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Some Electrical Properties of Natural Crystals of Iron Pyrite

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Room-temperature Hall mobilities of natural single crystals of iron pyrite with carrier concentrations of approximately $10^{18}/\text{cm}^3$ were found to be approximately 100 cm^2/volt-sec for electrons and 1 for holes. Resistivity as a function of temperature was measured on six samples in the range from −196°C to 403°C; from this measurement the width of the forbidden band was estimated to be 1.2 ev.

ALTHOUGH iron pyrite received some use as a crystal detector in the past, along with the more widely known galena, there is comparatively little information available regarding its electrical properties. The *International Critical Tables* quote some conductivity data[1] by Koenigsberger, Beckman, and Heaps and a Hall coefficient obtained by Smith.[2] The conductivity data were not measured over a temperature range sufficiently wide to permit an estimate of the width of the forbidden band, and the Hall coefficient data were not accompanied by conductivity data which would permit an estimate of carrier mobility.

Because synthesis of iron pyrite crystals suitable for electrical measurements proved to be difficult, natural crystals were selected for measurement. Specimens were sawed from several different single crystals in the approximate dimensions 1×0.5×0.1 cm. These wafers were lapped with carborundum powder and etched with a mixture of 60 parts HNO_3 and 40 parts HF. With a thermoelectric probe, four *p*-type and two *n*-type wafers were selected for measurement, *n*- and *p*-type wafers being eliminated. Although these wafers were cut from single crystals, etching revealed many inhomogeneities, which possibly were due to strains.

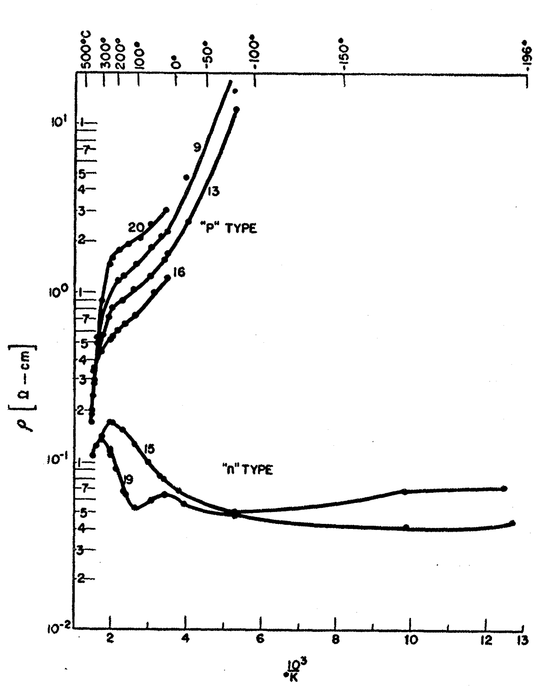

FIG. 1. Resistivity as a function of reciprocal temperature for mineral iron pyrite.

Hall coefficients were measured at room temperature by means of a 10.5-kilogauss magnetic field from a permanent magnet and currents of 10 to 25 ma dc. Results are shown in Table I.

After the Hall-coefficient measurements were made, resistivities as a function of temperature were measured on all six samples in a single run. No protective atmosphere was used. From Fig. 1 the width of the forbidden band can be estimated to be about 1.2 ev.

TABLE I. Room-temperature electrical properties.

Sample No.	Thermoelectric type	R cm³/coul	N 10^{18}/cm³	ρ Ω−cm	Hall μ^a cm²/volt-sec
9	*p*	2.8	2.6	2.2	1.3
13	*p*	2.3	3.2	1.6	1.4
15	*n*	−7.6	0.97	0.078	98
16	*p*	1.9	4.1	1.2	1.6
19	*n*	−6.5	1.1	0.063	103
20	*p*	6.3	1.2	3.1	2.0

[a] Another *n*-type sample not included in this group exhibited an electronic Hall mobility of 168 cm²/volt-sec.

Also evident from Fig. 1 is the striking difference in conductivities between the *n*-type and *p*-type samples at low temperatures. From the slopes of the plots, the acceptor activation energy can be estimated roughly at 0.1 ev, while the donor activation energy is very much less. Because of this wide difference, two of the *p*-type samples and the two *n*-type samples were spectrographically analyzed. However, no distinction between the two types could be made in this way. As a point of interest, these samples had an extremely high purity, considering that they were natural crystals; all four showed silicon as the major impurity in a concentration roughly estimated at 0.03 percent.

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[1] *International Critical Tables* (McGraw-Hill Book Company, Inc., New York, 1933), Vol. 6, pp. 154, 155, 422.
[2] Reference 1, p. 416.