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R. N. SHEFTAL, Yu. F. OGRIN, V. N. LUTSKII, M. I. ELINSON

ON THE ORIENTING ACTION OF MICA ON THE GROWTH OF THIN Bi FILMS

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In paper ([1]) the possibility was shown of obtaining single-crystal Bi films on the cleavage plane of mica. But when bismuth is deposited on mica in a vacuum of $\sim 10^{-6}$ mm Hg, residual gases and oil vapors are present, which can be adsorbed by the surface of the substrate and form a layer of some thickness. As a result, the deposition of Bi occurs not on the surface of the mica, but on this layer. Nevertheless, under certain conditions bismuth films are obtained as single-crystalline or well textured. It is therefore of interest to determine how strong the orienting action of a mica substrate is on the growth of thin—up to 1500 Å—bismuth films.

For this purpose, a layer of celluloid was applied to mica (muscovite) cleaved in air along the cleavage plane. The thickness of the layer varied from 70 to 350 Å and depended on the amount of celluloid dissolved in amyl acetate. Special experiments established the absence of pores in the celluloid film.

The experiment was carried out as follows: on a substrate platform were placed one plate of pure mica, 5 mica plates with celluloid layers of different thickness deposited on them, and a glass substrate also covered with a celluloid film 70 Å thick. Bi was deposited simultaneously on all 7 substrates at a temperature of 80°. The vacuum during deposition was $2 \cdot 10^{-6}$ mm Hg and the film deposition rate was 50 Å/min.

Electron diffraction patterns from the films obtained are shown in Fig. 1. The electron diffraction pattern from a single-crystal Bi film obtained on mica without an intermediate layer is shown in Fig. 1a. The orientation of bismuth films is preserved at intermediate-layer thicknesses of 70 and 150 Å (Fig. 1b, c). For the Bi film obtained on mica with an intermediate-layer thickness of $\sim$ 350 Å, the orientation is almost not revealed (Fig. 1g), and, finally, the Bi film deposited on glass with a thin celluloid film is, as is seen from Fig. 1d, completely disoriented.

To explain this result one may invoke two mechanisms of the orienting action of the substrate.

Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

The first consists in the fact that the real surface of mica contains structural defects, active centers. Interacting with the basic lattice, they determine epitaxial overgrowth (see ([2])). In the same paper ([2]) it is indicated that the action of such active centers extends to several microns.

The second mechanism of the orienting action of the substrate through a celluloid layer reduces to the fact that the celluloid film, in general outline, repeats the geometry of the steps of the cleavage plane of the mica not only on the contacting side, but also on the outer side. This mechanism is confirmed by work ([3]), in which silver was deposited on a KCl cleavage and on the corresponding carbon replica. The structure and surface of the silver layer on the carbon replica and on the KCl cleavage were identical. It may be said,

Fig. 1. Electron diffraction patterns from bismuth films obtained on mica with an intermediate layer increasing in thickness. **a** —without a collodion layer; **b** —thickness of the collodion layer $\sim$ 300 Å; **c** —thickness of the collodion layer $\sim$ 1500 Å; **d** —thickness of the collodion layer $\sim$ 2500 Å; **e** —thickness of the collodion layer $\sim$ 700 Å on glass.

Fig. 2. Electron diffraction patterns from bismuth films obtained in the second experiment. **a** —bismuth on mica treated with water; **b** —bismuth on a fresh cleavage of NaCl; **c** —bismuth on a cleavage of NaCl treated with water.

that in (3) the geometry of the surface played a decisive role in the formation of the oriented layer.

Regardless of which of the indicated mechanisms is actually realized, the fact of the orienting action of a single-crystal substrate through an intermediate layer appears to be unquestionable. To clarify the role of steps in oriented growth, we prepared two corresponding cleavages, of NaCl and mica. One of the NaCl plates was dissolved in bidistilled water until the steps were eliminated and was then rinsed in absolute alcohol in order to stop further dissolution. Assuming that the action of water on active centers in NaCl and mica substrates should be identical, with the sole difference that in the case of mica the steps on the cleavage plane remain, we also treated the mica substrate with water.

All 4 substrates were placed in a vacuum system, and bismuth was deposited on them simultaneously. The results of the second experiment are shown in Fig. 2a, b, c. The Bi film obtained on water-treated mica is single-crystalline (Fig. 2a). The electron diffraction pattern from the Bi film obtained on a fresh NaCl cleavage is also a spot pattern (Fig. 2b), while the bismuth film deposited on

the water-treated NaCl surface was polycrystalline (Fig. 2c).

Institute of Radio Engineering and Electronics
Academy of Sciences of the USSR

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