Intense lasing is produced when voltages are applied simultaneously to the capillaries and to the electrodes. The dependence of the generation energy for this case on the electrode voltages is shown by the solid lines in Fig. 1. As shown by the photograph in Fig. 2c, the plasma jet becomes much longer in this case. The field of the working volume draws out the plasma cloud without changing its cross section. The generation energy reaches 0.1 J. The laser pulse has an intense spike on the leading front, with approximate duration 0.1 μsec. It is important that under optimal conditions the voltage on the working-chamber electrodes is 2 kV, not enough to break down the gas in the working volume in the laser and to obtain lasing in the absence of gas jets in the volume. The sharp increase of the generation energy as shown in Fig. 1, when the plasma jets and the accelerating voltage in the working volume act simultaneously, takes place if the pulses feeding the working volume and the capillaries are carefully synchronized.

No lasing takes place when the working volume is filled with pure CO_2 and nitrogen is fed through the capillaries under pressure. On the other hand, intense lasing takes place if helium is fed through the capillaries. For the plasma-jet CO_2 laser to operate it is apparently important to have plasma formations come out of the capillaries. Practically no vibrationally-excited molecules come out of the capillaries.

Our experiments have thus demonstrated the promising prospects of the new plasmotron method of exciting gas-discharge CO_2 lasers. An increase of the energy input to the capillaries will apparently make it possible to use higher pressures.

The authors thank N.A. Karpov and Yu.N. Petrov for numerous discussions.

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SUPERCONDUCTING TRANSITION TEMPERATURE, ELECTRIC RESISTANCE, AND OPTICAL ABSORPTION SPECTRA OF Be AND Zn FILMS EVAPORATED TOGETHER ON CERTAIN DIELECTRICS

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Submitted 27 April 1972
ZhETF Pis. Red. 15, No. 11, 668 - 673 (5 June 1972)

According to contemporary theoretical notions, the realization of the electron-electron superconductivity mechanism would raise considerably the superconducting transition temperature [1]. The electron-electron mechanism might be realized, for example, in thin layers consisting of a metal and of a suitable organic compound [2]. One of the possible variants is the use of a porphyrin complex as the nonmetallic component.

The results of an investigation of the superconducting transition temperature T_c of beryllium films evaporated simultaneously with zinc etioprophyrin

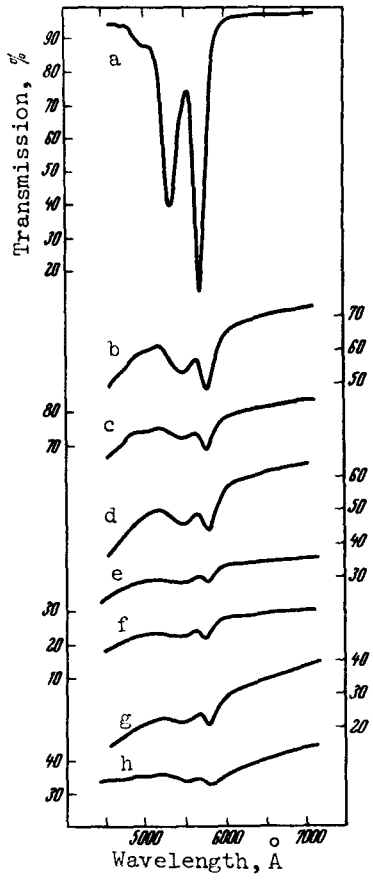

Fig. 1

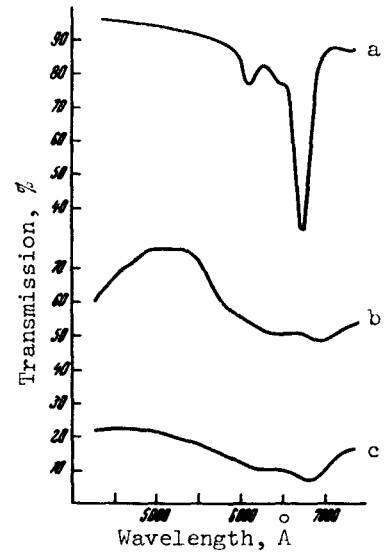

Fig. 2

Fig. 1. Absorption spectra of zinc etioporphyrin complex: a) Zn-ep solution in n-octane; b, c) films of pure Zn-ep; d, e, f) Be + Zn-ep films of different thicknesses; g, h) Zn + Zn-ep films.

Fig. 2. Absorption spectra of zinc phthalocyanine complex: a) Zn-ptc solution in ethanol, b) pure Zn-ptc film, c) Zn + Zn-ptc film.

were reported in [4]. The value of T_c of such "metal-organic" films was 1.5 - 2.0°K higher than the maximum transition temperature 8.6°K on the plot of T_c against the thickness of pure beryllium films [5]. Since analogous results were obtained when Be was evaporated jointly with potassium chloride, it was suggested that the small increase of T_c in such systems is due not to the electron-electron mechanism but to three-dimensional quantization of the electrons in the small-size Be crystallites separated by the dielectric [6][1]. In this case the metal and the dielectric component are a mechanical mixture and there is no interaction between them.

It was therefore of interest to investigate the optical absorption spectra of systems consisting of a metal and zinc etioporphyrin (Zn-ep). Such investigations were performed both on the previously studied Be + Zn-ep system and on the Zn + Zn-ep system. In addition, we investigated the absorption spectra of films consisting of Zn and zinc phthalocyanine (Zn-ptc).

The films were prepared by simultaneous evaporation of the components on a substrate kept at the temperature of liquid helium. The device in which the evaporation took place and the system for measuring T_c are described in detail in [5]. The device was used to measure the superconducting transition

[1]) It is not excluded that the change of T_c in such a dispersed system may be due to the change of the phonon spectrum (cf., e.g., [7, 8]).

temperature and the dependence of the film resistance on the temperature during the annealing time. The absorption spectra were obtained with an SF-10 spectrophotometer at room temperature.

For comparison, we obtained the optical absorption spectra of films containing only organic substances, and also the spectra of solutions of Zn-ep in octane and of Zn-ptc in ethanol. Figures 1 and 2 show the spectra obtained at room temperature for the system metal + Zn-ep and the system Zn + Zn-ptc, respectively.

The absorption spectrum of the Zn-ep solution in the visible region consists of two intense bands with maxima at 5680 and 5320 Å (Fig. 1a). The first band corresponds to an electronic transition and the second is vibrational in origin (vibronic band).

The spectrum of a film of pure Zn-ep (Figs. 1b and 1c) also has two analogous absorption bands. These bands are broader than those in the spectrum of the solution, and are shifted towards longer wavelengths. The maxima in this case are located at 5800 and 5500 Å.

The aforementioned absorption bands of crystalline Zn-ep are retained in the absorption spectra of the films obtained by joint evaporation of Zn-ep with beryllium or zinc (Figs. 1d - 1h). In many samples, the absorption bands experience a small short-wave shift relative to the spectrum of the film of pure Zn-ep, by an amount ∿50 Å.

The absorption spectrum of the Zn-ptc solution consists of two bands with maxima at 6750 and 6120 Å (Fig. 2a). In the absorption spectrum of pure Zn-ptc, these bands are very strongly broadened and shifted to the long-wave side relative to their position in the spectrum of the solution (Fig. 2b). In the absorption spectra of films obtained by simultaneous evaporation of Zn and Zn-ptc, the indicated smeared-out absorption bands of the crystalline Zn-ptc are retained and are shifted towards shorter wavelengths by an amount ∿100 Å (Fig. 2c).

Thus, a comparison of the optical spectra shows that the absorption spectra of the organic component in "metal-organic" films practically coincide with the absorption spectra of pure organic films. A small short-wave shift may be due to the finely-dispersed organic component in a film obtained by joint evaporation of the metal and the dielectric (see [9] concerning the influence of the granule dimensions on the optical spectra).

Our measurements, in the thickness range 50 - 1000 Å, of T_c of pure zinc films have shown that $T_c = 1.4°K$ and is independent of the thickness[2]. The transition temperature of Zn films evaporated jointly with Zn-ep exceeded this value. The maximum T_c, equal to 2.0°K, was observed for films consisting of the metal with Zn-ep in a ratio 3:1.[3] For films with a larger Zn-ep concentration, T_c decreases sharply and the films become non-superconducting. At a layer thickness ∿300 Å the value of $R_\square$ (the resistance of a film in the form of a square) amounted to 5 ohms for zinc films and ∿50 ohms for Zn + Zn-ep films having the maximum value of T_c. Films with $R_\square \gtrsim 500$ ohms did not become superconducting down to 1.0°K. Such a behavior of T_c and $R_\square$ was observed by Abeles

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[2] The values of T_c and the temperature dependence of the resistance agree well with the data obtained long ago by Buckel and Heisch [10].

[3] All the optical measurements were performed mainly on films having this composition.

and Hanak for the Al + SiO_2 system [11]. The resistance of all films of Zn evaporated jointly with Zn-ep decreased during the course of heating. The $R_{\square}(T)$ dependence for several layers with different concentrations is shown in Fig. 3. It should be noted that at the start of recrystallization (up to temperatures ~100°K), $R_{\square}$ varies with temperature in a reversible fashion.

The data obtained on the behavior of the resistance and T_c favor the hypothesis advanced earlier, that a jointly evaporated metal-dielectric film, and particularly a metal + Zn-ep film, constitutes a finely-dispersed system of metallic particles that do not interact with the dielectric. Data on the optical absorption spectra in the wavelength range 4000 - 7500 Å also seem to confirm this point of view, since the occurrence of a chemical bond between the metal and the dielectric should be revealed on the absorption curve. The slight increase of T_c of such systems can result either from a change of the phonon spectrum, or the consequence of the appearance of size quantization in the minute metal crystallites surrounded by the dielectric.

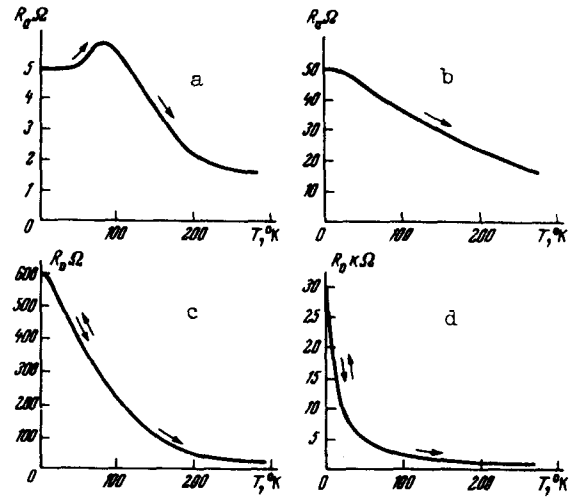

Fig. 3. Dependence of the resistance of Zn + Zn-ep films on the temperature during the course of heating: a) pure Zn film, T_c = 1.4°K, b) Zn + Zn-ep film, T_c = 2.0°K, c) Zn + Zn-ep film, traces of superconductivity at 1.0°K, d) Zn film with large content of Zn-ep, is not superconducting down to 1.0°K.

In spite of the fact that the interpretation of the experimental data do not require the use of the electron-electron superconductivity mechanism, the possibility, in principle, of realizing of such a mechanism in the investigated system is not excluded. It is possible that such a mechanism cannot be realized because of the presence of a barrier between the metal and the organic compoment.

The authors are grateful to V.G. Nazin for help with the experiments.

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