Abstract

THE EFFECTS OF PRE-IRRADIATION ANNEALING ON THE THERMOLUMINESCENCE, DIELECTRIC LOSS, AND OPTICAL ABSORPTION OF LiF:Mg

by

Roderick McLellan Grant, Jr.

Under the Supervision of Professor John R. Cameron

The character of the radiation-induced thermoluminescent glow peaks in LiF:Mg (70 ppm and 100 ppm by spectrographic analysis) are affected by pre-irradiation isothermal annealing. The effects were studied at annealing temperatures between 25°C and 150°C. At temperatures below 100°C the pre-irradiation annealing kinetics of one of the glow peaks which appears in both samples at about 105°C has been correlated with the annealing kinetics of quenched-in Mg^{++}-cation vacancy complexes as measured by dielectric loss techniques. After the sample has been annealed for one hour at 400°C and cooled in about 3 minutes to room temperature, almost all of the magnesium is found to be associated with cation vacancies in the 70 ppm and 100 ppm samples. The total glow curve area is greater by a factor of 30 in the 100 ppm sample as compared to the glow curve from the 70 ppm sample, but the 105°C glow peak associated with the Mg^{++}-cation vacancy complex is proportional to the measured number of these complexes in the two samples.

An optical absorption band appearing at 380 mu after irradiation to about 10^5 R has also been correlated with the

105°C glow peak. Changes in the optical absorption spectrum occur as a result of pre-irradiation annealing and also as a result of pulse annealing after irradiation to remove the 105°C glow peak. These suggest a complex interaction between several color centers. A band at 310 mu is enhanced by either pre-irradiation annealing or by pulse annealing after irradiation. A band at 220 mu grows as a result of the pulse annealing procedure, but it is apparently not affected by the pre-irradiation annealing. The F band at 250 mu decreases as a result of the pulse annealing procedure, but it is apparently not affected by the pre-irradiation annealing. The F band at 250 mu is reduced by the pulse annealing procedure, but optical bleaching of the 380 mu band does not affect the F band.

The 105°C glow peak decays at room temperature to 50% of its initial value in 10 hours, after which time the decay proceeds at a slower rate which is dependent on the concentration of impurity. One component of the 380 mu absorption band also decays with a half life of about 10 hours, but this component only represents about 20% of the total band. The second component of the absorption band decays more slowly, with about 25% of the original band still present after two weeks. This behavior, together with other considerations, suggests that only a fraction of the filled Mg^{++}-cation vacancy traps participate in thermoluminescence; i.e., the efficiency of the trap in terms of

photons emitted per color center is apparently low. It is suggested that temperature-dependent chemical reactions may occur in the crystal which (a) break up the color center and produce a new color center without the release of an electron, and/or (b) combine two different color centers to form a third color center without the release of the trapped electron from either original center. The efficiency of the thermoluminescence of the glow peak being studied appears to depend on the availability of recombination centers, which suggests the possibility that the thermoluminescence depends on the proximity of these centers, and hence may indicate a tunneling process for the recombination mechanism.