

Effect of Plastic Flow upon Color Centers in Alkali Halide Crystals*

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GYULAI and Hartly¹ found an enhancement of charge drift in NaCl when the crystal was deformed plastically. Seitz² has interpreted this effect in terms of an electrolytic current associated with the generation of positive- and negative-ion vacancies during plastic flow. He estimated that a vacancy concentration of approximately 10^{18} per cc was produced by a strain of ten percent. On the other hand it is well known that isolated negative-ion vacancies and simple clusters of vacancies can trap electrons to form *F* and other centers; e.g.,

the *F'* center, a negative-ion vacancy+two electrons;
 the *M* center, and *F* center+one pair of vacancies;
 the *R* centers, two negative-ion vacancies+one or two electrons.

One expects, therefore, that plastic flow will affect the absorption spectrum of a crystal containing color centers. We have found that the yellow color of a NaCl crystal containing *F* centers changes to blue after plastic deformation and simultaneous exposure to white light, whereas the undeformed crystal maintains its coloration for a long time. The change of color occurs more quickly the greater the magnitude of the plastic deformation. This effect has been investigated in the following experiments.

In a synthetic (Harshaw) NaCl crystal, *F* centers were produced electrolytically with a concentration of about 3×10^{16} per cc. The crystal was then irradiated with intense blue light through a filter, the transmission maximum of which coincided approximately with the *F*-absorption maximum, until the growth of the *M* and *R* bands ceased. (Curve *I* in Fig. 1, measured at room temperature.) Then the crystal was subjected at room temperature to a plastic strain of six percent under a red light. No observable change in the absorption bands occurred after this treatment. However, if the deformed crystal was irradiated with

F light, the *F* band bleached rapidly and the *M* and *R* bands were enhanced. Curves *IIa* and *IIb*, measured at room and liquid N₂ temperature, respectively, illustrate this effect. After further irradiation curves *IIIa* and *IIIb* were obtained. Complete bleaching of *F* centers was possible by prolonged irradiation with *F* light. This indicates that vacancies are generated by the plastic flow and that their concentration is larger than that of the original *F* centers.

Somewhat different results were obtained if the crystal (irradiated at room temperature with blue light as before) was subjected to plastic flow at liquid N₂ temperature and kept at this temperature. Complete bleaching of the *F* band could not be obtained by irradiation of *F* light under these circumstances.

The observed partial bleaching of the *F* band was accompanied by the formation of *F'* centers in this case and no enhancement of the *M* and *R* bands occurred. If the crystal was warmed to room temperature in the dark, however, a slight enhancement of the *M* band was observed. Subsequent irradiation at this temperature with *F* light produced the same effect as in a crystal deformed at room temperature. Hence it appears that the vacancy aggregates generated by the plastic flow at low temperature do not act as effective traps for electrons released optically from the *F* center. After the warming up, the vacancy aggregates decompose and migrate.

More quantitative experiments with NaCl and KCl crystals containing different concentrations of *F* centers will be carried out with different magnitudes of plastic deformation.

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² F. Seitz, *Phys. Rev.* 80, 239 (1950).

Superconductivity of Pure Metallic Rhenium

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THE occurrence of superconductivity in rhenium was first reported by Aschermann and Justi,¹ who observed a sharp drop in the electrical resistance of a sintered rhenium rod at about 0.95°K. In later measurements upon rhenium powder Goodman² and Daunt and Smith³ found magnetic evidence for the onset of superconductivity in the neighborhood of 2.4°K. In view of the discrepancy between the sintered rod and powder results, it was thought to be worth while to prepare a solid rod of metallic rhenium so that reliable data could be obtained on the superconducting transition temperature and other superconducting properties of the bulk metal. We have, therefore, fabricated a rhenium rod of length 2 inches and of diameter $\frac{1}{4}$ inch by zone-melting compressed rhenium powder⁴ in an argon arc furnace. Spectrographic analysis of this rod indicated that the total impurity content was less than 0.01 percent; the high purity of the material may also be judged from its residual resistance value, which was only 0.00068 of the ice-point resistance.

Both electrical resistance and magnetic induction measurements indicated that the pure rhenium rod became superconducting at 1.699°K. Below this temperature the destruction of superconductivity by a magnetic field occurred quite sharply at well-defined values of the field strength which could be represented by the equation

$$H_c = 188[1 - (T/1.699)^2] \text{ oersteds.} \quad (1)$$

At the lowest temperature, 1.16°K, the induction rose to about 95 percent of the normal value just above the critical field strength, and the removal of a field of about five times the critical value caused the expulsion of more than 99 percent flux. This tendency of rhenium to exhibit nearly ideal superconducting behavior is

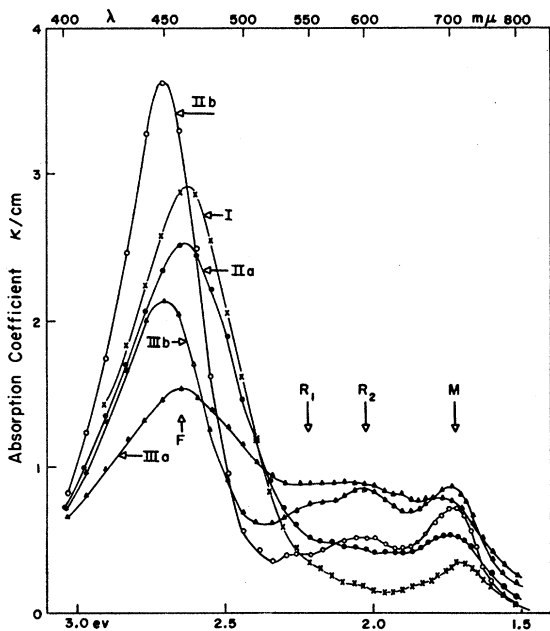


FIG. 1. Optical bleaching of *F* centers in NaCl crystal after plastic deformation. Curve *I*: absorption spectrum of the crystal previous to *F* light irradiation. Curve *II*: after two hours irradiation with *F* light. Curve *III*: after further four hours irradiation with *F* light. *a*, *b* indicate the measurements at room and liquid N₂ temperature, respectively.