NEW METHOD IN THE INVESTIGATION OF RADIATION-STIMULATED LUMINESCENCE OF CaF_2:TRF_3 CRYSTALS

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If the radioluminescence (RL) at both 300°K and 77°K is connected with the simultaneous glow of several types of TR^{3+} optical centers, then the RL spectrum is very complicated and it is difficult to separate from it line groups connected with individual activator centers. Nor is sufficient information obtained in this case from investigations of the photoluminescence (PL) and absorption, since different sets of optical TR^{3+} centers participate in the recombination RL processes and in the intracenter PL processes, in CaF_2:TRF_3.

We have found [1] that CaF_2:TRF_3 crystals that are γ-irradiated at 770°K, annealed to 300°K, and again cooled to 77°K continue to glow with sufficient intensity and for a long time at liquid-nitrogen temperature. Afterglow at 77°K was observed also for crystals irradiated at 300°K.

The observed afterglow uncovers, in our opinion, new possibilities for the investigation of both the spectral composition and the mechanisms of radiation-stimulated luminescence processes.

It was obvious that if a large number of TR^{3+} optical centers take part in the radiation-stimulated optical processes, the afterglow spectra at 77°K from samples γ-irradiated at different temperatures and with different doses, subjected after the γ-irradiation to photo-discoloring or to a definite thermal annealing, will be different. A comparison of these afterglow spectra at a single temperature is very convenient also because no unknown temperature effects (for example, temperature changes in the emission spectra of still uninvestigated TR^{3+} centers) need be taken into account, as would be necessary if RL or thermally-stimulated emission spectra are to be compared at different temperatures.

It is thus possible to resolve the complex spectra of radiation-stimulated luminescence of CaF_2:TRF_3 crystals into more elementary components, and to obtain thereby data on the recombination processes that occur there.

Using the method described above, we could separate a number of individual line groups in the spectra of radiation-stimulated emission of CaF_2:TRF_3 (TR = Pr, Nd, Tb)[1)]. By way of an example, we consider several groups exhibiting the most typical behavior (see the figure, and also the figures of [1]).

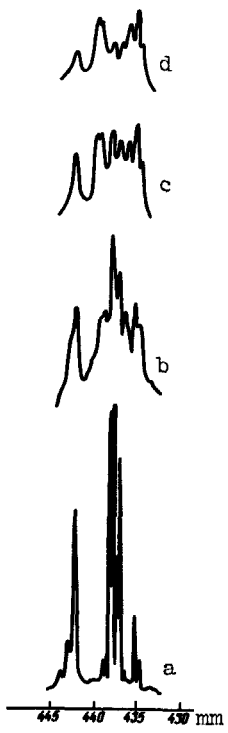
[1)]For CaF_2 crystals activated with ions of the end of the rare-earth series (Dy, Ho, Er), where the predominant role is played by cubic TR^{3+} centers, annealing to 300°K (or γ-irradiation at 300°K) did not lead to noticeable changes in the afterglow spectrum at 77°K [1]. The afterglow at 77°K of CaF_2:TRF_3 (TR = Sm, Eu, Tu) crystals annealed to 300°K was not intense enough in our case to permit analysis. However, comparative investigation at 77°K of the RL (afterglow) spectra and of the photoluminescence spectra of CaF_2:TRF_3 (TR = Sm, Eu) revealed an effective participation of the noncubic TR^{3+} sites in the radiation-stimulated processes, which is characteristic of CaF_2 crystals activated by ions of the first half of the series.

Thus, several lines of the 77°K-afterglow spectra of samples γ-irradiated at 77°K and then annealed to 300°K line, either disappear (in the case of Nd^{3+} these are most lines attributed in [2] to cubic sites, and for Pr^{3+} these are the 477.6, 478.4, 479.8, 487.0, 487.8, and 495.3 nm lines) or become less intense than the remaining ones, especially in the case of γ-irradiation at 300°K (the 436.9, 437.8, and 438.0 nm lines of Tb^{3+}). Another group of lines remains quite noticeable after annealing to 300°K, but its relative intensity decreases in the case of γ-irradiation at 300°K (it disappears completely in the afterglow of $CaF:NdF_3$).

These are the lines connected with tetragonal sites, in the case of Nd^{3+}, the 477.1, 489.8, and 490.0 nm lines for Pr^{3+}, and the 434.5, 435.1, and 438.9 nm lines for Tb^{3+}. There are also groups of lines that become sufficiently intense only after annealing to 300°K, and increase most noticeably if the γ-irradiation is at 300°K. This group includes the 865, 877, 894, and 902 nm lines in the afterglow of the crystal with Nd, 481.9, 482.3, 484.2, 484.8, and 485.3 nm for Pr, and the most clearly the 439.8 nm for Tb. In the case of Pr, these lines pertain to at least two centers, since the 485.3-nm line did not appear in the afterglow of a sample partly photo-discolored in liquid nitrogen (by unfiltered radiation from an SVD-120A lamp).

The distinct similarity seen in the behavior of the line groups under consideration for different TR may be evidence that they belong to like optical centers.

It can be assumed that, during the course of the annealing to 300°K, the recombination of the holes released by thermal emission from a number of TR^{2+} sites, and the ionic processes that occur at 300°K, lead to a noticeable reduction in the number of certain recombination centers that participate in the afterglow processes at 77°K, and to a possible formation of other centers.



Section of afterglow spectrum (transition $^5D_3 - {}^7F_4$) of the afterglow, at 77°K, of a $CaF_2:TbF_3$ (0.1 wt.%) crystal exposed to a γ-ray dose 5×10^6 rad: a) γ-irradiation at 77°K, b) γ-irradiation at 77°K and annealing to 300°K, c) γ-irradiation at 273°K, d) γ-irradiation at 300°K.

It has thus been found that for an entire series of TR ions (especially for the first half of the series), the spectra of the low-temperature thermal emission, attributed in [3] to the emission from cubic sites only, are non-elementary and are due to the emission from several optical TR^{3+} centers that take effective part in the recombination processes.

One can hope that, jointly with other methods of investigating multi-center systems, the procedure considered here for the study of radiation-stimulated emission will make it possible also to identify a number of hitherto uninvestigated activator centers.

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THERMOELECTRIC POWER OF ALUMINUM IN STRONG MAGNETIC FIELDS AT LOW TEMPERATURES

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Of all the transport phenomena, the Seebeck effect is among the most sensitive to external influences and to the energy state of the electrons in metals [1 - 3]. Investigations of the influence of strong magnetic fields on the thermoelectric power can yield information on the energy spectrum of the metal and reveal the roles and values of the thermoelectric-power components due to the distribution function of the electron energies and to electron-phonon interaction.

There have been no prior investigations of the influence of magnetic fields on the magnitude, sign, and anisotropy of the thermoelectric power of aluminum. There have been a few studies [4, 5] of only the temperature dependence of the thermoelectric powers of polycrystalline samples.

We have undertaken a study of the influence of a constant magnetic field of intensity up to 50 kOe on the anisotropy and the temperature dependence of the thermoelectric power of aluminum in the 5.4 - 79°K range. The object of the investigation was a single crystal measuring 3 × 4 × 60 mm, cut from an ingot. After preparation and mounting in the calorimeter, the ratio R(273°K)/R(4.2°K) of the sample was ∿6000. The same sample was used earlier to measure the thermal conductivity in strong magnetic fields [6].

The investigation procedure was similar to that described in [6, 7]. The temperature gradient over the working length of the sample ranged during the experiment from 0.15°K at low temperatures to 1.2°K at high ones. The measurements were made in steps of 1 - 2°K. The thermoelectric power was determined from three points corresponding to different values of the gradient, the cold-junction temperature being kept constant. The measurement error was ±0.025 μV/deg.

The anisotropy of the thermoelectric power of aluminum was determined at 9.6 and 49.3°K. The measurements were made in a 50-kOe transverse magnetic