Investigation of Phosphor Materials via Thermally Stimulated Luminescence Spectroscopy

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Thermally stimulated luminescence (TSL) entails the perturbation of a material from a stable configuration, after which the material is thermally stimulated, by raising the sample temperature, back to equilibrium via radiative processes [1]. When the perturbation is in the form of ionization of impurity ions or charge transfer processes, and subsequent trapping of carriers into metastable electronic states, TSL becomes a useful tool to study the electron transfer cross sections, trap and hole properties, and relaxation processes. TSL, studied as a function of the excitation radiation energy, comprises thermally stimulated luminescence spectroscopy (TSLS).

Here we present TSLS as a technique for locating the ground state of activator ions in phosphor and scintillator materials relative to the host conduction and valence bands. TSL probes the occupation of carrier traps; thus the use of tunable radiation allows the determination of the threshold for filling the electron traps, which coincides with the threshold for the ionization of the activator.

The experimental apparatus consists of a tunable excitation source, a liquid nitrogen cryostat and luminescence detection. The tunable illumination is provided by either a xenon or deuterium lamp, filtered by a monochromator or interference filters. The cold finger cryostat includes a heating element and temperature sensor, thus allowing the sample temperature to be cycled between 80K and 500K. Luminescence detection is accomplished via a photomultiplier tube or a CCD camera attached to a monochromator.

For the experiment, the sample is mounted onto the cold finger and illuminated at low temperature (80K). The sample temperature is then linearly raised, without illumination, to 500K during several minutes while simultaneously recording the thermally stimulated luminescence. The sample is then cooled again and the process is repeated for a different illumination wavelength. Plotting the integrated TSL signal as a function of the illumination wavelength allows the determination of the ionization threshold of the activator ion.

Advantages of TSLS over complimentary techniques, such as photoconductivity, include applicability to bulk and powder samples, high sensitivity, impurity specific signals, and a distinction between electron and hole carriers.

We present results for CaS:Eu and other phosphor materials, and compare results to those obtained via photoconductivity.

This work was supported in part by a grant from general Electric,

References

[1] R. Chen and S.W.S. McKeever, *Theory of Thermoluminescence and Related Phenomena* (World Scientific,Singapore, 1997).
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