

# ON THE ALLOTROPIC TRANSFORMATION OF YTTERBIUM IN LAYERS CONDENSED ON A COLD SUBSTRATE

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Fig. 1. Dependence of resistance on temperature for ytterbium films of thickness  $\sim 3000 \text{ \AA}$  (a) and  $\sim 18000 \text{ \AA}$  (b). The dark points denote the reversible course of  $R(T)$  for the annealed film

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## Abstract

## Full Text

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## PHYSICS

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# ON THE ALLOTROPIC TRANSFORMATION OF YTTERBIUM IN LAYERS CONDENSED ON A COLD SUBSTRATE

The phenomenon of low-temperature polymorphism was discovered in films of a number of metals obtained by condensation onto a substrate cooled to low temperatures (<sup>1-6</sup>). In this connection, the method used was analysis of the features of the temperature-dependence curves of electrical resistance during warming of the films obtained; this method is very sensitive for detecting polymorphic transformations.

The present communication is devoted to the detection, by means of the indicated method, of a new allotropic modification in films of the rare-earth metal ytterbium obtained by condensation on a plane-polished glass surface cooled with liquid helium. The technique used in the work was that described previously (<sup>10</sup>).

**Fig. 1.** Dependence of resistance on temperature for ytterbium films of thickness  $\sim 3000 \text{ \AA}$  (a) and  $\sim 18000 \text{ \AA}$  (b). The dark points denote the reversible course of  $R(T)$  for the annealed film.

Ytterbium of purity 99.8% was used as the starting material. The condensation rate was  $20 \div 30 \text{ \AA/sec}$ . Changing the condensation rate from 3 to  $200 \text{ \AA/sec}$  had no noticeable effect on the properties of the films. Seventeen ytterbium films were studied in the thickness range from 240 to  $18000 \text{ \AA}$ . The films were warmed at a rate of  $\sim 0.1 \text{ deg/min}$ . Increasing the heating rate by a factor of

Fig. 2

Figure 2: Fig. 2

10 did not affect the character of the curve of the dependence of the resistance  $R$  on temperature  $T$ .

In films with thickness less than 3000 Å, at a temperature of 14°K a sharp drop of the resistance by ~ 75% is observed (over a temperature interval of less than 0.1°). Figure 1a shows the dependence  $R(T)$  for one of the films of thickness ~ 3000 Å. It should be noted that in the course of condensation, upon passing through the “critical” thickness (~ 3000 Å), a stepwise decrease of the resistance by the same 75% is also observed\*.

\* Something analogous was observed by Suits (7) on vanadium films. He associates this phenomenon with a possible polymorphic transition.

As is seen from Fig. 2, in films thicker than 3000 Å at 14° K there remains a small jump in resistance, which decreases with increasing thickness and disappears completely in films about 7000 Å thick. This is connected with the existence of wedge-shaped film edges whose thickness is less than the critical value. Thus, in freshly condensed ytterbium films of thickness less than 3000 Å a new allotropic modification is present. On warming to 14° K, a phase transition occurs in the films, either from an amorphous metastable state to a crystalline one, or from one crystalline state to another. The process proceeds at high speed—in several minutes at the transformation temperature and practically as a jump upon overheating by several degrees.

**Fig. 2.** Dependence of the magnitude of the resistance drop at the transition temperature on the layer thickness  $d$ :

$$\Delta R/R = (R_{4.2^\circ\text{K}} - R_{15^\circ\text{K}})/R_{4.2^\circ\text{K}}.$$

Analogous jumps in resistance on the curves  $R(T)$  were observed during phase transitions in bismuth (1-3), beryllium (4,5), gallium (3,9), where the existence of a new phase was confirmed by superconductivity.

The formation of a new allotropic modification in thin ytterbium layers condensed on a cold substrate is apparently explained by a change in the thermodynamic conditions due to the large contribution of surface energy to the free energy of the film.

The existence of new phases in thin films of a number of metals (V, Be, Ni, Cr, Co) was first observed and explained from the standpoint of thermodynamics by A. I. Bublik and B. Ya. Pines (8). However, these authors observed phase transitions in layers 20-100 Å thick, formed at room temperature. The fact that in ytterbium layers formed by low-temperature condensation the critical thickness is considerably larger is evidently connected with the creation of a large

effective surface of the layer under such nonequilibrium condensation conditions. For ytterbium layers thicker than 5000 Å, the  $R(T)$  curves show a drop in resistance at a temperature of 340–360° K within an interval of  $\sim 10^\circ$  (Fig. 1b), caused, as X-ray diffraction analysis showed, by recrystallization.

In conclusion, it should be noted that the low-temperature modifications of bismuth, beryllium, iron (<sup>5</sup>), and some other metals have not been studied as a function of thickness. In light of the present work, it is of interest to investigate low-temperature layers of the above-mentioned metals in the region of larger thicknesses.

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## REFERENCES

1. R. Hilsch, *Rec. Intern. Conf. of Low Temperature, Physics*, Oxford, 1951, p. 119.
2. N. V. Zavaritskii, *DAN*, **86**, 687 (1952); **91**, 787 (1953).
3. L. Bosio, A. Defrain, J. Epelboin, *J. Phys. et Radium*, **23**, 877 (1962).
4. B. G. Lazarev, E. E. Semenenko, A. I. Sudovtsov, *ZhETF*, **37**, no. 5 (11), 1461 (1959).
5. B. G. Lazarev, E. E. Semenenko, A. I. Sudovtsov, *ZhETF*, **40**, no. 1, 105 (1961).
6. B. G. Lazarev, E. E. Semenenko, A. I. Sudovtsov, *ZhETF*, **39**, no. 4 (10), 1165 (1960).
7. J. C. Suits, *Trans. IX Vacuum Symposium*, 1962, p. 74.
8. A. I. Bublik, B. Ya. Pines, *DAN*, **87**, 215 (1952).
9. W. Buckel, R. Hilsch, *Zs. Phys.*, **138**, 109, 136 (1954).
10. B. G. Lazarev, E. E. Semenenko, A. I. Sudovtsov, *ZhETF*, **40**, no. 1, 105 (1961).

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