Energy migration processes in undoped and Ce-doped multicomponent garnets single crystal scintillators

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1. Experiments
2. Results and discussion
   1) $Gd_xY_{3-x}Ga_xAl_{5-x}O_{12}$ (x=1,2,3)
   2) $Gd_3Ga_3Al_2O_{12}:Ce^{3+}$
3. Conclusions

1. **Experiments**

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Chemical formula	temperature interval for decay time measurements	temperature interval for PL emission measurements
$Gd_1Y_2Ga_1Al_4O_{12}$	8-500 K	8-300 K
$Gd_2Y_1Ga_1Al_4O_{12}$	8-500 K	8-300 K
$Gd_2Y_1Ga_3Al_2O_{12}$	8-500 K	8-300 K
$Gd_1Y_2Ga_3Al_2O_{12}$	8-500 K	8-300 K
$Gd_3Ga_1Al_4O_{12}$	8-500 K	8-300 K
$Gd_3Ga_3Al_2O_{12}$	8-70 K	8-60 K
$Gd_3Ga_3Al_2O_{12}$:Ce 0.1%	8-70 K	8-300 K

Condition of the measurements for undoped and Ce^{3+}- doped samples

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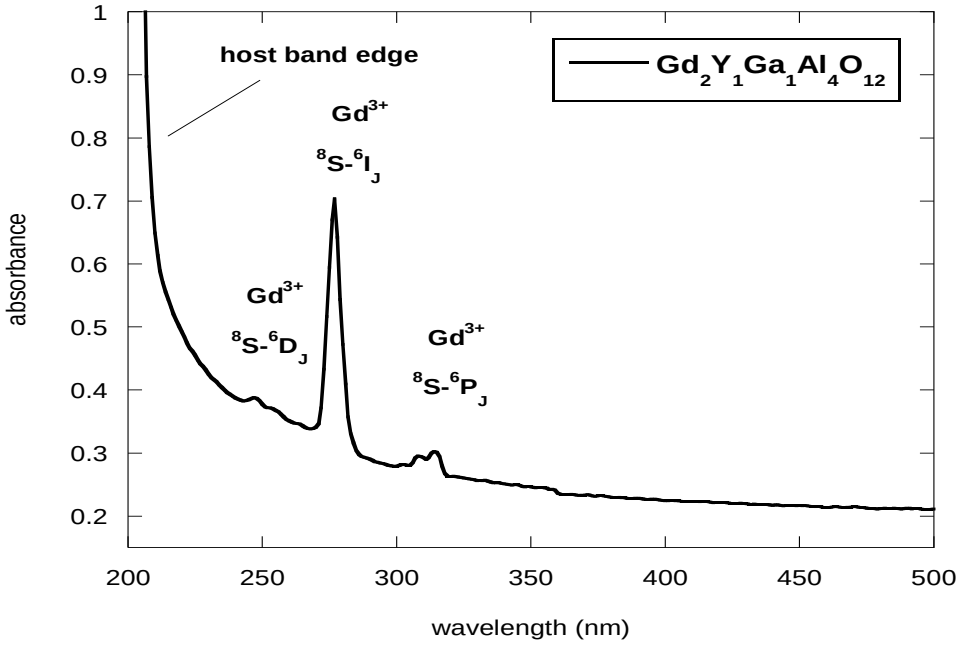
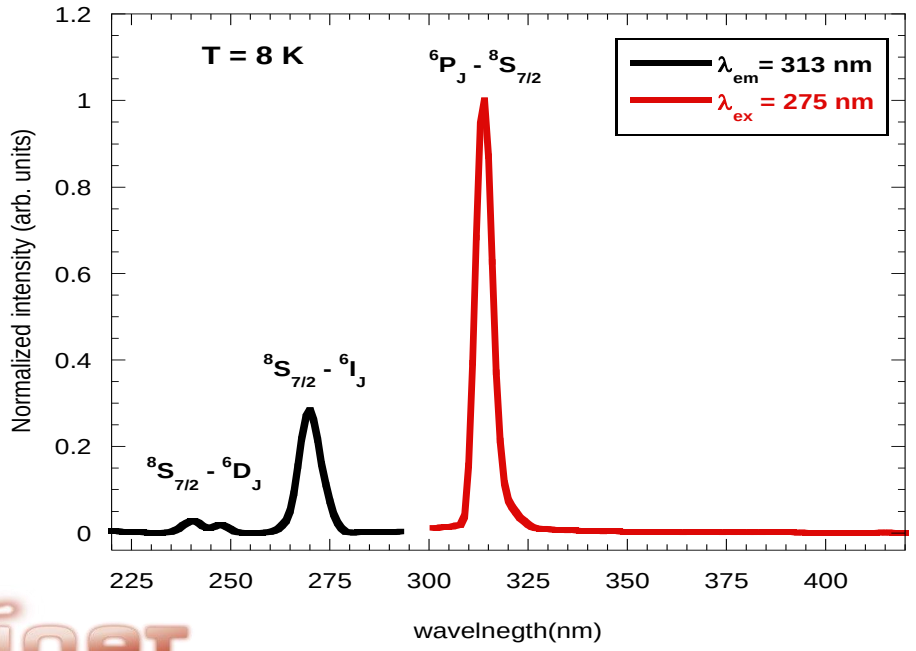
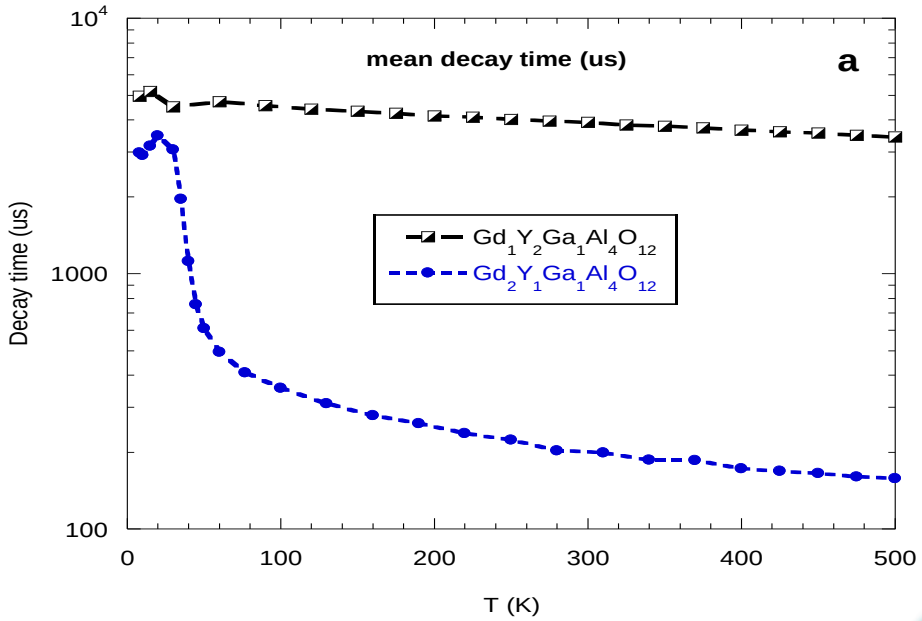


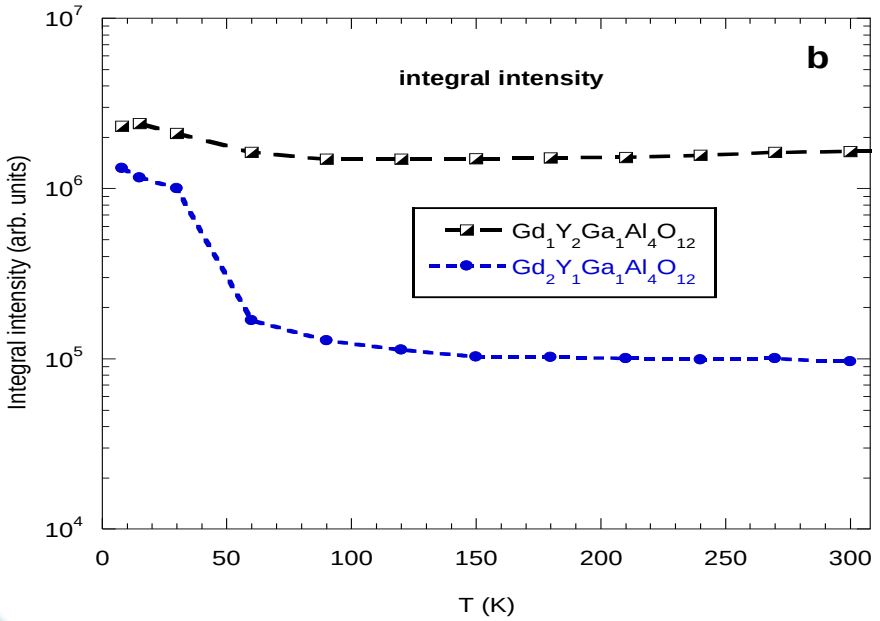
Absorption spectrum of $Gd_2Y_1Ga_1Al_4O_{12}$. Intense Gd^{3+}-related peak at 270 nm as well as host lattice absorption region ($\lambda \leq 220$ nm) are evident.

PL excitation (λ_{em}= 313 nm) and PL emission (λ_{ex}= 275 nm) spectra of $Gd_2Y_1Ga_1Al_4O_{12}$. Observed peak with maximum around 314 nm is typical for $^6P_J - {}^8S_{7/2}$ emission in Gd^{3+} ions.



Results and discussion





Temperature dependence of decay time (a) and PL intensity (b) in the $Gd_1Y_2Ga_1Al_4O_{12}$ and $Gd_2Y_1Ga_1Al_4O_{12}$

Intensities and decay times of Gd^{3+} emission decrease with increasing Gd^{3+} content – concentration quenching.

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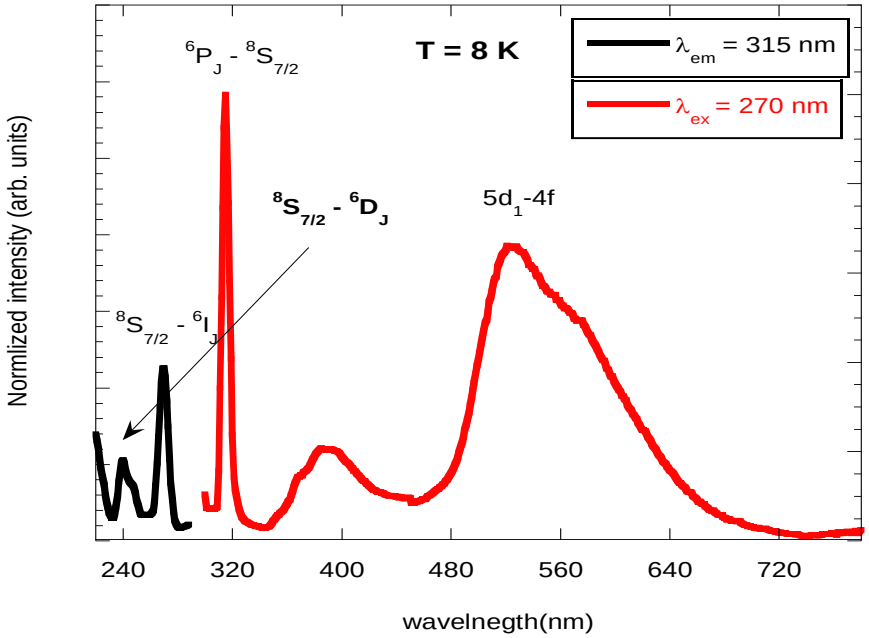
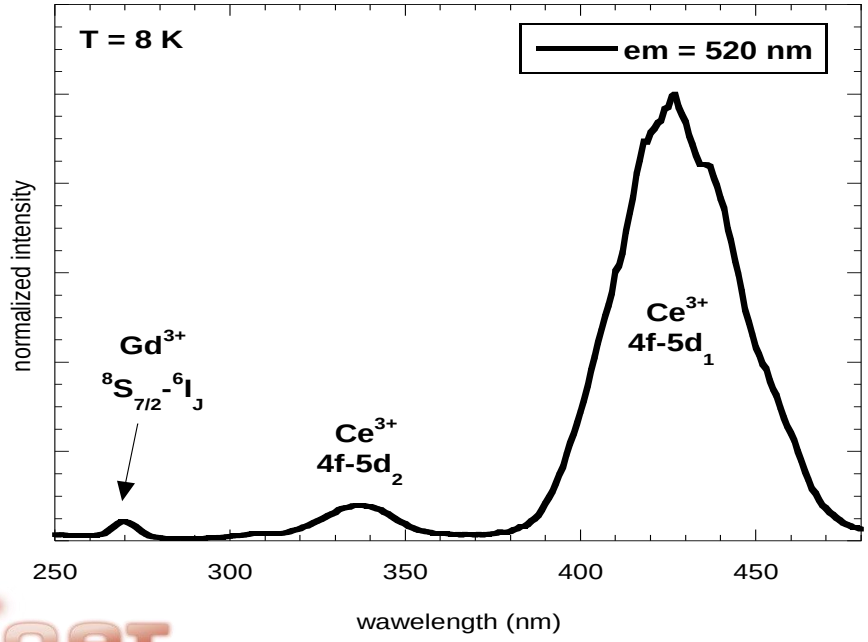


PLE and PL spectra of $Gd_3Ga_3Al_2O_{12}:Ce^{3+}$ .The emission of Ce^{3+} is observed upon excitation at $^8S - {}^6I_J$ absorption band of Gd^{3+}. (ET from Gd^{3+} to Ce^{3+} ions).

PLE spectrum monitored at maximum of Ce^{3+} emission. Presence of weak line at 270 nm (Gd^{3+} – related) confirm the energy transfer from Gd^{3+} to Ce^{3+}.



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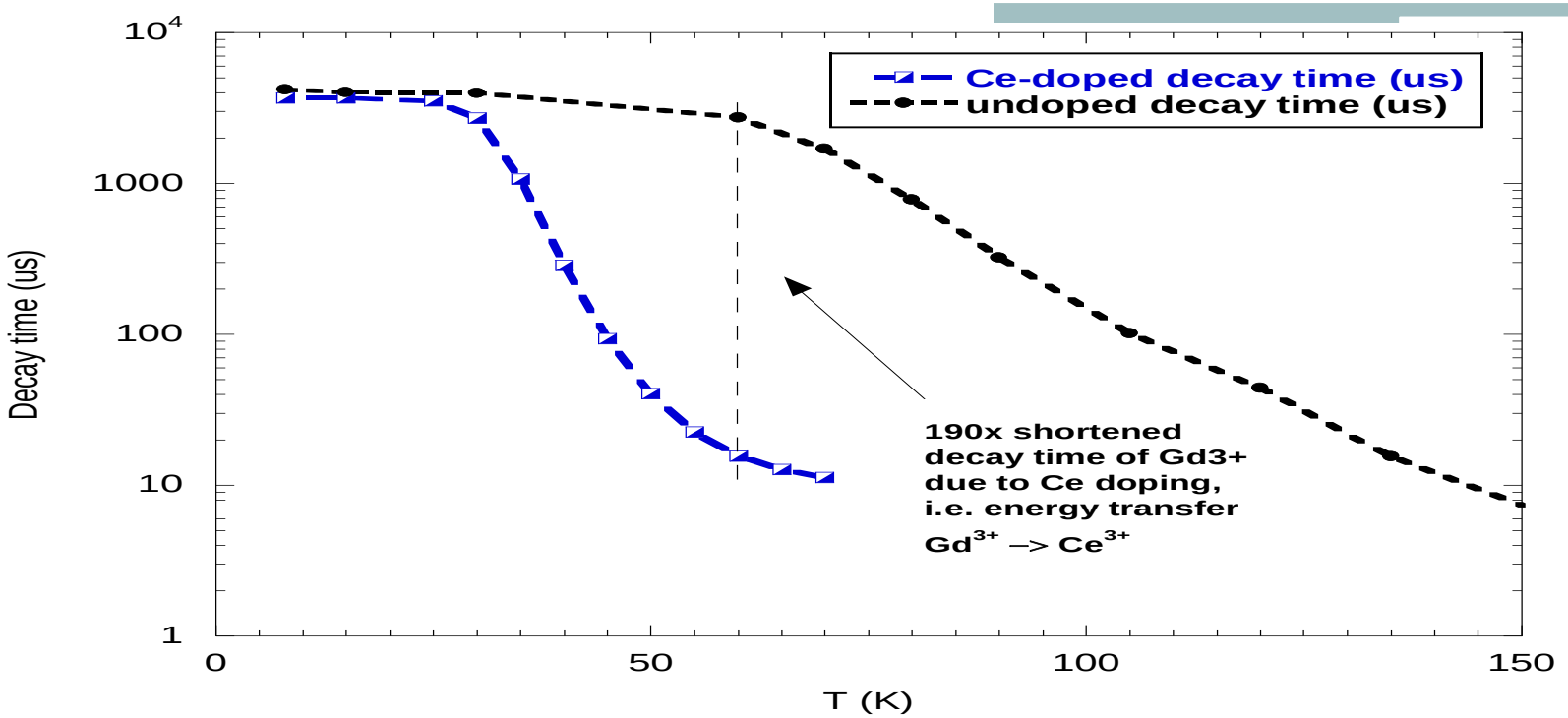
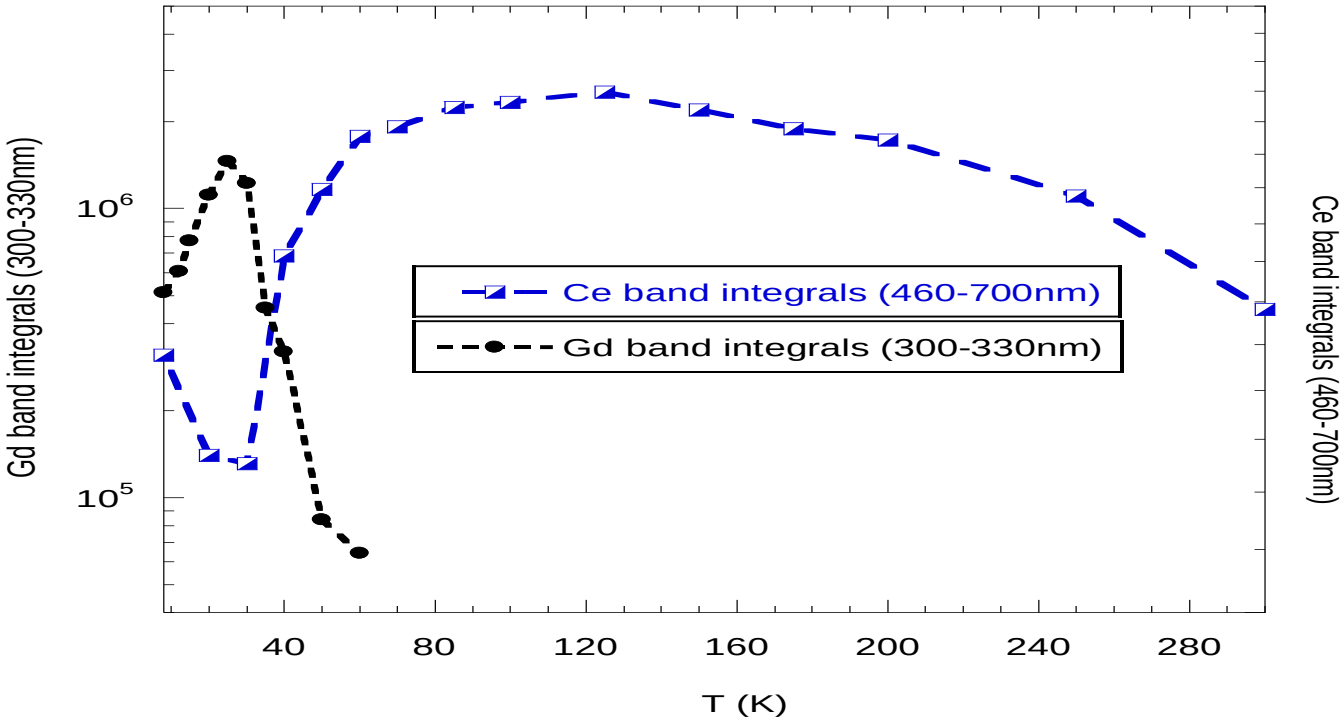


Temperature dependence of 4f – 4f PL decays of Gd^{3+} in undoped and Ce^{3+} – doped $Gd_3Ga_3Al_2O_{12}$ (λ_{ex}= 270 nm, λ_{em}= 315 nm). For the Ce – doped sample, the decay time shortened much rapidly , becoming at 60 K as much as 190 times shorter than that in the undoped sample.

Results and discussion



Temperature dependence of Gd and Ce – related emission bands in $Gd_3Ga_3Al_2O_{12}$:Ce upon excitation at ^8S – ^6I_J absorption band of Gd^{3+}. Emission intensities redistribution of Gd- and Ce-related bands is evident in the range 25-70 K

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Conclusions

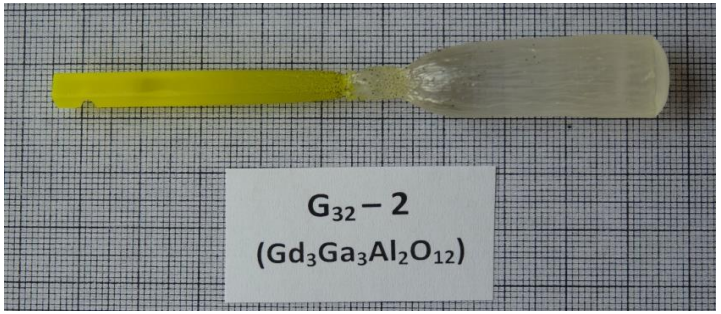
All investigated samples shown energy migration in Gd^{3+} sublattice.

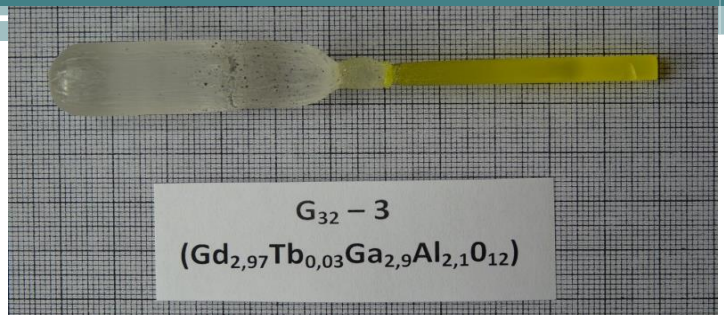
In undoped samples concentration quenching in Gd^{3+} sublattice was observed.

The temperature dependence of carried out measurements shown phonon assistance in energy migration

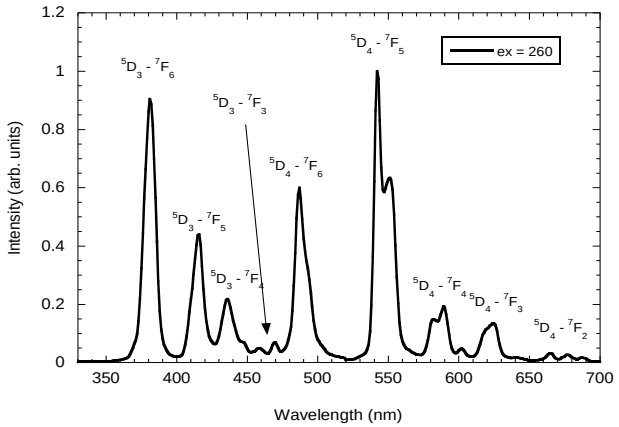
Nonradiative energy transfer from Gd^{3+} to Ce^{3+} in the Ce-doped $Gd_3Ga_3Al_2O_{12}$ was proved .

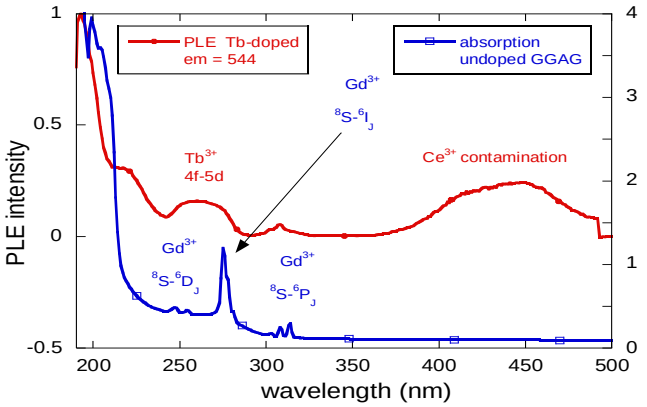
$Gd_3Ga_3Al_2O_{12}$ (GGAG) bulk crystal

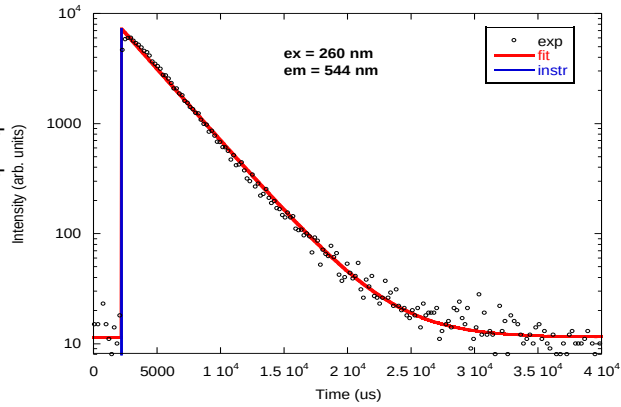




Crystals grown by Czochralski method in IP Prague laboratory (seeds from C&A Japan)







In Tb^{3+} grown crystal the emission spectrum shows full set of emission lines starting from $^5D_3$ and $^5D_4$ levels of Tb^{3+}. PLE spectrum shows 4f-5d transition of Tb^{3+} below 280 nm, fingerprint of Gd^{3+} absorption lines at 305-210 nm , the broad band around 450 nm might be due to Ce^{3+} contamination. Decay time of 544 nm line is 3.3 ms, consistent with strongly forbidden character of Tb^{3+} 4f-4f transitions

Acknowledgements

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