

order of  $2 \times 10^{-15}$  coulomb were readily detected in the Hall experiment. As expected the primary photoresponse of the AgCl crystal was fast, less than one microsecond.

An approximate value of the Hall mobility for this one sample at  $89 \pm 6^\circ\text{K}$  is  $370 \pm 70$   $\text{cm}^2/\text{volt-sec}$  and is shown in Fig. 1 along

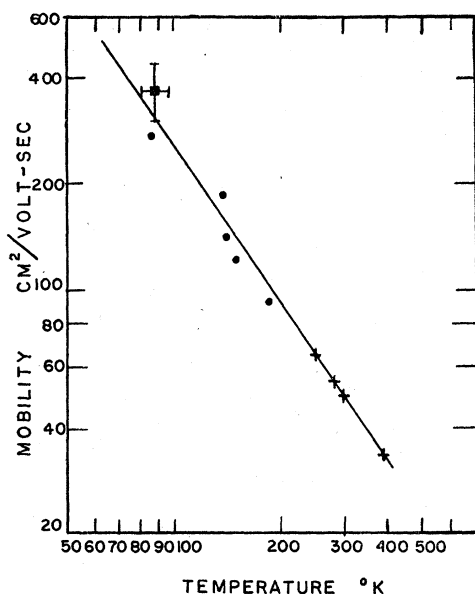


FIG. 1. Electron mobility in silver chloride. ■ Hall mobility for crystal No. IV; ● electron drift mobility for crystal No. IV; + data of Haynes and Shockley for AgCl (reference 3).

with the drift mobility values. The crosses at higher temperature in this graph are the values of Haynes and Shockley<sup>3</sup> utilizing the "print-out effect" in AgCl, a technique which is not applicable at liquid nitrogen temperature. Although the figure for Hall mobility at low temperature is approximate, the reproducibility was reasonably good. Under the conditions of the experiment one is led to believe that the effects of space charge are unimportant. The value of Hall mobility decreased with increasing temperature similar to the drift mobility, but accurate results are not available for intermediate temperatures at this time. Within experimental error the Hall voltage was linear with magnetic field up to at least 10 000 gauss. Since the crystal counter measurements indicate that there is no appreciable hole conductivity at  $85^\circ\text{K}$ , it may be reasonable to assume that we have measured here the electronic Hall mobility. The polarity of the effect was as expected for electrons.

It is interesting to compare the data with the theory of Low and Pines.<sup>4</sup> Their approximation  $kT \ll \hbar\omega$  should be valid for AgCl at  $85^\circ\text{K}$ . We take values of  $\epsilon = 12.3$ ,  $n^2 = 4.04$ ,<sup>5</sup> and  $\lambda_e \approx 90\mu$ .<sup>6</sup> The drift mobility value of 270 then agrees best with theory for an effective mass of the electron  $m \approx 0.5$  electron masses.

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## Perfect Crystals of Zinc Sulfide

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IT is a well-known fact that crystals deform plastically at strains much lower than predicted for perfect crystals. This is usually interpreted to signify the presence in real crystals of dislocations which move under the influence of a relatively small stress.<sup>1</sup> Galt and Herring<sup>2</sup> have shown that the small ( $1.8 \times 10^{-4}$  cm in diameter) "whiskers" of tin reported by Compton *et al.*<sup>3</sup> are relatively perfect single crystals in the sense that they may be bent elastically to a strain of 1 percent without plastic deformation.

We have recently grown crystals of zinc sulfide which similarly appear to be free of dislocations, and we have some preliminary information which suggest these perfect crystals have several unusual properties. The crystals are grown by sublimation in an atmosphere of hydrogen, and the crystals of interest crystallize as needles, up to about  $5 \times 10^{-3}$  cm in diameter and several millimeters long. It is believed these crystals may have grown from a single screw dislocation with its Burger's vector parallel to the needle axis.

X-ray diffraction patterns from the needles show that they are single crystals of hexagonal zinc sulfide (wurtzite) and that the needle axis coincides with the crystallographic *c* axis. Whereas most zinc sulfide crystals grown by this technique possess a high density of stacking faults (aperiodic errors in the sequence of layers normal to the *c* axis), these crystals appear free from such defects as is shown by the absence of diffuse streaking in the x-ray photographs. The crystals also fail to show under the polarizing microscopic the usual pattern of striations parallel to the basal planes characteristic of the non-perfect crystals.

The needles are remarkably flexible and may be bent elastically without plastic deformation. After measuring the deflection produced by hanging known loads from the tip of a crystal rigidly anchored at the opposite end, Young's modulus was estimated to be about  $7 \times 10^{11}$  dynes/cm<sup>2</sup>. We have induced elastic strains up to  $1\frac{1}{2}$  percent by bending the crystal between a fixed plate and the face of a micrometer.

Hexagonal zinc sulfide is thermodynamically unstable at room temperature with respect to the cubic polymorph (sphalerite). Ordinary crystals of hexagonal zinc sulfide, which contain stacking faults and presumably the usual complement of dislocations, begin to disorder when heated to about  $400^\circ\text{C}$  and at higher temperatures will transform to a twinned single individual of the cubic form. In contrast to this, the flexible crystals must be heated to  $750^\circ\text{C}$  to produce a comparable disorder, thus showing the important role dislocations play in the mechanism of the transformation.

The photoconductivity of these perfect crystals has been compared with ordinary single crystals of zinc sulfide which possess the stacking faults described above. In each case the crystal was irradiated with a strong source of 3650 Å light (B-H4 lamp) and a voltage applied between silver paste electrodes to produce a photocurrent density of the order of  $10^{-6}$  amp/cm<sup>2</sup>. The ordinary crystals took 50 to 500 sec to decay by a factor of  $10^3$ , whereas the perfect crystals decayed too rapidly (less than 5 sec) to be detected by the electrometer. The slow response of the ordinary ZnS crystals has been associated with electron traps well below the conduction band. The concentration of these traps would thus appear to be significantly diminished. Hence, one might suspect these electron traps are associated with dislocations. An alternative is that the traps and dislocations are independent products of the presence of a foreign impurity or other generator of crystal imperfections.

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<sup>3</sup> Compton, Mendizza, and Arnold, *Corrosion* **7**, 327 (1951).