EFFECT OF PLASTIC DEFORMATION ON COLOR CENTER FORMATION AND BLEACHING IN SODIUM CHLORIDE CRYSTAL*

By Ryo Kiyama and Fumio Okamoto

Introduction

In the previous paper[1] the authors reported the effect of plastic deformation upon F-centers produced in alkali halide crystals by electrolysis. Now the authors have studied the effect of plastic deformation on color center formation in NaCl crystal and the bleaching effect of plastic deformation in NaCl crystal darkened by γ-ray irradiation.

Burstein, Smith and Davisson[2] have reported that x-irradiation of plastically deformed KCl crystals forms the F-, R- and N-bands and the extent of color center formation is enhanced in moderately deformed crystals. Smekal[3] and Schroeder[4] have found that the F-centers in alkali halide crystals darkened by x-rays are bleached by plastic deformation. The authors have found that (1) the deformed NaCl crystal darkened by γ-ray irradiation shows dark yellow color, which is changed to blue by F-light exposure, whereas the coloration of undeformed crystal is yellow, which is scarcely changed by F-light exposure, and (2) the F-centers produced in undeformed NaCl crystal by γ-ray irradiation are bleached by plastic deformation and the optical bleaching of the deformed crystal by F-light exposure is more rapid than that of undeformed crystal. These effects of plastic deformation have been investigated by measuring the absorption spectra at room temperature.

Experimentals

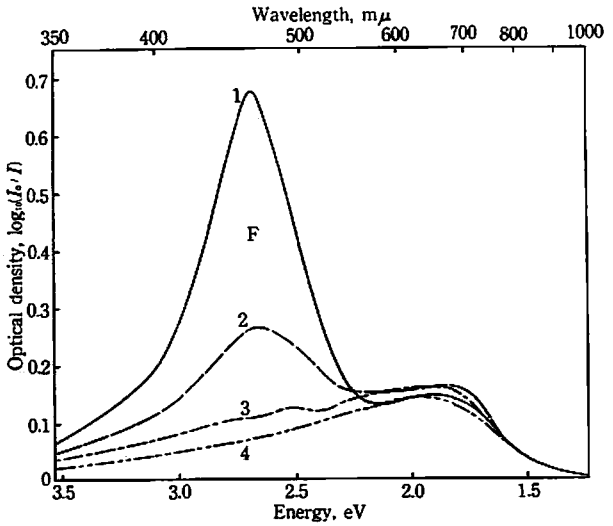
The crystal pieces used in this work were cleaved from large single-crystal block synthesized in this laboratory. The γ-ray irradiation was performed at room temperature for 30 days using radioactive Co^{60}. The plastic deformation was carried out by die-casting with a pressure of 5,000 kg/cm^2 in the dark at room temperature as in the previous investigation[1]. The optical absorption measurements were made over the wavelength range from 350 to 1000 mμ at room temperature on Beckman Model D U Spectrophotometer. The optical bleaching was accomplished in the spectrophotometer at 464 mμ, the wavelength of the F-band maximum, with the slit set at 2 mm.

* *This investigation has been done by F. Okamoto, being in the postgraduate course, under the direction of Prof. R. Kiyama.*

1) R. Kiyama and F. Okamoto, *This Journal*, 25, 1 (1955)
2) E. Burstein, P. L. Smith and J. W. Davisson, *Phys. Rev.*, 86, 615 (1952)
3) A. Smekal, *Z. Physik*, 55, 289 (1929)
4) H. J. Schroeder, *ibid.*, 76, 608 (1932)

Results

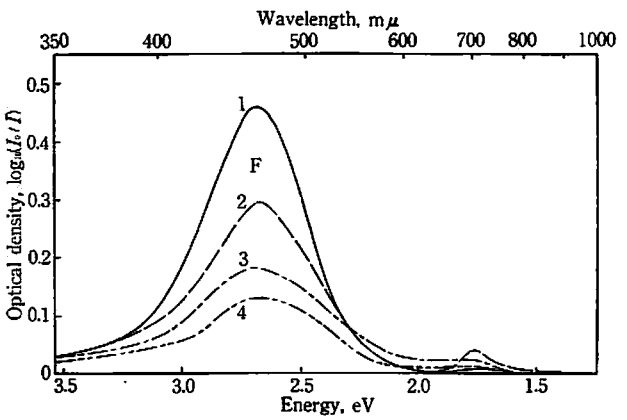
Color center formation in plastically deformed crystal The crystal cleaved to a square plate of about 4.0×4.0×1.7mm was deformed to a thin disk of 6mm in diameter and 0.95mm in thickness and then the deformed crystal was darkened by γ-ray irradiation for 30 days with the undeformed crystal arranged for comparison. The absorption spectra of these deformed and undeformed crystals are shown by curve 1 in Figs. 1 and 2 respectively. By comparing the spectra it was found that in the deformed crystal the F-center formation was markedly increased and broad absorption band was formed on the long wavelength side. Then both the deformed and undeformed crystals were exposed to F-light. The bleaching of F-centers in the deformed



1: absorption spectrum of deformed crystal darkened by γ-ray irradiation for 30 days
2: after 5 minutes exposure to F-light
3: after further 20 minutes exposure
4: after further 30 minutes exposure

crystal thickness=0.95mm

Fig. 1 Absorption spectrum of color centers produced in plastically deformed NaCl crystal by γ-ray irradiation and its changes by exposure to F-light



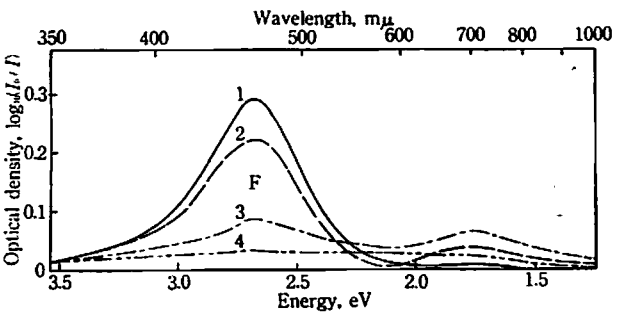
1: absorption spectrum of undeformed crystal darkened by γ-ray irradiation for 30 days
2: after 5 minutes exposure to F-light
3: after further 20 minutes exposure
4: after further 30 minutes exposure

crystal thickness=1.40mm

Fig. 2 Absorption spectrum of color centers produced in undeformed NaCl crystal by γ-ray irradiation and its changes by exposure to F-light

crystal was so rapid that the F-centers almost vanished by 55 minutes F-light exposure, whereas the bleaching of F-centers in the undeformed crystal was slow and the F-centers still existed after 55 minutes exposure as shown by curves 2, 3 and 4 in Figs. 1 and 2 respectively. The long wavelength band in the deformed crystal was scarcely changed by the 55 minutes exposure (curve 4 in Fig. 1).

Bleaching effect of plastic deformation The crystal cleaved to a square plate of about 4.0×4.0×1.9mm was darkened by γ-ray irradiation for 30 days and then the colored crystal was deformed to a thin disk of 6mm in diameter and 1.08mm in thickness. As a result of this deformation the height of the F-band was reduced by about 24 percent and the long wavelength band was slightly developed as shown by curves 1 and 2 in Fig. 3. After the deformation the crystal was exposed to F-light.



1: absorption spectrum of undeformed crystal darkened by γ-ray irradiation for 30 days
2: immediately after plastic deformation in the dark
3: after 5 minutes exposure to F-light
4: after further 10 minutes exposure
crystal thickness=1.08mm

Fig. 3 Changes of the absorption spectrum of color centers in NaCl crystal by plastic deformation and exposure to F-light

The F-centers were very rapidly bleached and almost vanished by 15minutes F-light exposure, whereas the bleaching of the F-centers in undeformed crystal was slow and the F-centers still existed after 55 minutes exposure as shown in Fig. 2. The long wavelength band was slightly enhanced by 5 minutes F-light exposure and decreased with the lapse of exposing time (curves 3 and 4 in Fig. 3).

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The Laboratory of Physical Chemistry,
Kyoto University