

Concentration-Dependent Emission Spectra in Cr³⁺:GGG Transparent Nanoceramics

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In recent years Cr-doped garnets attracted a lot of attention due to their unique properties. Interpretation of spectroscopic properties of Cr³⁺ ions in garnets is difficult due to the variation of the crystal field strength in a large range resulting in the presence of Cr³⁺ ions in octahedral sites with different local crystal field strengths. This is relevant also for nanostructured materials such as Cr³⁺-doped nanopowders. Despite the large number of works, a lot of questions remain concerning the luminescence properties of Cr³⁺ ions in nanomaterials.

In the present work we report the studies of optical properties of Cr³⁺:GGG nanoceramics synthesized by high isostatic pressure (HIP) method at relatively low temperature. Cr:GGG nanoceramics doped with 0.1 at.%, 0.2 at.%, and 0.3 at.% of chromium ions were obtained.

Synthesized nanoceramics consist of crystallites with the average sizes of 17 nm and the average lattice parameters $\sim 12.40 \text{ \AA}$. High temperature emission spectra show the presence of at least four different CrO₆ optical active centers in Cr:GGG nanoceramics. The presence of satellites of R-lines confirms uniform distribution of local crystal fields around different chromium ions. The change in the concentration of Cr³⁺ ions do not influence the room temperature optical properties of Cr:GGG nanoceramics. Excitation and emission spectra, and lifetimes were the same for the investigated samples. No difference in the calculated Racah parameters was detected for different Cr³⁺ concentrations.

The low temperature emission spectra depend on the chromium content and the increase in Cr³⁺ concentration caused an increase in the ratio of broadband ${}^4T_{2g}({}^4F)$ emission intensity to overall Cr³⁺ emission. At the same time no difference was detected in the peak position and width of ${}^4T_{2g}({}^4F) \rightarrow {}^4A_{2g}({}^4F)$ broadband emission. The difference in the low temperature emission spectra was explained by the energy transfer between chromium ions in the sites with different local crystal field strength. Cr³⁺ ions in the low crystal field site have higher probability of emitting photons rather than transferring the excitation energy to the nearby Cr³⁺ ions. The increase in concentration of Cr³⁺ ions caused an increase in the energy transfer between Cr³⁺ ions thus increasing the ratio of emission intensity of Cr³⁺ ions in low crystal field to the total luminescence.

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