Academy of Sciences of the Czech Republic

Luminescence Quenching and Scintillation Characteristics in $(Y,Gd)_3Al_5O_{12}$ Single Crystals Doped with Ce^{3+}

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LUMINET

Fyzikální ústav Akademie věd ČR, v. v. i.

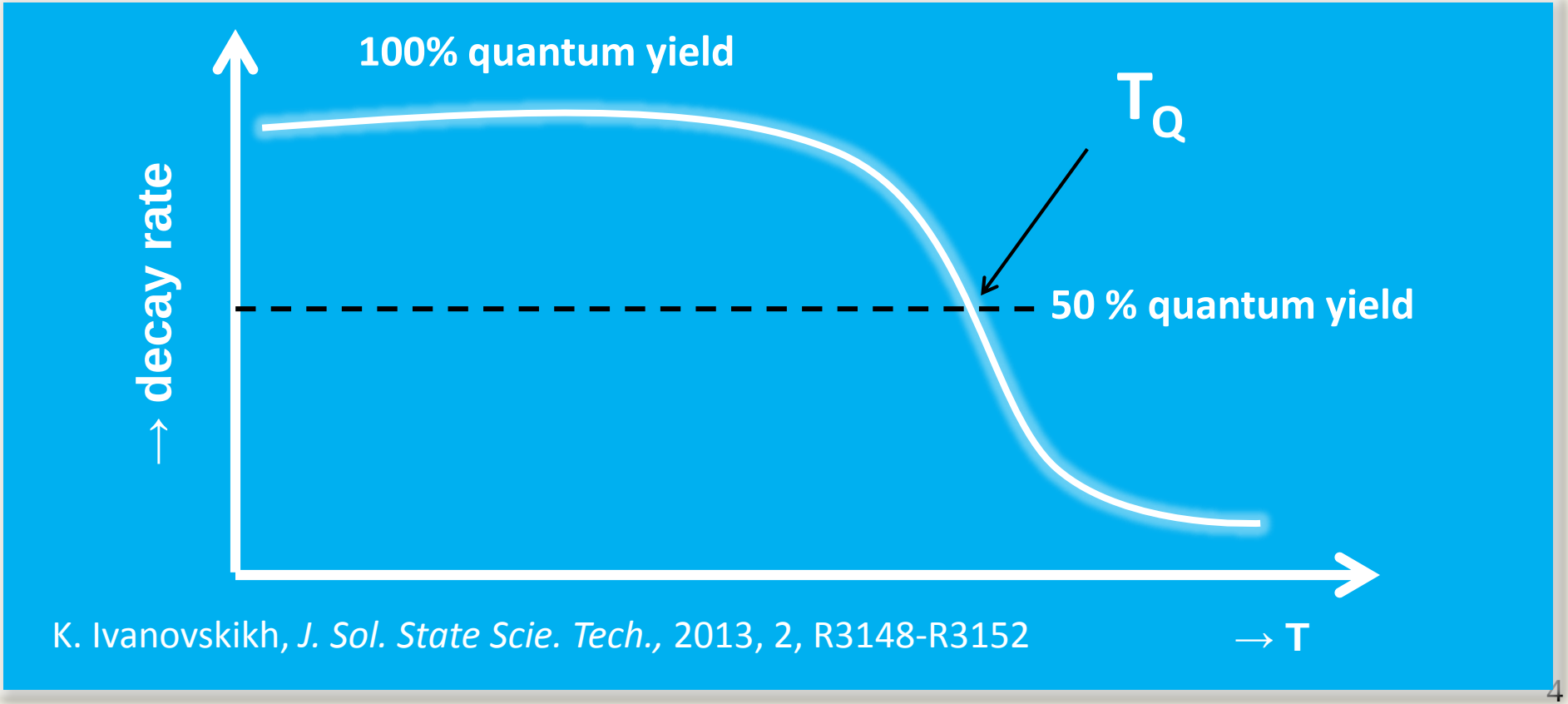
Outline

Outline

Introduction and Aims

What temperature quenching (T_Q) is ?

The temperature quenching T_Q- is defined as the temperature at which the radiative decay rate and non-radiative decay rate are equals



K. Ivanovskikh, *J. Sol. State Scie. Tech.*, 2013, 2, R3148-R3152

Introduction and Aims

How can we determine the T_Q

I) temperature dependence of the luminescence intensity measurements

II) temperature dependence of the luminescence decay time measurements

erroneous values due to

- Temperature dependence of the absorption strength
- Temperature dependence of energy migration and reabsorption

V. Bachmann, *Chem. Mater.,* 2009, 21, 2077–2084
D. Robbins, *J. Electrochem. Soc*., 1979 126, 1550-1555

Introduction and Aims

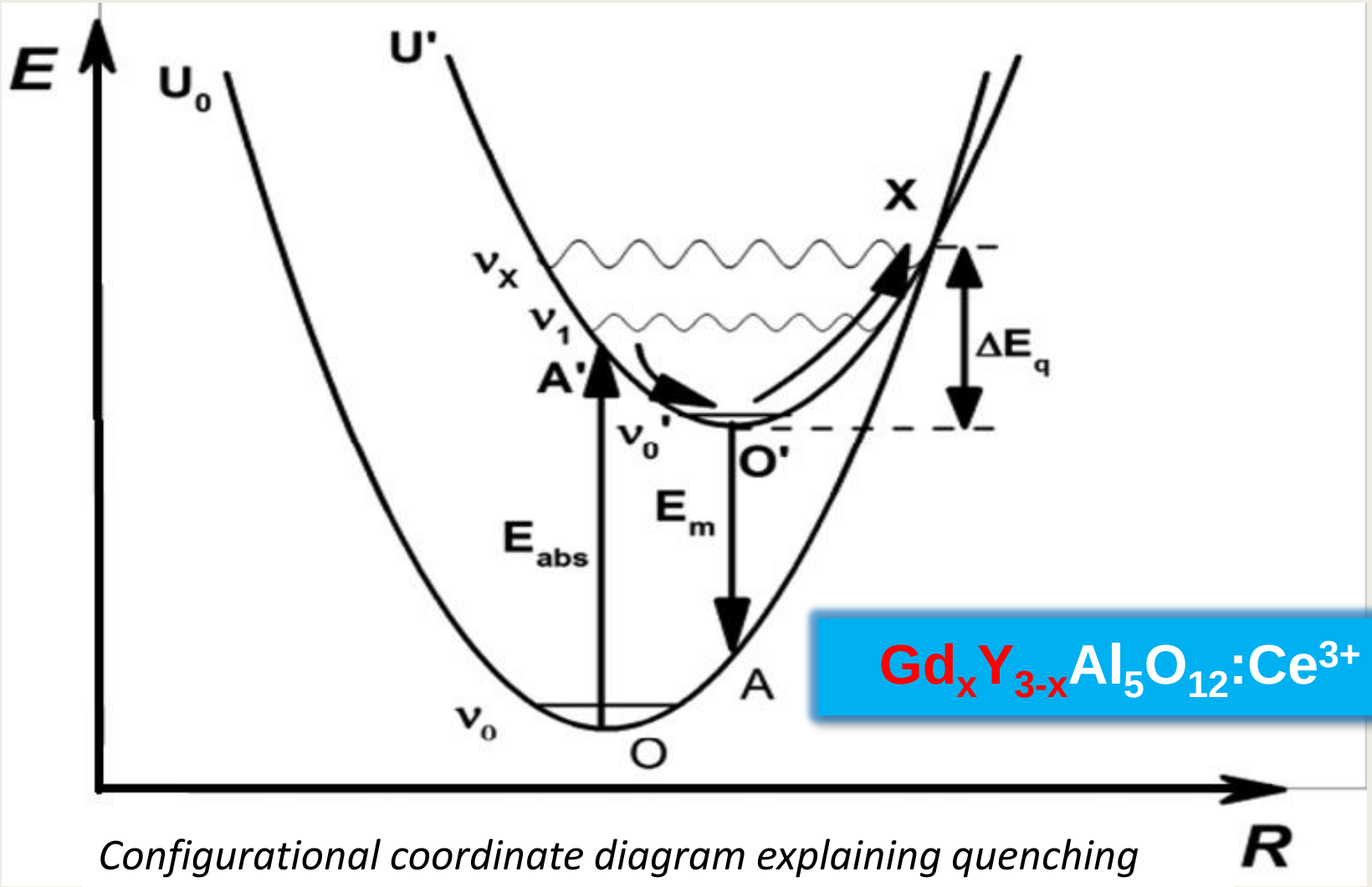
Models of the T_Q in Aluminum Garnets

- in low concentrated Ce-doped YAG the onset of thermal quenching starts around 600 K

- but in $(Y,Lu,Gd)_3(Al,Gd)_5O_{12}:Ce^{3+}$ the onset of thermal quenching depends on Y/Gd and Al/Ga ratio and is set in at lower temperature related to $YAG:Ce^{3+}$

Introduction and Aims

Configurational Coordinate Model

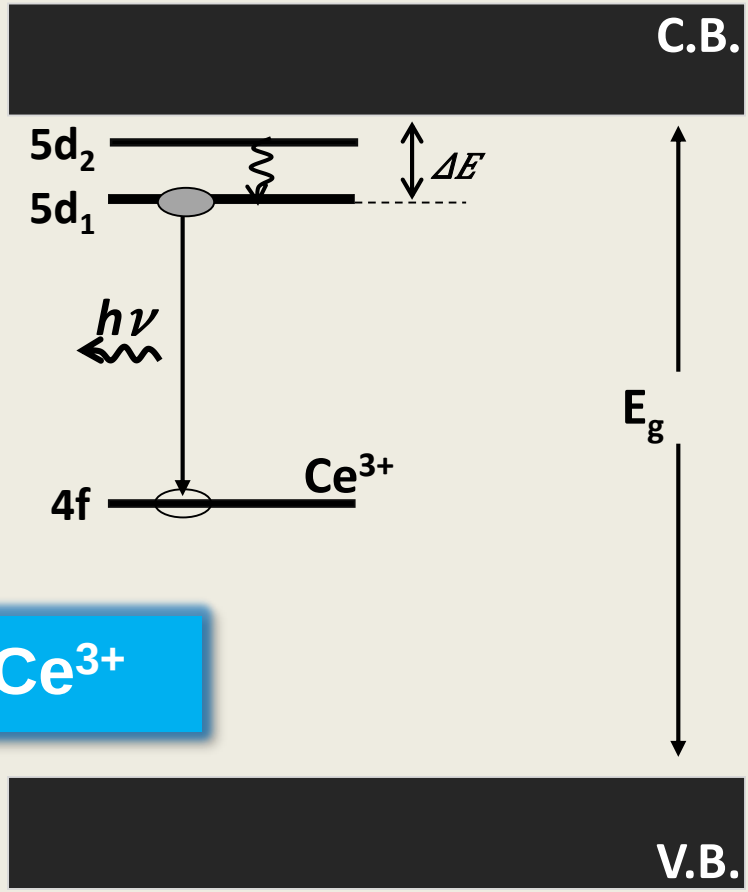


$Gd_xY_{3-x}Al_5O_{12}:Ce^{3+}$

Configurational coordinate diagram explaining quenching mechanisms for Ce^{3+} emission in $(Y,Gd)_3Al_5O_{12}$

Introduction and Aims

Thermally Activated Photo-ionization Model

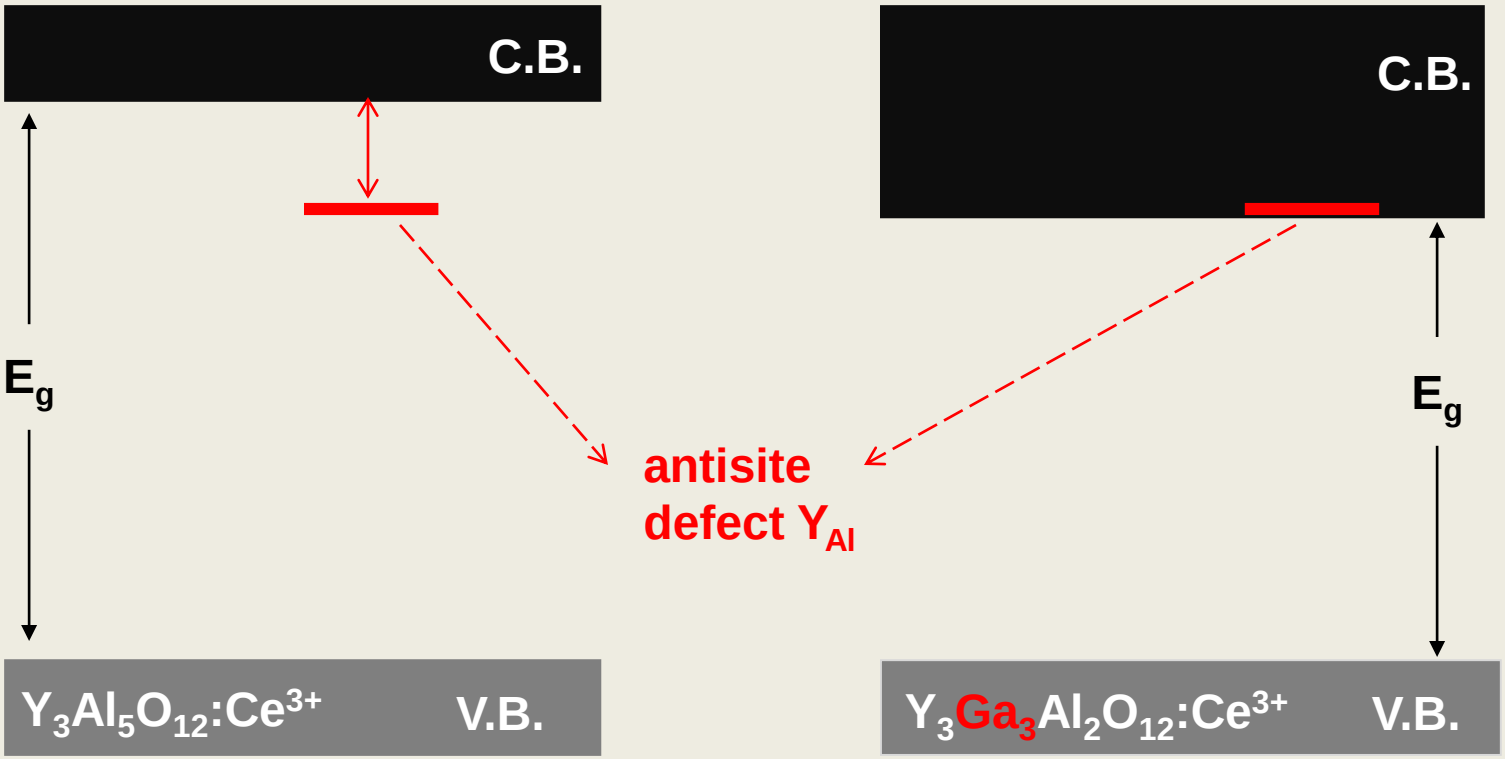


$Y_3Ga_xAl_{5-x}O_{12}:Ce^{3+}$

Energy level diagram depicting the position of the valence band, conduction band, and 5d–4f emission bands for $Y_3(Ga,Al)_5O_{12}$:Ce samples. ΔE - energy barrier for thermal quenching.

Introduction and Aims

‘Band-gap Engineering ‘ – Influence on the TQ in Garnets



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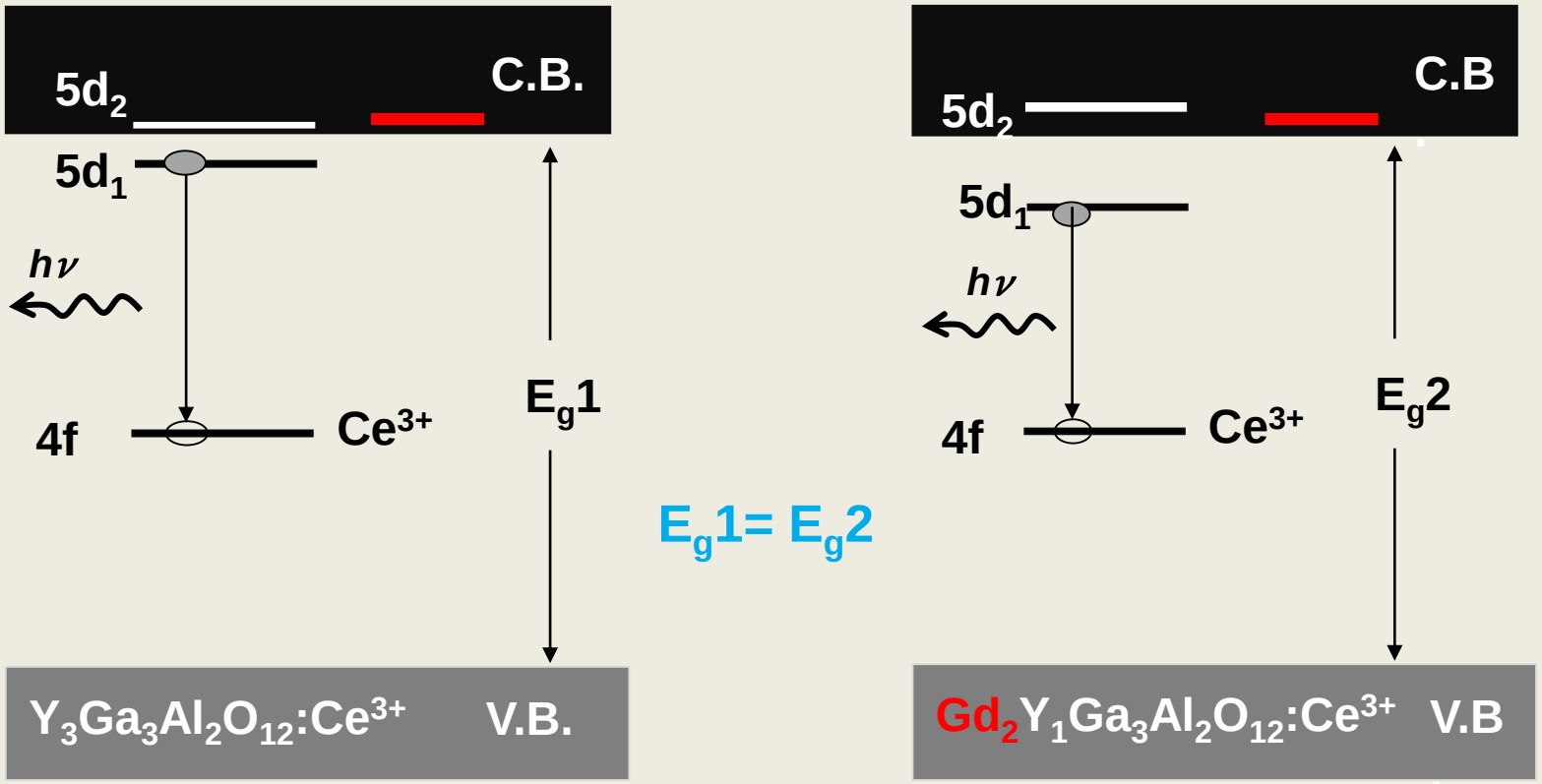
Introduction and Aims

‘Band-gap Engineering ‘ – Influence on the TQ in Garnets



down-energy shifts of $5d_1$ level in the Ce^{3+} caused by Gd co-doping

Introduction and Aims

The aim of this study is to reveal the shifts in the optical properties of garnets caused by Gd co-doping:

- ✓ **Shifts in the onset of temperature quenching**
- ✓ **Shifts in photoluminescence intensity**
- ✓ **Shifts in the position of $5d_1$-4f emission band**

Outline

1 Introduction and Aims

2 **Experiments**

3 Results and Discussion

- 3a Absorption, Excitation and Emission Spectra
- 3b Radioluminescence Spectra
- 3c Temperature Quenching Model

4 Conclusions

Experiments

Characterization by:

- ✓ absorption measurements
- ✓excitation measurements
- ✓ emission measurements
- ✓ radioluminescence measurements
- ✓ temperature dependence of the luminescence decay time

$Gd_xY_{3-x}Al_5O_{12}:Ce^{3+}$

x= 0.75, 1, 1.25, 1.5, 1.75, 2

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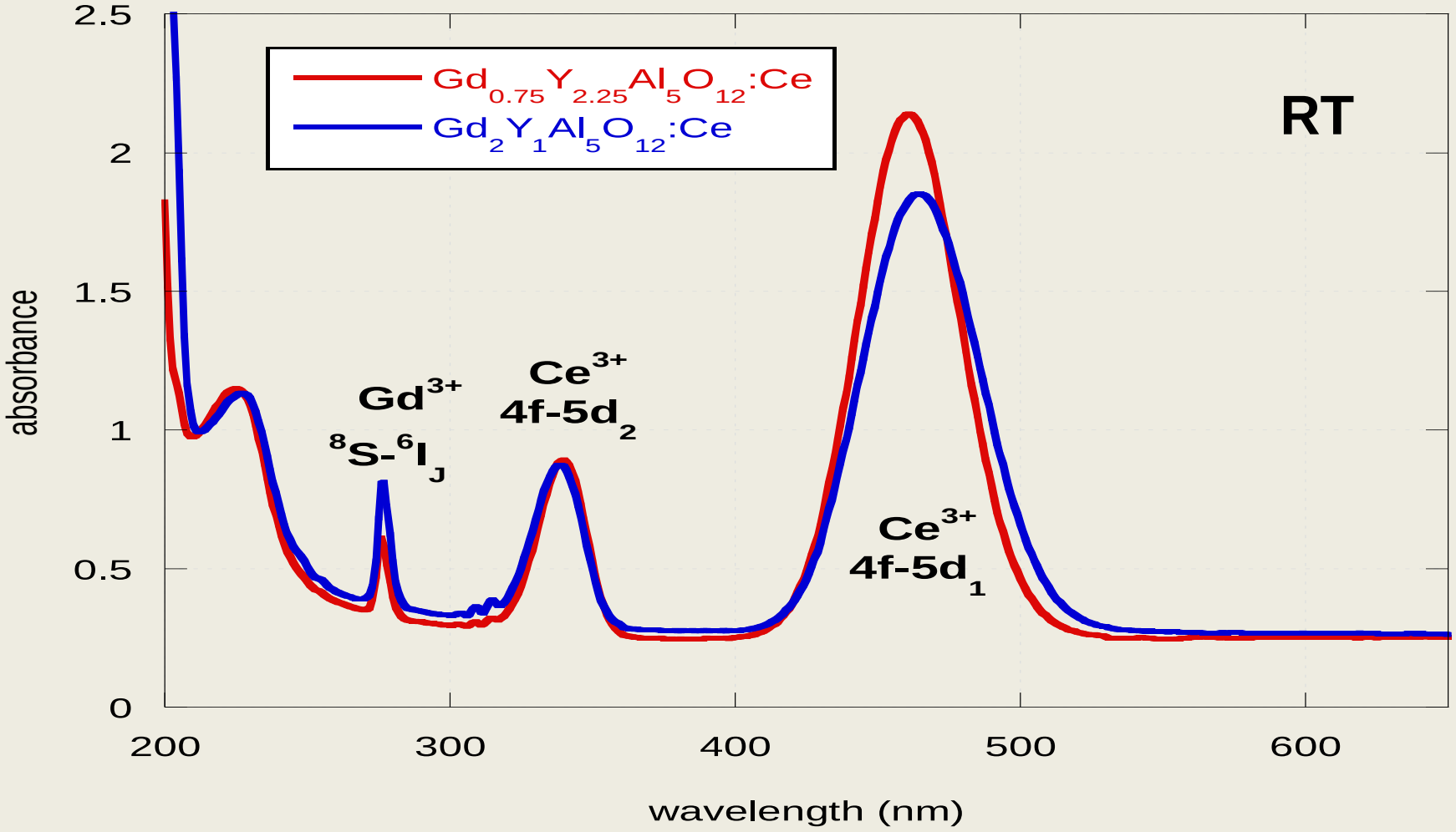
Results and Discussion

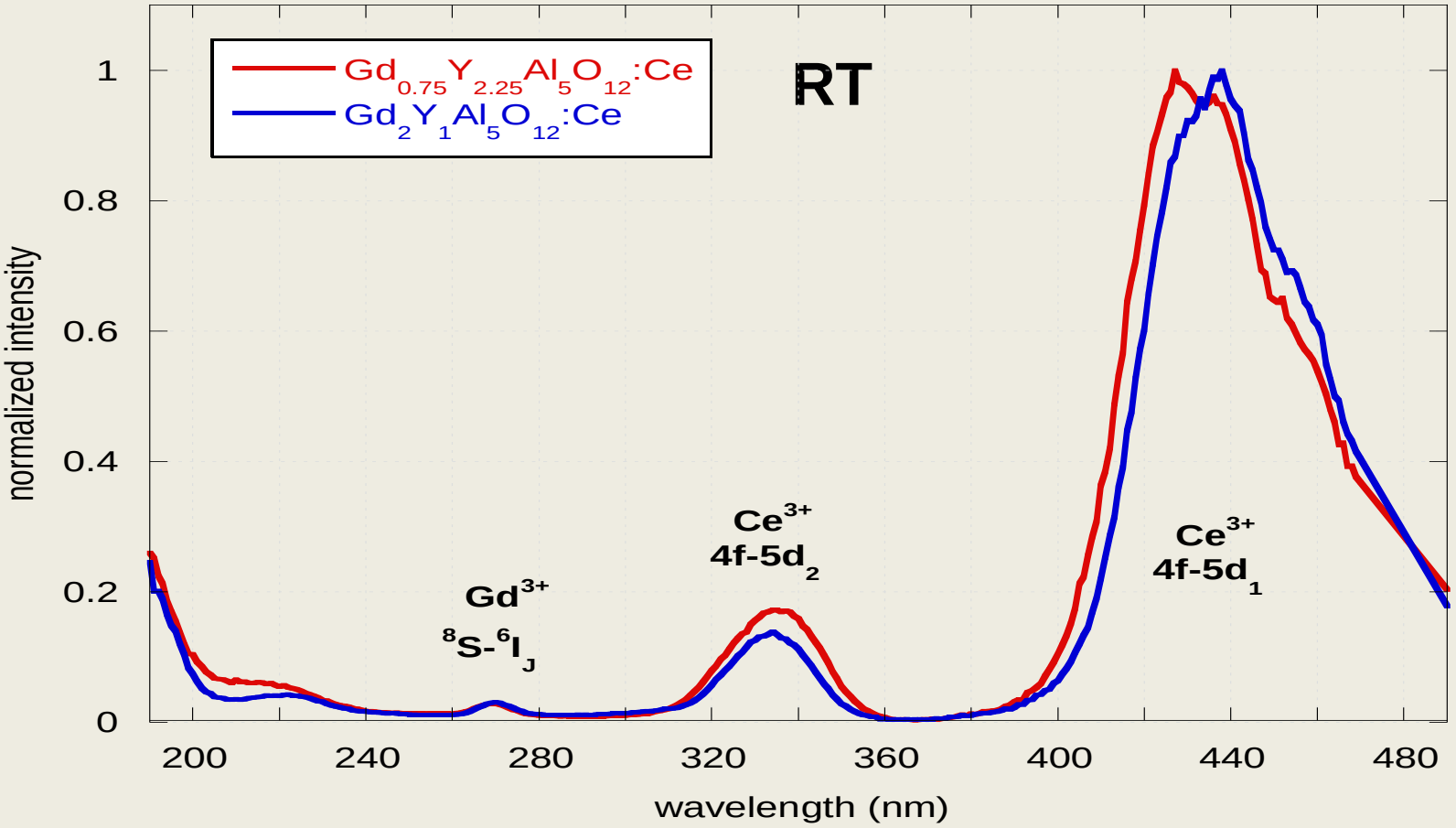
Absorption characteristics



Absorption spectra of Ce-doped $Gd_xY_{3-x}Al_5O_{12}$ (x=0.75 and 2)

Results and Discussion

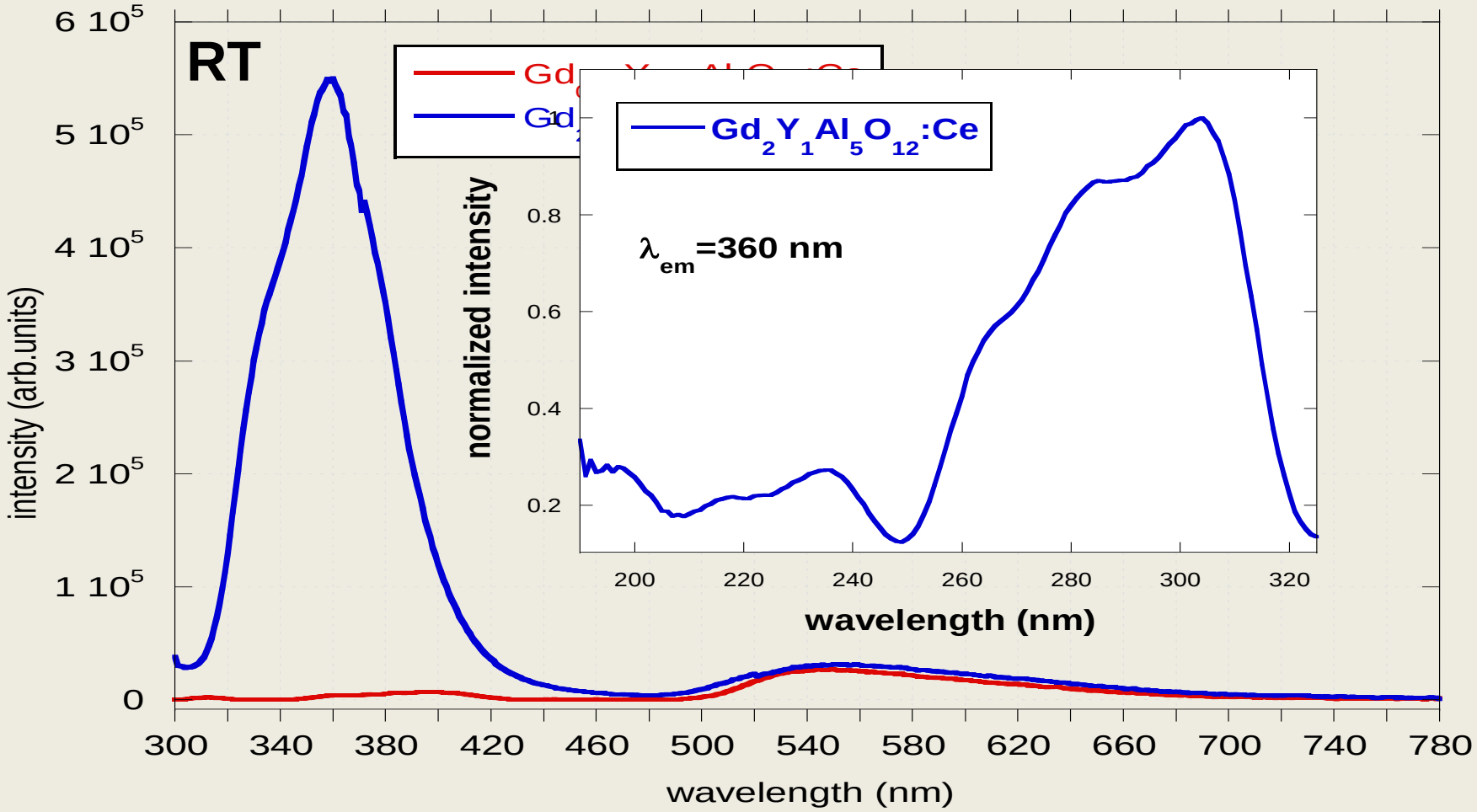
Excitation characteristics



The excitation spectra of Ce-doped $Gd_xY_{3-x}Al_5O_{12}$ (x=0.75 and 2) were taken for emission at 520 nm corresponding to $5d_1$-4f emission transition of Ce^{3+} ions.

Results and Discussion

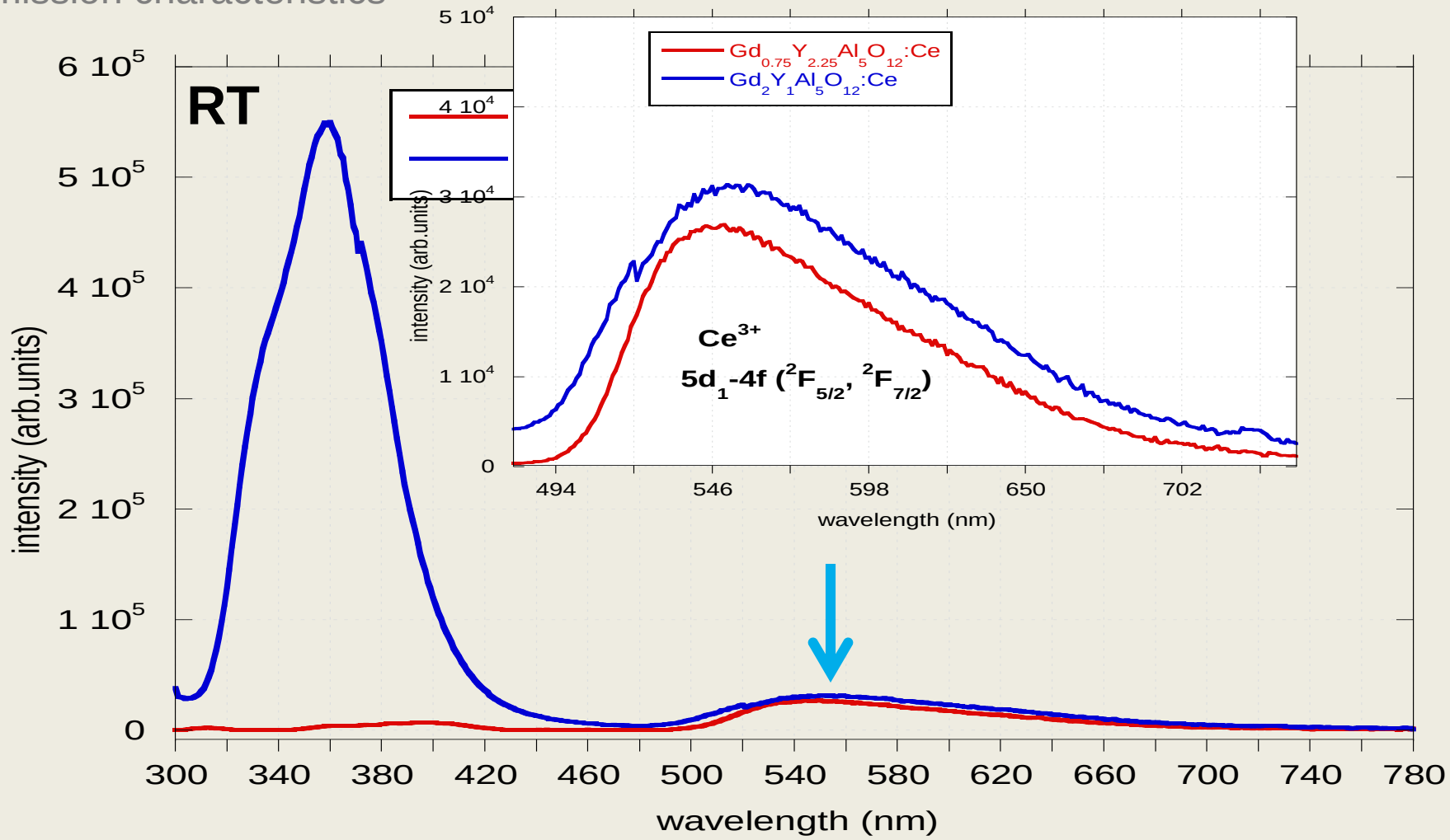
Emission characteristics



Emission spectra of Ce-doped $Gd_xY_{3-x}Al_5O_{12}$ (x=0.75 and 2) measured for excitation at 270 nm.

Results and Discussion

Emission characteristics



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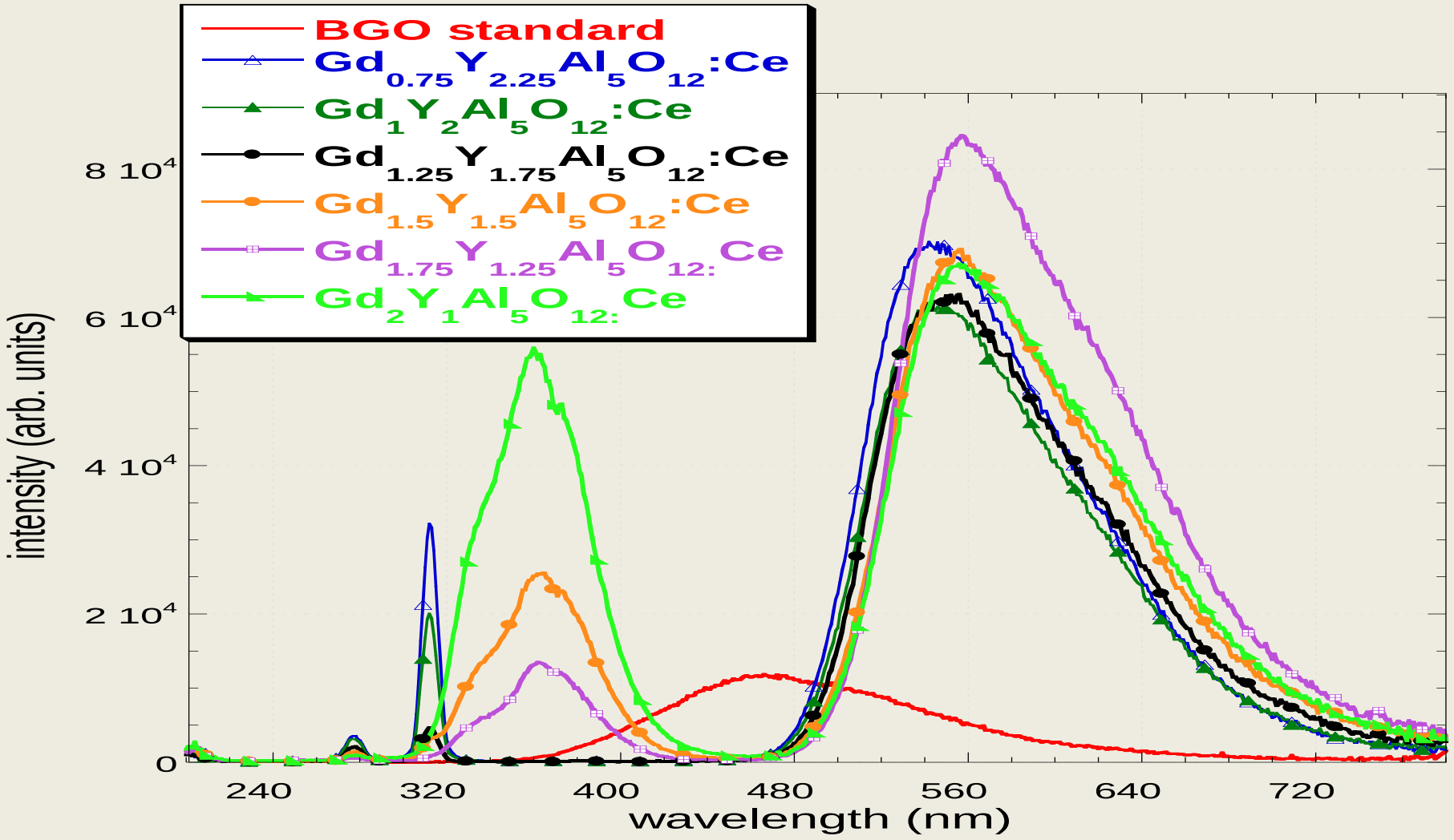
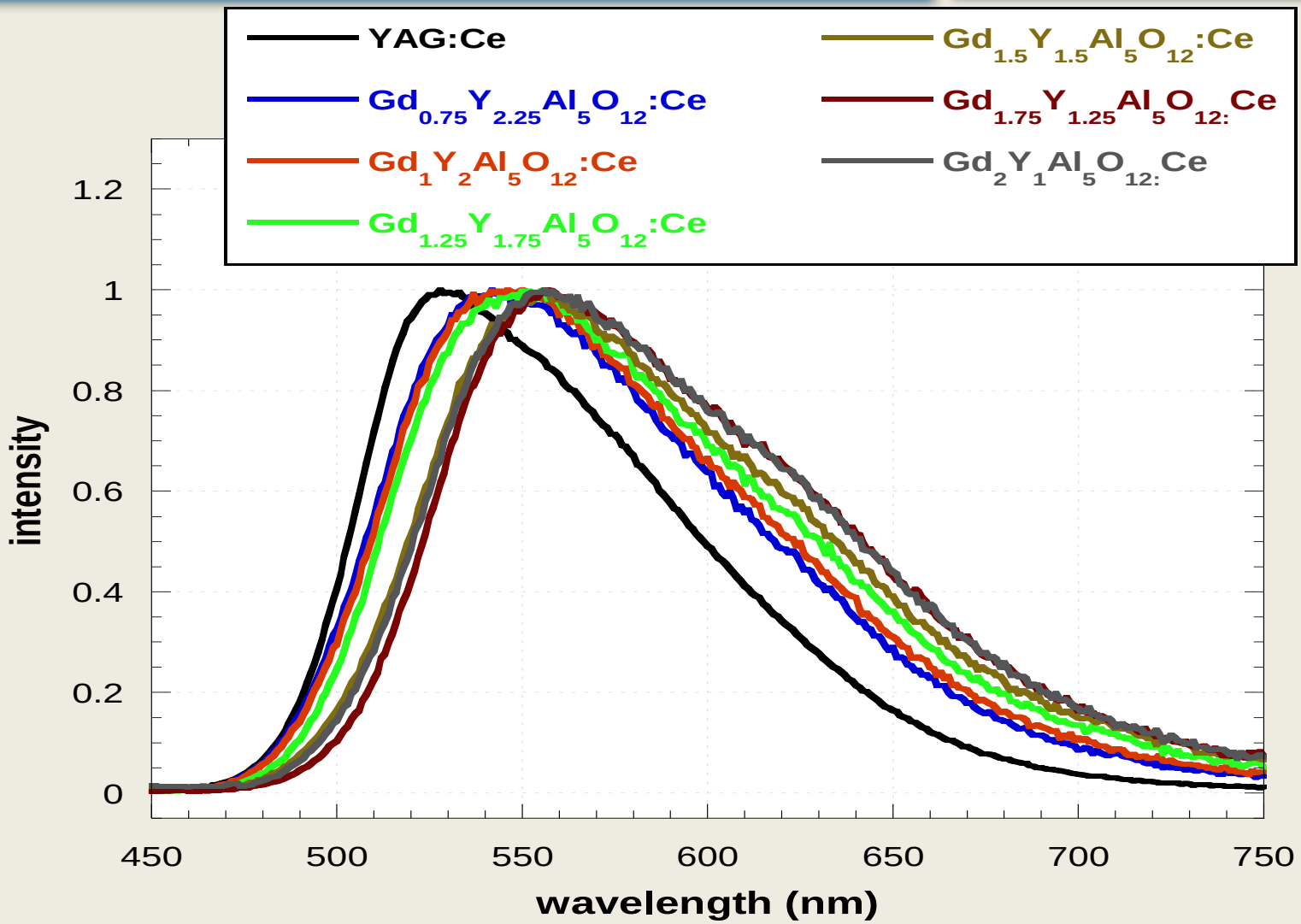
Results and Discussion



Radioluminescence spectra of Ce-doped $Gd_xY_{3-x}Al_5O_{12}$ under soft X-ray excitation

Results and Discussion



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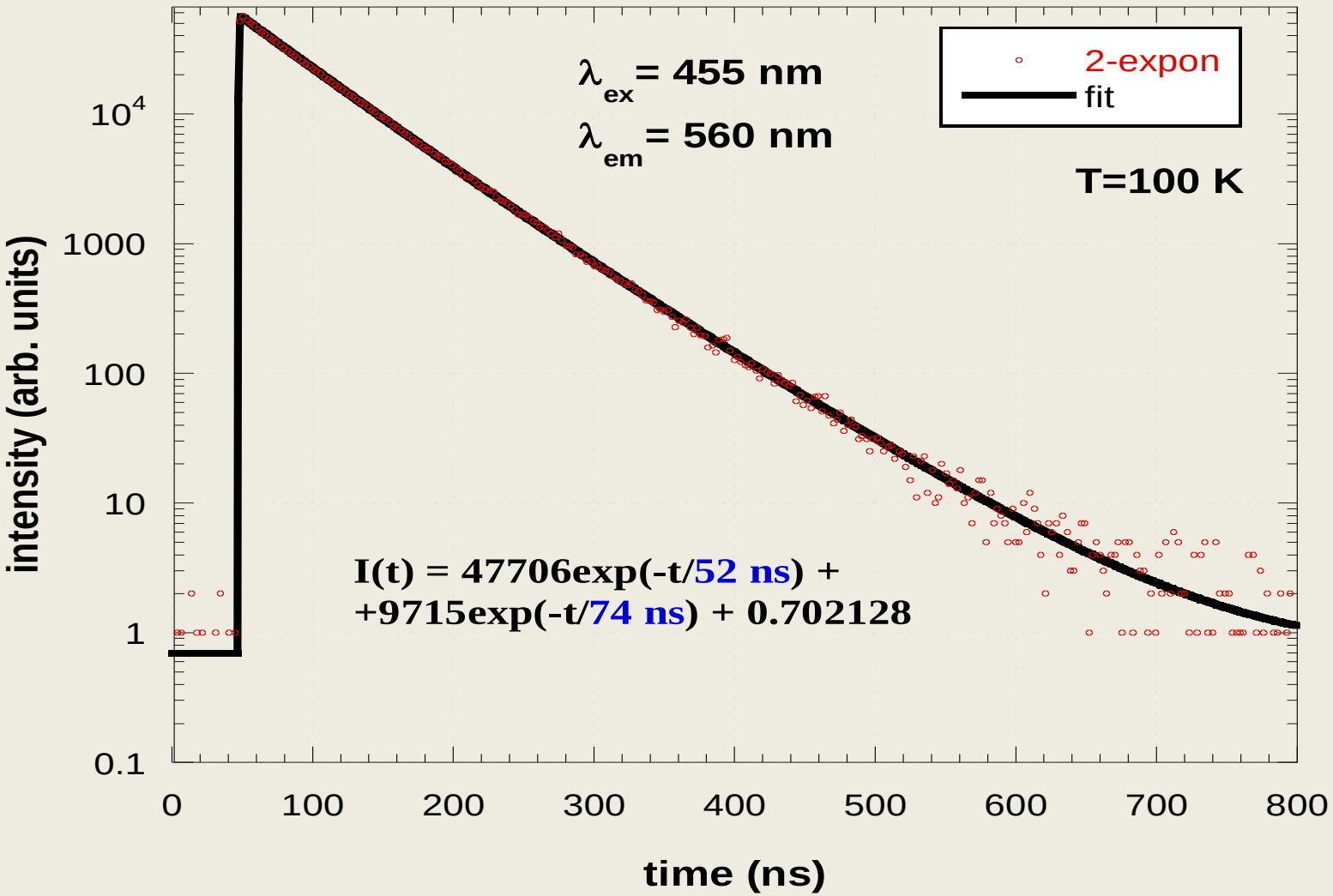
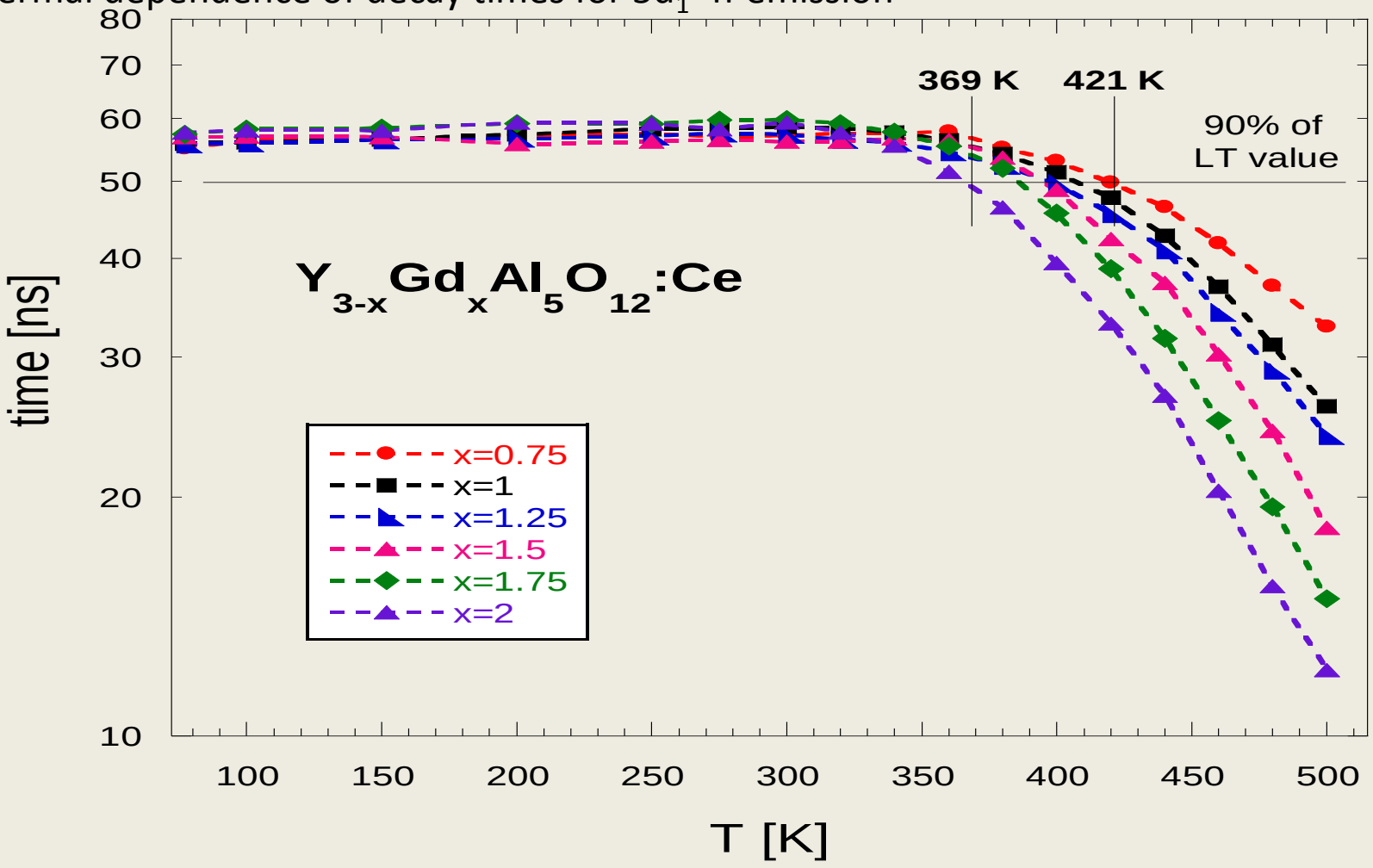


Decay time of Ce^{3+} luminescence in $Gd_{1.5}Y_{1.5}Al_5O_{12}:Ce^{3+}$

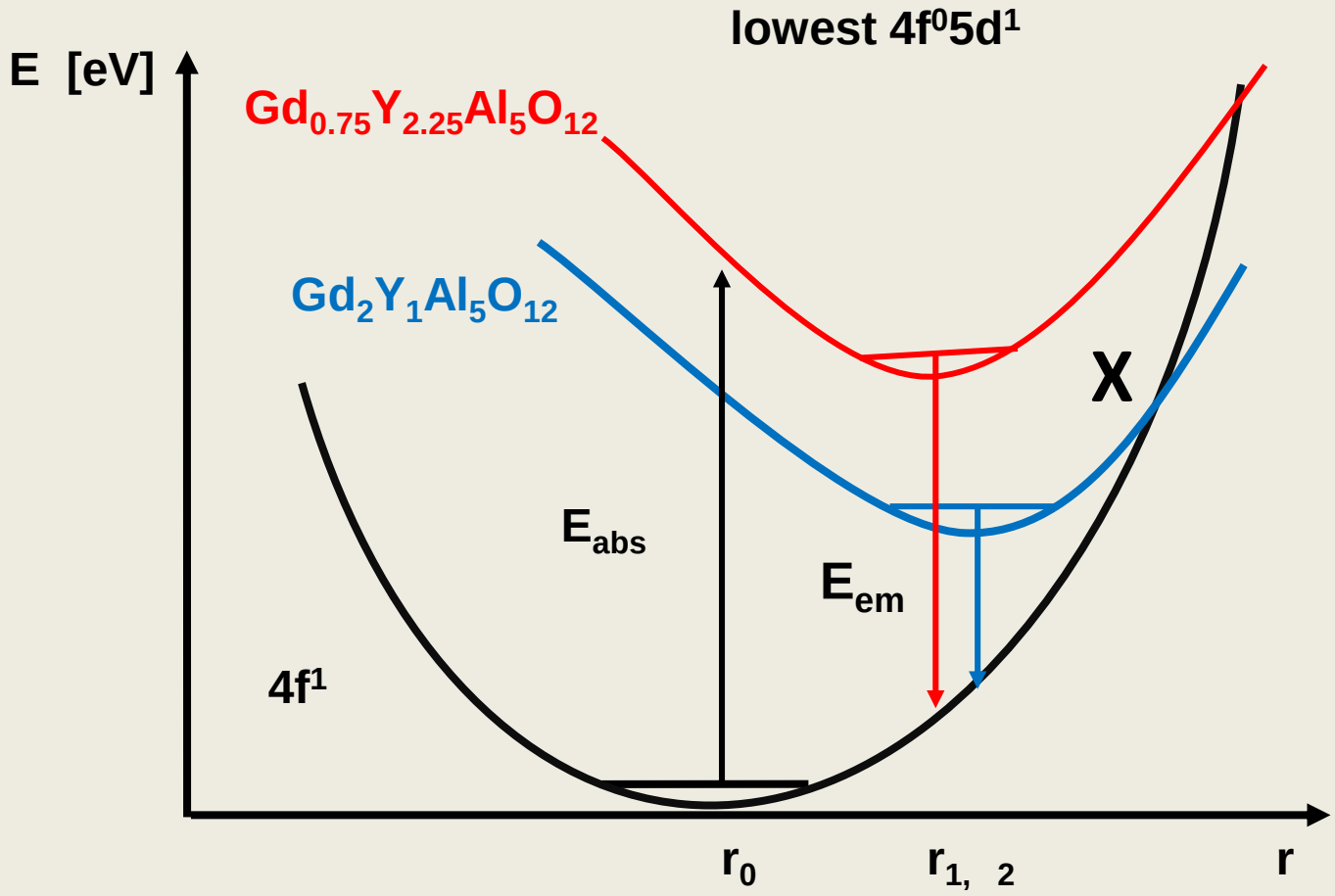
Results and Discussion

Thermal dependence of decay times for $5d_1$-4f emission



Shifts in the onset of thermal quenching caused by changes in crystal field strength

Results and Discussion



Configurational coordinate diagram explaining quenching mechanism for Ce^{3+} emission in $(Y,Gd)_3Al_5O_{12}$ single crystals

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Conclusions

✓ Gd co-doping into YAG:Ce^{3+} host lattice caused:

- shifts of the onset the luminescence quenching toward lower temperatures
- shifts of the $5d_1$-4f emission band toward lower energies

✓ luminescence quenching in these samples can be explained by configurational coordinate model

✓ Nonradiative energy transfer from Gd^{3+} to Ce^{3+} in the Ce-doped $(Y,Gd)_3Al_5O_{12}$ was observed.

Acknowledgment

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and to you for your attention!