane of the crystal cut is not its principal crystallographic plane, the more “intense” spots appear in directions making smaller angles with the normal to the plane of the cut.

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CITED LITERATURE

1. G. K. Wehner, Phys. Rev., **102**, 690 (1956).
2. G. K. Wehner, G. S. Anderson, J. Appl. Phys., **31**, 2305 (1960).
3. V. E. Yurasova, ZhTF, **28**, 1966 (1958).
4. M. Koedam, A. Hoogendoorn, Physica, **26**, 351 (1960).
5. V. E. Yurasova, N. V. Pleshivtsev, I. V. Orfanov, ZhETF, **37**, 966 (1959).
6. V. A. Molchanov, V. G. Telkovskii, DAN, **136**, 801 (1961).
7. V. A. Molchanov, V. G. Telkovskii, Vestn. Mosk. univ., No. 1 (1961).
8. V. A. Molchanov, V. G. Telkovskii, V. M. Chicherov, DAN, **137**, No. 1 (1961).
9. S. L. Mandel'shtam, *Introduction to Spectral Analysis*, Moscow, 1946.

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