the compound with higher degree of instability having the higher critical temperature.

As already noted, the superconductivity may occur in non-equilibrium phases because the electron-phonon interaction parameter may turn out to be larger for these phases than for the equilibrium phases; this is apparently also the cause of their instability.

Unstable phases should probably be characterized by weaker interactions between the atoms in these phases, i.e., the quasielastic coupling constant should be smaller than in the stable phases. It can then be assumed that the average oscillation frequency in them is lower, and the average distance between the atoms is larger, than in the stable phases. The latter circumstance should lead to a smaller overlap of the electron ψ-functions, and consequently to the formation of narrower bands. These may be precisely the factors that play the major role in the onset of their superconductivity.

[1])T_c was defined as the midpoint of the transition curve.

[2])Naturally, the accuracy of the absolute value of ρ is governed by the validity of this assumption.

[3])This formula can be easily obtained from the Gor'kov formula [5] for χ and from the BCS expression for the jump of the specific heat.

[4])Indeed, following such a change of γ the difference in T_c should be larger than the observed one. It is not excluded that the actually observed smaller difference in T_c is a consequence of the low value of the Debye temperature of a freshly-condensed film.

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EMISSION OF ELECTRON-HOLE DROPS IN GERMANIUM AT 0.5°K

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We have investigated the radiative recombination of electron-hole (e-h) drops in pure Ge at 1.3 - 0.5°K, for the purpose of constructing the phase diagram of an electron-hole liquid and a free-exciton gas at 0.5°K. The threshold concentration of the excitons at which the e-h drops are produced at 0.5°K is estimated at $\lesssim 3 \times 10^{12}$ cm^{-3}. No new emission lines (e.g., exciton-molecule lines) were observed. The broadening of the e-h drop emission lines is attributed to the influence of deformations in the region of the condensation nuclei.

At temperatures 1.5 - 4.2°K there appears in the photoluminescence of pure Ge a new emission line of energy E_{max} = 708.5 meV [1], due to radiative annihilation of electron-hole (e-h) drops [2 - 4].

It is also known that a number of broad-band semiconductors (CuBr, CuCl, Cu_2O, CdSe) have in their emission spectra, at certain excitation levels, a line due to exciton-molecule

annihilation. The biexciton binding energy with allowance for the electron-mass anisotropy was calculated by Brinkman, Rice, and Bell[1] and found to be $\mathcal{E}_m \sim 0.1$ meV. According to theoretical estimates and a large number of experimental studies, the binding energy of the e-h drops in Ge, or the "work function" for going from the metallic state to the gas of free excitons is 1.5 - 2.5 meV [5 - 7]. It follows from energy considerations that at 1.5 - 4.2°K (kT ∿ 0.4 meV) the probability of binding into biexcitons is negligible in comparison with the probability of e-h drop production.

We deemed it of interest to investigate the recombination radiation of pure Ge at lower temperatures by lowering the excitation level, since one can expect a new exciton-molecule emission line at a temperature ∿ 0.5°K (kT ∿ 0.4 meV).

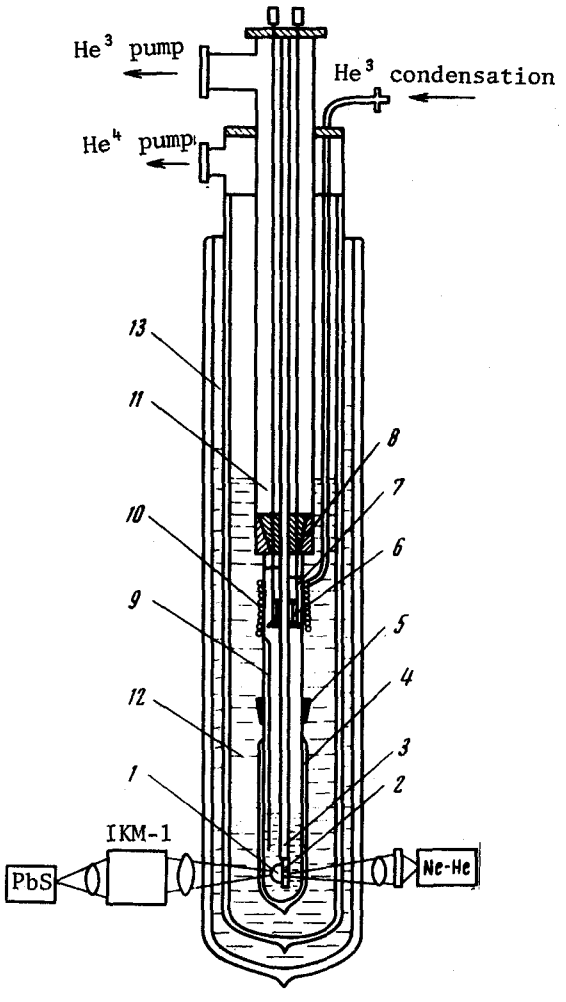

Fig. 1. Diagram of instrument: 1) Ge sample, 2) copper plate, 3) suspension tube, 4) dewar with He^3, T = 0.5°K, 5) copper-glass transition, 6) adjustment device, 7) screen, 8) ground-glass joint, 9) capillary, 10) coiled tubing, 11) tube for He^3 evacuation, 12) He^4 bath, T = 1.3°K, 13) nitrogen dewar

We investigated samples of pure Ge with residual-impurity concentration $N_A + N_D \sim 5 \times 10^{12}$ cm^{-3} and 5×10^{11} cm^{-3}, prepared in the form of a Weierstrasse sphere (of diameter 6 or 4 mm) to increase the yield of the recombination radiation from the sample. The excitation was with a helium-neon laser operating at 1.15 μ wavelength. The emission spectra were recorded with not more than 3 mW optical power incident on the sample. The spectra were registered by the usual method with synchronous detection. The spectra were analyzed with an IKM-1 grating spectrometer. The receiver was a cooled photoresistor based on PbS. The spectral width of the slit was 0.8 - 1.5 meV. The Ge sample was in a glass cryostat in an internal dewar filled with He^3 (Fig. 1) [8]. The sample was secured with Apiezon-M adhesive to a copper plate. To decrease the heat rise of the sample, the contact area between the plate and the He^3 was ∿ 25 cm^2. Direct measurements of the sample temperature with a sensitive carbon thermometer glued to the sample have shown that the heat rise at an incident power ∿ 3 mW does not exceed 0.1° if the bath temperature is ∿ 0.5°K (sample area 20 - 28 mm^2). The laser-excitation intensity was varied with calibrated neutral filters, and the minimum incident light power at which the emission of the e-h drops could still be registered was 150 μW.

When the temperature was lowered from 1.3 to 0.5°K, the emission intensity of the purest Ge sample ($N_A + N_D \sim 5 \times 10^{11}$ cm^{-3} increased by 20 - 30%, whereas the emission intensity of the more highly doped sample remained practically unchanged.

It was of interest to determine the threshold at which the e-h-drop line appears at 0.5°K, by lowering the illumination power. In other words, it was of interest to determine the point on the phase diagram of electron-hole liquid and the free-exciton gas at T = 0.5°K. It was found that at 0.5°K the e-h-drop emission sets in at an average non-equilibrium carrier density ∿ 3×10^{12} cm^{-3} (assuming $L_{exc} \sim 0.5$ mm and $\tau_{exc} \sim 10^{-6}$ sec). It should be recognized that this is an overestimate, since the only input radiation incident on the photoreceiver is the one gathered in the solid angle determined by the aperture of the focusing

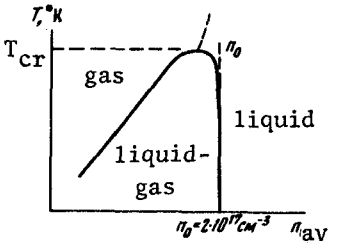

Fig. 2. Schematic phase diagram for e-h liquid and gas of free excitons: T_{cr} - critical temperature, n_{av} - average exciton density, n_0 - equilibrium carrier density in e-h drop.

lens, i.e., $\sim$ 1% of the radiation emitted into the half-space. The use of samples in the form of a Weierstrasse sphere increases this value by one order of magnitude).

We note that no other emission lines or splitting of the emission lines of the e-h drops was observed in the entire interval of the employed optical-excitation intensity (150 μW - 3 mW).

When the temperature is lowered, the maximum of the e-h drop emission line does not shift, but the width of the line increases somewhat. Whereas at 1.5 - 4.2°K the line width $\Delta\mathcal{E}$ amounts to 3.1 $\mp$ 0.2 meV, at 0.5°K we have $\Delta\mathcal{E}$ = 3.5 ± 0.2 meV.

The line broadening cannot be connected with the change of the equilibrium concentration n_0 in the drop. In fact, the right-hand branch of the liquid-gas phase diagram is practically vertical at low temperatures, i.e., n_0 can change noticeably only at temperatures close to T_{cr} (Fig. 2).

We assume that at low temperatures, when the drop dimension is greatly decreased (thus according to the certain data[1)], the drop radius decreases from 10 to 4 μ in the temperature interval 3.5 - 2.5°K), the tensions at the points of drop condensation can lead to a broadening of the line on the side of the long-wave edge [2] as a result of an inhomogeneous shift of the emission-line maxima of different e-h drops.

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[2)]These results were taken from a paper by V. S. Bagaev, N. A. Penin, N. N. Sibol'din, and V. A. Tsvetkov, soon to be published in Fiz. Tverd. Tela (Sov. Phys.-Solid State).

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