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Thermal Glow Luminescence in Plastically Deformed KCl Crystal

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It has been found that plastically deformed KCl crystals show simple glow luminescence irrespective of crystal histories by the X-ray or exciton-light irradiation. These glow have been attributed to the recombination of electron and hole trapped by single vacancy and vacancy cluster. Intensity of 250°C peak has been confirmed to increase as the square of exciton density. From this, the exciton effect in deformed crystal has been discussed.

The present report was pointed to the investigation of the effect of plastic deformation on the thermal glow emission of KCl crystal irradiated by X-ray and ultraviolet light at room temperature. The deformation was found to enhance the glow luminescence intensity and make the glow curve simple irrespective of the crystal histories so far as used in this investigation.

1. X-ray Irradiation

Thermal glow luminescence peaks in X-rayed crystal are shown by *a* and *b* in Fig. 1. The

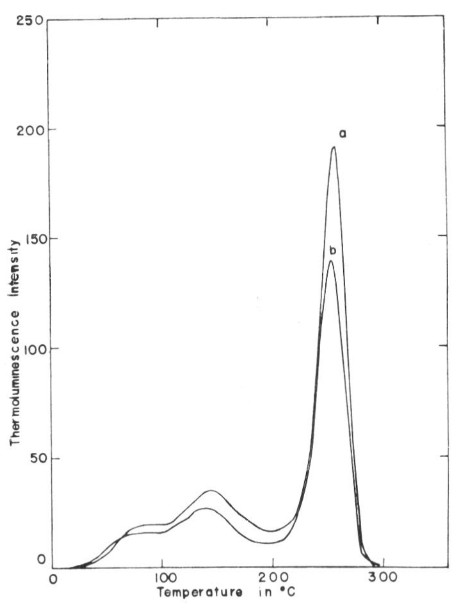

Fig. 1.

glow curve consists of three peaks which appear at 80°, 140° and 250°C. The peak of 250°C is one thousand times stronger than that in undeformed crystal. From the spectral absorption change in the heating process and the stimulation of emission by red light, the glow peaks of 80° and 140°C are considered to be due to the recombination of electrons released from *M* and *N* centers with the trapped holes and the strong peak of 250°C will be ascribed to the recombination of *F*-electron and V_3-hole.

The peak intensity of 250°C is also much enhanced by the deformation *after* the X-ray irradiation as shown in Fig. 2. Curve B is

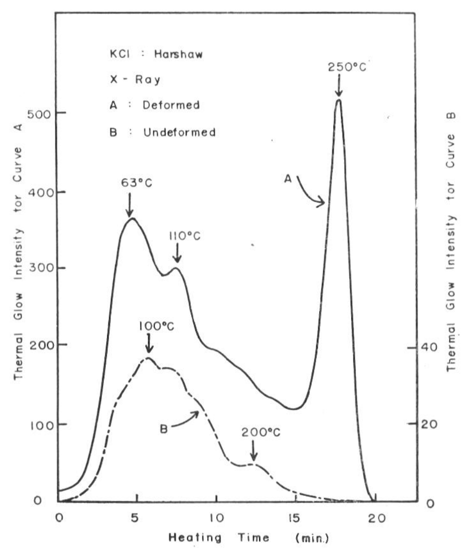

Fig. 2.

the glow curve in an undeformed X-rayed crystal and curve A is that in a deformed crystal *after* the X-ray irradiation. This fact will indicate that the perturbed crystalline field caused by the plastic deformation increases the recombination probability of *F* with V_3 center. This is supporting the hypothesis of Bonfiglioli.

2. Ultraviolet Irradiation

The thermal glow curve of deformed KCl crystal irradiated by UV light is different from that in X-rayed one. As shown in Fig. 3,

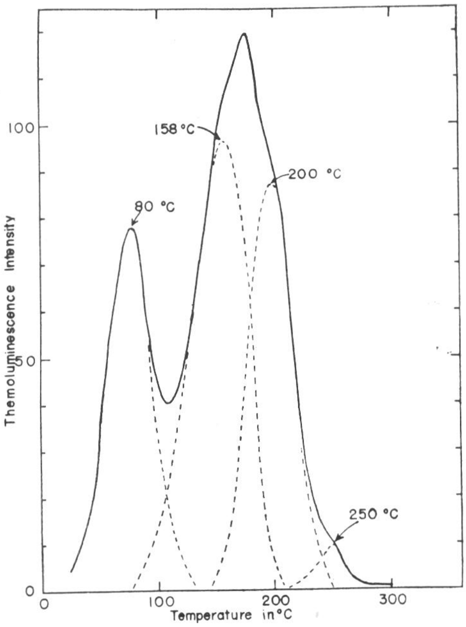

Fig. 3.

the glow consists of four peaks at 80°, 158°, 200° and small 250°C. The two peaks of 158° and 200°C are most prominent. The peak intensities increase with increasing deformation as shown in Fig. 4. After the deformed crystal was annealed to 300°C for short time, the glow intensity decreased as in an undeformed one. On the other hand, the density of dislocation line in deformed crystal was found not to decrease appreciably by the heat treatment at 400°C for twenty hours. Therefore, the effect of deformation upon the glow luminescence is not attributed to the dislocation but to the vacancy cluster generated by

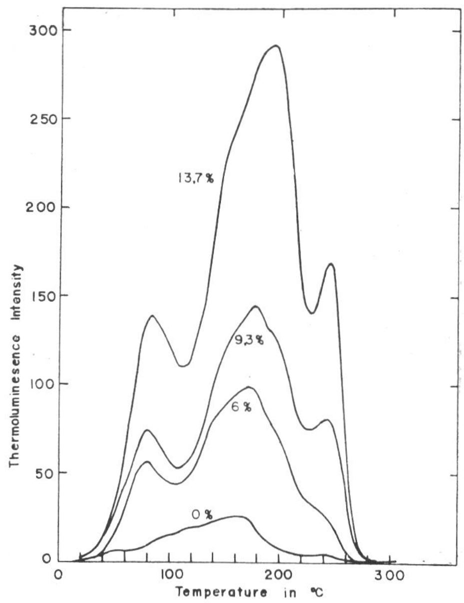

Fig. 4.

the plastic flow. The peak of 250°C was found to appear in only the vicinity of the illuminated surface. In the vicinity of the illuminated surface the density of exciton generated by UV-light is large compared to that inside the crystal as considered from the shape of the fundamental absorption band of crystal.

We are tentatively considering that the peak of 158° and 200°C are attributed to the electron and hole recombination in the trapped states existing very close to each other at the vacancy cluster. The peak of 250°C is common in both cases of X-ray and exciton-light and this peak is considered to increase in intensity as the square of exciton density. Exciton interacts with vacancy clusters and dissolves them into the simpler vacancies and another exciton is trapped and decomposes into the electron and hole.

DISCUSSION

Akasaka, K.: How much was the X-ray dosage you applied to the specimens? It is well known that glow shapes and temperatures are strongly dependent on irradiation dosage.

Ueta, M.: In our work, the X-ray dosage was rather of low level. However, in the work of Wiegand and Smoluchowski, the high dosage of X-ray has the similar effect as the plastic deformation for vacancy generation. Therefore, the work in deformed crystal will correspond to the case of high dosage of X-ray irradiation.

Akasaka, K.: You mentioned that the lower temperature peaks will be due to the ejection of electrons from complex centers. In our results on KCl-thermoluminescence, the lower temperature peaks tend to decrease with increasing irradiation dosage although the amount of complex centers increases with dosage. This appears to me to be in contradiction with your interpretation.

Ueta, M.: As I showed in the first slide, the thermoluminescence intensity depends much on the crystal history and changes to crystals to crystals cleaved, even in the crystals from the same ingot. Therefore the quantitative comparison of glow intensity with optical density of complex centers should be made very carefully.

Klick, C. C.: It should be interesting to know whether the emission spectrum in any of the thermal glow peaks is identical with that seen by Onaka, Fujita and Fukuda* reported in their paper on irradiation in the α center. If such an identification could bemade it might allow the assignment of one of the peaks as due to the recombination of an exciton at an isolated vacancy.

* *Proc. Int. Conf. Cryst. Latt. Def. (1962)*: J. Phys. Soc. Japan **18** Suppl. II (1963) 263.

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Electron Conduction and Breakdown in Gamma Ray Irradiated KCl Crystals

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Pulse F band photoconduction upto prebreakdown range and dielectric breakdown field of γ irradiated KCl crystals were investigated. From the electric field saturation of pulse photocurrent, mobility $\times$ life time ($\mu\tau$) and relative value of quantum yield for photoconduction (η) were obtained at various temperature and F center density. Apparently η increases at about $-60°C$ with increasing temperature. $\mu\tau$, however, decreases. Current multiplication possibly due to impact ionization of F center were found only just below the breakdwon field. In nearly perfect KCl, temperature dependence of breakdown field well coincides with the theory which takes into account the electron interaction with polar optical phonon. γ ray introduced defects increases low temperature pulse breakdown field possibly through inelastic impurity scattering and also increases d.c. breakdown field around room temperature due to the space charge effect of the trapped electrons.

1. Introduction

von Hippel's early experiments[1] on dielectric breakdown of alkali halide crystals revealed the nature of lower temperature breakdown to be the results of electron avalanche with penetrating intuition based on the effects of crystal imperfections, and have been followed by a series of theoretical formulations by many workers[2]. The efforts to compare these theoretical value with experimental data have confronted various difficulties partly due to improper experimental data suffering from secondary factors such as dislocations and vacancies. We have tried[3] to get nearly intrinsic breakdown data in KCl crystal to compare with the theory and to clarify the effect of point defects on the dielectric breakdown. The conventional measurement of the breakdown field only can not reveal the mechanism without knowing the behaviours of hot electrons at prebreakdown range. To this purpose F band pulse photoconduction upto prebreakdown range and breakdown field were measured simultaneously for KCl crystal in which controllable amount of imperfections had been introduced by γ irradiation.