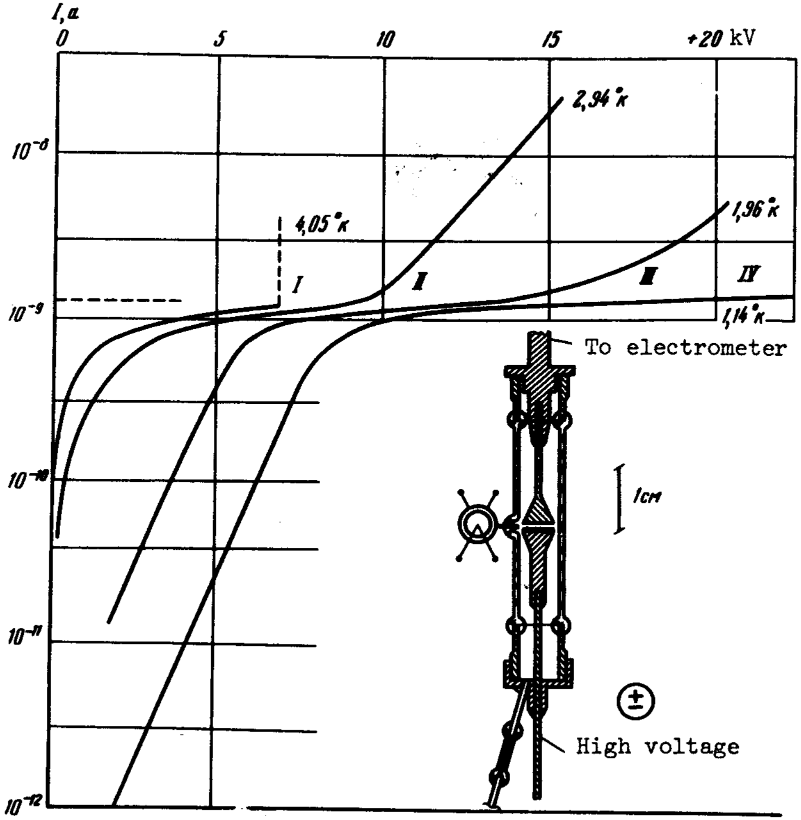
INDUCED CURRENTS IN He^3 CRYSTALS AT HIGH FIELD INTENSITIES

K. O. Koshishev, Yu. Z. Kovdrya, L. P. Mezhov-Deglin, and A. I. Shal'nikov
Institute of Physics Problems, USSR Academy of Sciences; Institute of Solid State Physics, USSR Academy of Sciences
Submitted 30 September 1969
ZhETF Pis. Red. 10, No. 9, 427 - 429 (5 November 1969)

We have previously investigated [1,2] induced currents in liquid and crystalline He^4 at field intensities not exceeding 7000 V/cm. We have continued these investigations up to fields of 8×10^5 V/cm on He^3 crystals grown in the pressure range 50 - 156 kg/cm^2.

The figure shows the current-voltage characteristic of a diode (distance between electrodes ~300 μ), on one of whose electrodes is located a β source of titanium tritide, which emits ~5.7×10^7 electrons/sec with an average energy 5.7 keV, corresponding to a total



Current-voltage characteristics for diodes I (liquid), and II, III, IV (crystals) at P = 156 kg/cm^2.

current 1.3×10^{-9} A.

As seen from the family of the log I = f(V) curves plotted for the liquid and crystals at the same pressure but at different temperatures (for the motion of positive charges), the bends of the curves lie in the region of currents close to the total source saturation current. The plot obtained for the liquid reveals the occurrence of breakdown already at field intensity 2×10^5 V/cm. In crystals, even at currents greatly exceeding the saturation current, no breakdown is observed, and further increase of the field intensity leads to melting of the crystal by the released heat. Thus, for crystals grown at pressures 50, 83, and 100 kg/cm^2 at 0.5, 0.8, and 1.7°K, this critical power amounts to (3, 4.5, and 13) $\times 10^{-5}$ W, respectively, and is determined by the complicated dependence of the thermal conductivity of the crystals on the density, orientation, temperature, and concentration of the He^4.[1)]

In our crystal grown at 156 kg/cm^2 in the temperature range 2.94 - 1.14°K, no breakdown was observed even at a voltage of 25 kV[2)], corresponding to a field intensity 8×10^5 V/cm. It follows from our experiments that with increasing crystal density and with decreasing temperature the mobility of the positive carriers decreases, but the uncontrolled melting of the crystals makes it impossible to obtain quantitative estimates.

We propose to continue these investigations using more perfect He^4 crystals, where the field intensities can be greatly increased near the maximum thermal conductivity [3].

[1] A. I. Shal'nikov, Zh. Eksp. Teor. Fiz. 47, 1727 (1964) [Sov. Phys.-JETP 20, 1161 (1965)].
[2] E. Ifft, L. P. Mezhov-Dglin, and A. I. Shal'nikov. Proc. 10th International Conference on Low Temperature Physics, VINITI, 1967, p. 224.
[3] L. P. Mezhov-Deglin, Zh. Eksp. Teor. Fiz. 49, 66 (1965) [Sov. Phys.-JETP 22, 47 (1966)].