SUPERCONDUCTIVITY OF Au-Ge FILMS OBTAINED BY EVAPORATING THE ALLOY WITH A LASER PULSE

N.E. Alekseevskii, V.M. Zakosarenko, and V.I. Tsebro
Institute of Physics Problems, USSR Academy of Sciences
Submitted 24 July 1970
ZhETF Pis. Red. 12, No. 5, 228 - 231 (5 September 1970)

It was shown in [1] that rapidly cooled alloys of the Au-Ge system containing from 66 to 30% Ge exhibit superconductivity. The critical temperature changes in this case from 1.63 to 1°K.

We have performed measurements on films obtained from an Au-Ge alloy condensed on a substrate maintained at the temperature of liquid nitrogen or helium. Such films were obtained by evaporating small amounts of the alloy with the aid of a beam from a pulsed neodymium laser. The films were prepared from an alloy containing 50% Ge, prepared by fusing the components in a high-frequency furnace in a quartz ampoule in a helium atmosphere. Such an alloy exhibited no superconductivity in the liquid-helium region down to 1.4°K.

The film-preparation experiments were performed in two variants. In the first variant a small piece of the alloy was placed in a special glass ampoule on a thin molybdenum holder. The ampoule was equipped with a cold finger, on the polished surface of which there was placed a thin mica substrate (Fig. 1a). The ampoule was evacuated at 10^{-6} Torr and a cold finger was filled with liquid nitrogen, after which the laser beam was focused on the alloy sample. To obtain a sufficiently thick layer it was necessary to apply three to five "shots" from the laser. As soon as a sufficiently thick film was produced on the mica substrate, the ampoule was unsealed, the liquid nitrogen being left in the cold finger of the ampoule. After unsealing, the ampoule together with the liquid nitrogen was placed in a helium cryostat, which was filled with liquid helium. A flat measuring coil, connected in a circuit similar to that described in [2], was dropped beforehand to the bottom of the ampoule cold finger. After filling

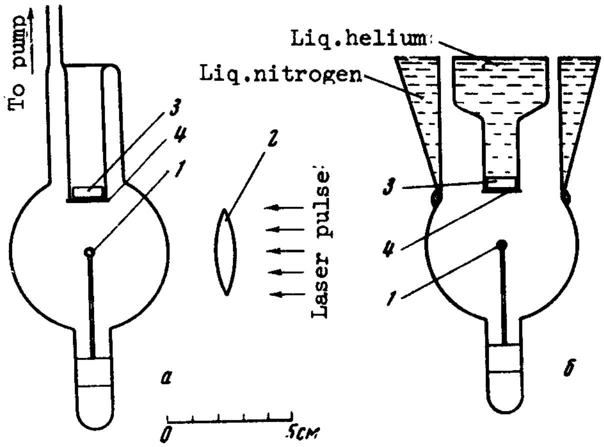

Fig. 1

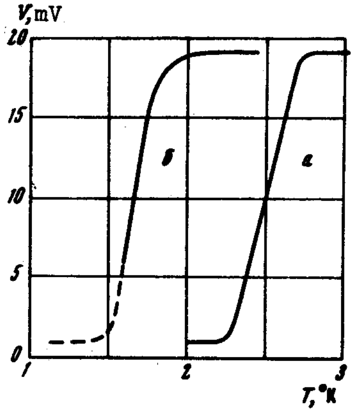

Fig. 2

Fig. 1. a) Overall view of the glass ampoule in which the film was condensed onto a substrate kept at liquid-nitrogen temperature. b) Lower part of the helium Dewar, in which the film was condensed on a substrate cooled to liquid-helium temperature: 1 - alloy batch, 2 - lens, 3 - measuring coil, 4 - mica substrate.

Fig. 2. Plots of the superconducting transitions of Au-Ge films: a - after heating to room temperature, b - immediately after preparation.

the cryostat with liquid helium, the liquid nitrogen in the cold finger froze, and the self-inductance of the measuring coil was measured as a function of the temperature.

In the second variant we used a specially constructed helium Dewar (Fig. 1b), the vacuum part of which served as the evaporation chamber. In this case the film was condensed on a mica substrate in thermal contact with a glass finger filled with liquid helium. The superconducting transition was revealed, as in the preceding case, by the change of the self-inductance of the measuring coil placed over the film.

In the films obtained by both methods, a superconducting transition was observed at 2.7°K. The measurement results are shown in Fig. 2. It is seen that a strong variation of the signal with the temperature sets in at 2.75°K and terminates at 2.25°K. After evaporation of the helium and heating of the film to room temperature, the transition into the superconducting state occurred at a temperature close to that obtained in [1] (see Fig. 2, curve a). It should be noted that in some cases a transition at this low temperature is obtained immediately after the sputtering.

The presented data show that evaporation of a film onto a strongly cooled strong substrate with the aid of a pulsed laser results in a new heretofore unknown modification of the Au-Ge system, which goes over upon annealing into the modification obtained by the authors of [1]. Such a new modification could probably be obtained because the rate of condensation upon evaporation with the aid of a laser is much higher than the rate realized in [1]. The higher critical temperature of this new modification agrees with the results obtained for other systems [3, 4], for which higher T_c were observed as a rule in phases less in equilibrium.

As already noted earlier [5], such a rise of T_c for non-equilibrium phases may be connected with the fact that the parameter of electron-phonon interaction for such phases is large enough, and possibly precisely because these phases are not in equilibrium. It is of interest to continue investigations of other non-equilibrium systems with the aid of the procedure described above, and also to study the structure of the phases obtained as a result.[1)] We hope to report the results of such investigations in the near future.

The authors are grateful to S.I. Vedeneev for great help in constructing the laser.

[1] H.L. Luo, M.F. Merriam, and D.C. Hamilton, Science 145, 581 (1964).
[2] N.E. Alekseevskii, V.I. Tsebro, ZhETF Pis. Red. 10, 181 (1969) [JETP Lett. 10, 144 (1969)].
[3] N.E. Alekseevskii, N.B. Brandt, and T.I. Kostina, Izv. AN SSSR ser. fiz. 16, 233 (1952).
[4] NBS Technical Note 408, 1966. Superconductive Materials and Some of Their Properties.
[5] N.E. Alekseevskii, Usp. Fiz. Nauk 95, 253 (1968) [Sov. Phys.-Usp. 11, 403 (1968)].