NONRADIATION-INDUCED THERMOLUMINESCENCE

by

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INTRODUCTION

The nonradiation-induced thermoluminescence (NRI-TL) of LiF powder was studied. Two different types of powder were studied: one was relatively pure optical grade scrap, obtained from the Harshaw Chemical Company in August, 1963 (H63A); the second material was TLD-100 LiF obtained from the same company. The methods of producing the various peaks of the glow curve or combinations of the peaks were studied. The observed peaks were classified as R (radiation-induced), T (Tribo- or mechanically-induced), S (shaking or perhaps charge-induced), and D (duration-induced, perhaps caused by absorbed gases). The principal difficulty in performing this study was the nonreproducibility of the magnitudes of all but the R peak; for this reason the results stated are, in general, qualitative rather than quantitative.

I. NRI-TL GLOW CURVES**MASTER**

The glow curves of H63A and TLD-100 differ principally in the location of the R-Peak. In H63A this peak occurs at about 110° C, whereas in TLD-100 the R-peak occurs at about 200° C. In the early work reproducibility of the NRI-TL peaks was very poor. It was improved by obtaining a more uniform crystal size. The reproducibility of the S-peak was best with powder of 120-180 mesh (Tyler). The standard deviation of the area of the S-peak was about 6-8%. The finer mesh

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powder (180-200) gave approximately twice the size S-peak but was less reproducible. The general form of the glow curves is shown in Fig. 1 and 2.

Fig. 1 Glow curves for LiF (H63A) showing the various components of the glow curve.

Fig. 2 Glow curves for LiF (TLD-100) showing the various components of the glow curve.

In both materials the T-peak appeared at approximately 140°C and the S-peak at approximately 315°C . An infrared filter (Corning 5-61) was used to absorb the contribution of blackbody radiation. If single crystals are used for the

measurements, the T-peak does not appear and the S-peak is reduced by a factor of about 30.

II. T-PEAK

The T-peak is the grinding-induced or tribo-thermoluminescence peak. In every case in which the T-peak was induced, the S-peak was also present. When a virgin crystal was ground, sifted, and the thermoluminescence read without any radiation, the T-, S-, and D-peaks were usually present. The magnitude of the T-peak was approximately equivalent to that of the R-peak after 1 to 2R. The magnitude of the S-peak under the same conditions was equivalent to an R-peak of about 30 R. Under these situations the D-peak was usually less than the S-peak in magnitude. Under normal handling of the powder the T-peak will not reappear. Further grinding or severe shaking of the powder in a metal sieve will generally cause the T-peak to reappear but with a reduced magnitude. It should be noted that in TLD-100 the T-peak occurs at nearly the same location as the R-peak and might not be observed for that reason.

III. S-PEAK

By shaking the powdered sample of LiF on a sheet of paper or by dumping the sample out of the heating pan and back in again, only the S-peak would appear in the glow curve. In the H63A material the area of the S-peak was approximately equal to the R-peak after 20-30 R. In TLD-100 the area was approximately equivalent to 2R. The S-peak also appears after the powder has been allowed to stand a number of hours. An attempt was made to graph the growth of this peak as a function of time at room temperature. The powder was left

in the original heating pan for various length of time, but the reproducibility was very poor. It was noted, however, that when the samples were kept in an oven of 150°C the results reproduced much better. A plot of the total area of the NRI-TL as a function of time at 150°C is shown in Fig. 3. Most of this area is due to the S-peak.

Fig. 3 Growth of the NRI-TL as a function of time at 150°C .

The S-peak was not induced by radiation but all exposure doses were 100 R or less.

The S-peak was suppressed by using N_2 gas during the heating cycle.

Since the S-peak could be stimulated by shaking the sample, it was postulated that the cause was related to the static electric charge acquired by the crystals during shaking. A Shonka electrometer was used to measure this charge. H63A powder was shaken on paper and then dumped into a pan connected to the fiber of the electrometer. A sample of approximately

60 mg acquired a positive charge of about 3×10^{-11} coulombs. This is equivalent to the sample losing approximately 10^8 electrons. In a separate experiment the powder was placed in a pan biased with ± 300 volts while it was exposed to x-rays to determine if this would tend to increase or decrease the S-peak; no effect was observed. Powder was also shaken on a biased Al plate (300v). The polarity of the bias was reversed and the results compared. There was no significant change in the S-peak.

IV. D-PEAK

If a sample of LiF powder is allowed to stand for several days or longer, the D-peak appears. For periods of about 1 month or less the size of the D-peak was usually less than that of the duration-induced S-peak. Because of the time involved in studying this phenomenon, no detailed data was obtained.

V. VACUUM-INDUCED THERMOLUMINESCENCE

When samples of H63A powder were evacuated to about .01 Torr and then returned to atmospheric pressure at various points of time, it was found to have a pronounced S-peak. The size of the peak was not reproducible but there was a rough correlation with the time the sample was under vacuum. No D-peak occurred under these conditions and no relationship between the S-peak and the grain size was observed.

CONCLUSIONS

Nonradiation-induced thermoluminescence has the following characteristics:

1. Reproducibility is poor.
2. It appears to be related to the surface area of the crystals.
3. It is suppressed in the presence of certain gases.

In agreement with Attix⁽¹⁾ we found a correlation with the electric charge on the crystals and the S-peak. In our case we found the same polarity in each test whereas Attix found varying polarity. It appears likely that the D-peak is due to the absorption of gases on the crystal surface. Our results generally confirm those of Attix⁽¹⁾ and Fowler⁽²⁾.

REFERENCES

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