CARRIER MOBILITY IN He^4 CRYSTALS

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As reported earlier [1], an attempt to use a five-grid time-of-flight procedure [2] to measure carrier mobility in solid He^4 was unsuccessful. The main difficulty was apparently the presence of defects in the crystals grown inside the measuring cell in an interelectrode space containing several grids, each of which led to successive violation of the "ideal" character of the crystal during its growth. We have attempted to use a measuring cell in which

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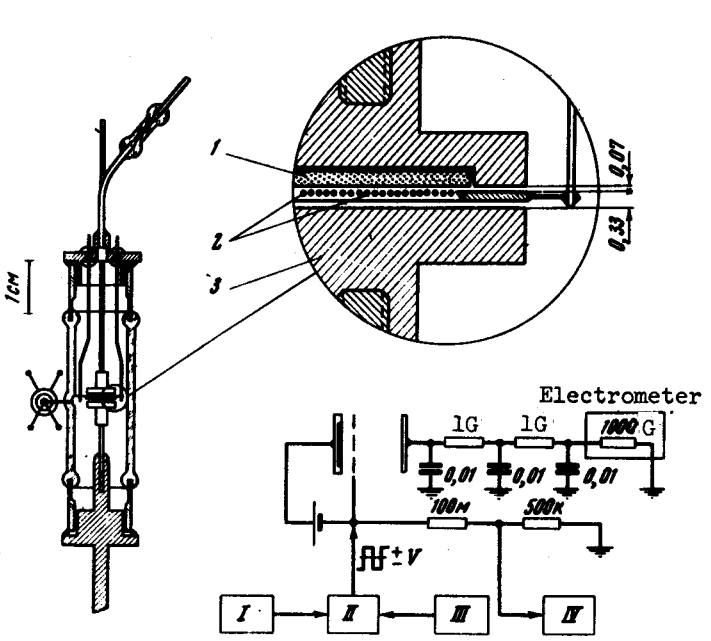

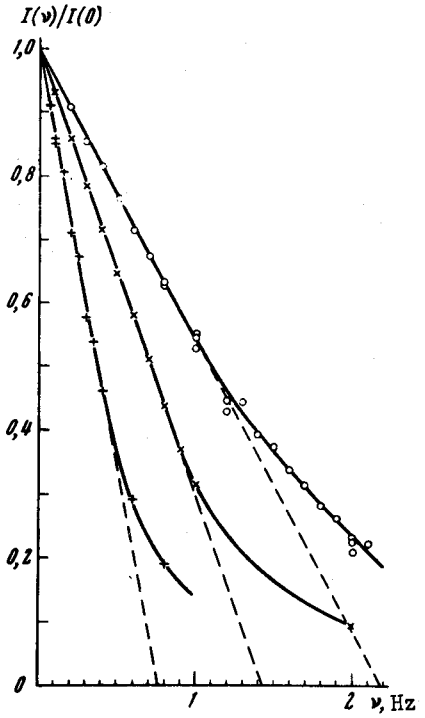

Fig. 1. 1 - Source, 2 - grid, 3 - collector, I - generator, II - amplifier, III - high-voltage source, IV - oscilloscope.

Fig. 2. Frequency dependence of the current for positive carriers (+ - T = 2.01°K, × - T = 1.76°K) and negative carriers (o - T = 1.96°K).

the number of grids was reduced to a minumum [3]. Figure 1 shows the cell employed by us. Its only grid, made from a klystron grid, was cut to a third and its frame was ground down to 180 μ. A dc voltage was applied between the grid and the source (a titanium-tritium target producing 9×10^7 electrons/sec) to draw the carrier of the desired polarity into the drift space. An alternating square-wave voltage with an amplitude swing up to 500 V was applied to the drift space.

The output current was measured with a Takeda Riken electrometer with an RC filter connected to its input to reduce the low-frequency noise. The time constant of the measuring apparatus with the filter included amounted to 100 sec. The electric measurement circuit is shown in Fig. 1.

The three-electrode cell was first used to measure the well known carrier mobilities in liquid He^4 in the temperature interval 2.0 - 4.2°K and at pressures up to 40 atm, determined from the intercept of the linear section of the function $I = f(\nu)$ on the abscissa axis. The obtained mobilities are in satisfactory agreement with the known data [2], and also with the results of our own measurements.

Following these control experiments, we proceeded to grow crystals in the cell at a pressure of 35 - 40 atm. Only by exercising very careful temperature control, after a number of failures, did we succeed in obtaining satisfactory samples.

As already noted earlier [1], a measure of "ideality" of the grown crystal is the decrease of the induced current upon solidification. In the better of

the crystals grown by us this decrease amounted to several per cent. In this study we investigated the samples in which the current decreased by a factor 2 - 3 after solidification.

Figure 2 shows plots of $I = f(\nu)$ for the two best samples. The calculated mobilities for the carriers of both signs in liquid and solid He^4 are listed in the table:

		P_{atm}	$T°$, K	E, V/cm	μ, $cm^2/V\text{-}sec$
+	Liqu.	36	2.62	$7.6 \cdot 10^3$	$0.9 \cdot 10^{-2}$
−	Liqu.	39	2.27	$1.52 \cdot 10^4$	$1.2 \cdot 10^{-2}$
+	Cryst.	38	2.01	$1.52 \cdot 10^4$	$5.7 \cdot 10^{-6}$
+	Cryst.	35	1.76	$1.52 \cdot 10^4$	$3.2 \cdot 10^{-6}$
−	Cryst.	38	1.96	$1.52 \cdot 10^4$	$9.7 \cdot 10^{-6}$

We have thus established that in fields of 15,000 V/cm the mobilities are smaller by more than three orders of magnitude than those observed in the liquid prior to solidification.

We plan to extend our mobility measurements to the region of maximum (pre-breakdown) field intensities, in which new important effects may be expected.

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