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PARAMAGNETIC RESONANCE DETECTION OF THE OPTICAL EXCITATION OF AN INFRARED STIMULABLE PHOSPHOR

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The effect of the optical excitation of a phosphor may in certain cases manifest itself by a change in the paramagnetic resonance spectrum of the phosphor. Attempts to observe such changes in inorganic phosphors have previously been made by Hershberger[1] and Low[2] without success. This Letter describes an experiment in which paramagnetic resonance absorption was used to observe the optical excitation of the infrared stimulable phosphor SrS:Eu, Sm.

The physical properties of this phosphor have been widely investigated, the most extensive investigations being those carried out by Keller et al.[3] One of the properties of this phosphor is its ability to store energy when optically excited with ultraviolet or blue radiation. This stored energy may subsequently be released by irradiation with either infrared (970 mμ) or orange (590 mμ) wavelengths.

A simplified band-theory model was proposed by Keller[3] to explain this and other properties of SrS:Eu, Sm. In brief, europium is present in the SrS lattice as Eu^{2+} and samarium as Sm^{3+}. Excitation by ultraviolet radiation corresponds to SrS base absorption with the formation of an electron-hole pair. The electron is subsequently trapped by the Sm^{3+} which becomes Sm^{2+} and the hole trapped at the europium site giving Eu^{3+}. Excitation by blue radiation results in a direct ionization of Eu^{2+} to Eu^{3+} with the electron subsequently being trapped by the Sm^{3+} site. In the case of either ultraviolet or blue excitation the net effect is to change Eu^{2+} to Eu^{3+} and Sm^{3+} to Sm^{2+}. The Eu^{2+} has an $^8S_{7/2}$ ground state which is paramagnetic.[2] The Eu^{3+} ground state is $^7F_0$ and is nonmagnetic. Excitation of this phosphor should therefore manifest itself by a diminution in the Eu^{2+} paramagnetic spectrum.

The stored energy may be exhausted by irradiating with the wavelength which removes an electron from the Sm^{2+} site to the conduction band. The Sm^{2+} may be ionized in two ways and hence there are two wavelengths, 970 mμ and 590 mμ, that may be used.[3]

A diminution in the magnitude of the Eu^{2+} paramagnetic spectrum when optically excited has been observed for a SrS:Eu, Sm phosphor of the following composition: SrS, 6% $SrSO_4$, 6% CaF_2, 0.02% Eu, and 0.02% Sm. The percentages are in terms of molar percent. The preparation has been described in reference 3. A Varian Associates 4500 EPR spectrometer was used. The rectangular cavity that was used operated in the TE_{102} mode and had one end removed and replaced with a stainless steel screen, 96×96 mesh, which allowed light to irradiate the sample in the cavity. The powder sample was mounted on a 0.9- by 0.4-inch Teflon button placed along the region of maximum H_1 field at the middle of the cavity. An Osram xenon arc lamp *XBO* 1001 combined with a Bausch and Lomb 33-86-40 grating monochromator were used to irradiate the sample. All measurements were made at room temperature.

A plot of the relative stored energy against wavelength of the exciting light was made in the following way. The sample was first brought to its exhausted state by irradiating with 970-mμ light for four minutes. The light was removed and the paramagnetic spectrum of Eu^{2+} in the exhausted sample was plotted. The sample was then irradiated with the particular wavelength of exciting light for four minutes. The light was removed. The Eu^{2+} paramagnetic spectrum was replotted, the diminution in its intensity being proportional to the stored energy in the phosphor. The sample was then once again exhausted with 970-mμ light before a second exciting wavelength was used. The results are given in Fig. 1. The heights have been corrected for constant number of exciting photons. The graph of Fig. 1 agrees favorably with that found by Keller, Mapes, and Cheroff[3] who used as a measure of the stored energy the intensity of the light emitted by the sample when 970-mμ light was incident on it.

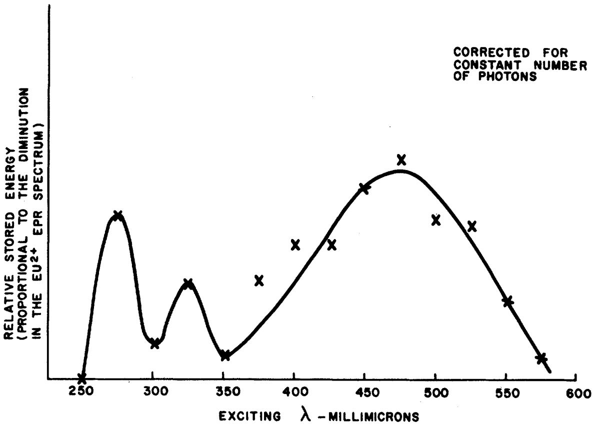

FIG. 1. Relative stored energy as measured by the diminution in the Eu^{2+} paramagnetic spectrum *versus* exciting wavelength.

As a measure of the efficiency of optical excitation it is noted that at the point of maximum optical excitation, 475 mμ, the Eu^{2+} paramagnetic spectrum decreased by 13 % in magnitude. This should be taken as a lower limit of the efficiency as the light absorption is not uniform throughout the sample, decreasing exponentially from the surface inward. We plan to measure the variation of efficiency as a function of the relative europium and samarium concentrations. The experiment will also be repeated at liquid helium temperatures looking for a change in the Sm paramagnetic spectrum.

It may be added that 590-mμ light was found to be equally as effective as 970-mμ light in exhausting the phosphor, which agrees with the results of Keller and Pettit.[3]

In conclusion the use of paramagnetic resonance absorption to detect the optical excitation provides an independent verification of the simplified band-theory model proposed by Keller[3] for this phosphor.

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TRITIUM AS A PRODUCT OF FISSION*

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Evidence is described that indicates that the triton is a previously unrecognized fission product. Tritium was shown to be present in a ratio of one triton per $(1-2)\times10^4$ fissions in samples of irradiated natural and enriched uranium and in an irradiated mixture of transuranium isotopes. The triton-to-fission ratio was within a factor of two for these samples even though the concentrations of tritium per gram of irradiated material ranged over a factor of one thousand. The lithium content of the irradiated uranium was proved not to be the source of the tritium; neither was the tritium present as the result of diffusion from the tritiated heavy water moderator of the Savannah River piles. Confirmation of the triton as a product of fission may contribute to the understanding of ternary fission and may have a practical application to burnup analysis.

A search of the literature of ternary fission showed that the formation of the triton in fission