Fast emitting oxide scintillators and phosphors: Energy transfer processes in $Ca_3Tb_2Si_3O_{12}:Eu^{3+}$

Irene Carrasco Ruiz
Luminescent Materials Group. UNIVR

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OUTLINE

Motivation

Sample details

Results

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Future work

MOTIVATION

Rare earth phosphors

- Emitting
- Multicomponent
- Tunable

→

- Displays
- Fluo lamps
- Imaging

→ Nanophosphors: great option for bioimaging and displays

Efficient VUV excited phosphors

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- Plasma display panels
- Hg- free lamps
- Imaging

↓

- Photon cascade emission → No practical VUV phosphor based on this phenomena
- Sensitization → Traditional way to enhance luminescence efficiency

- Tb^{3+} good sensitizer for Eu^{3+} red emission by exploiting its strong *4f-5d* absorption bands located in VUV.

→ VUV sensitization effect in Tb^{3+} - Eu^{3+} codoped systems paved the way to obtain efficient VUV phosphors.

- Green emission from Tb^{3+} and red emission from Eu^{3+} have many applications in lighting and displays.

- Energy transfer process involving Tb^{3+} - Eu^{3+} itself is quite complicated.

→ Interesting phenomena to study.

Silicate

↓

→ Good transparency in UV/VIS

→ Chemical stability

→ Low cost

→

Silico-carnotite type structure

↓

Good stability for RE doping from Eu-Lu ions

OBJECTIVE

Study the Tb^{3+}-Eu^{3+} energy transfer processes in $Ca_3Tb_2Si_3O_{12}$:Eu^{3+} .

METHODOLOGY

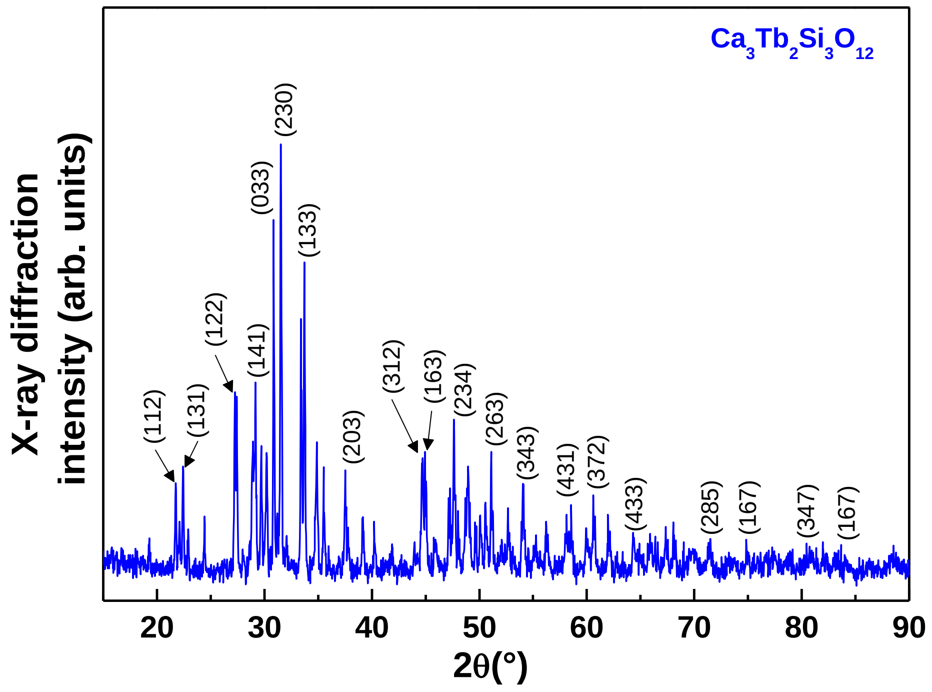
Performing RT luminescence and decay time experiments on both undoped and Eu^{3+} doped samples

SAMPLE DETAILS

$Ca_3Tb_2Si_3O_{12}$ and $Ca_3Tb_2Si_3O_{12}$:Eu^{3+} (5 mol%)

Synthesized by SSR (III TT at 1450 ^{o}C x 3h)

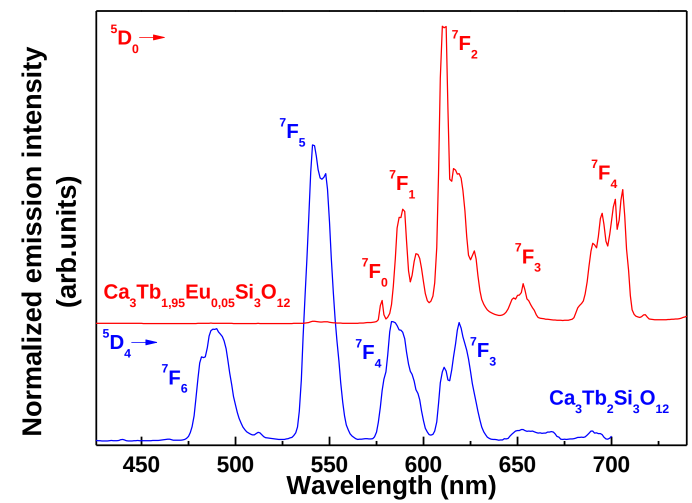
Pure phase

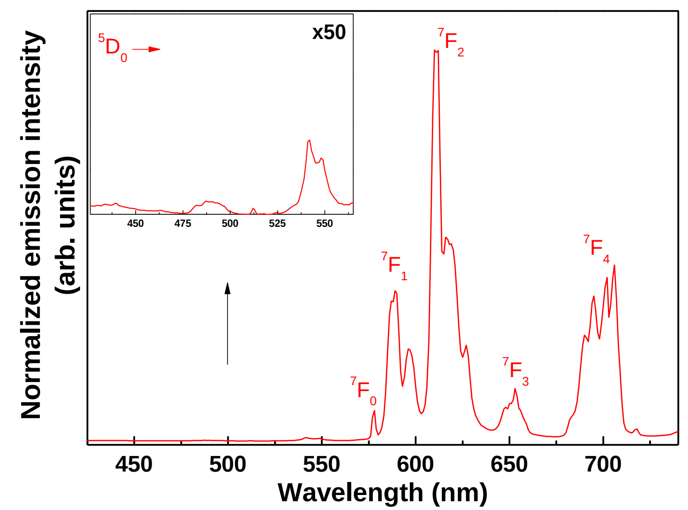


LUMINESCENCE RESULTS

RT EMISSION

λ_{exc} =377 nm $^5D_3$ (Tb^{3+})



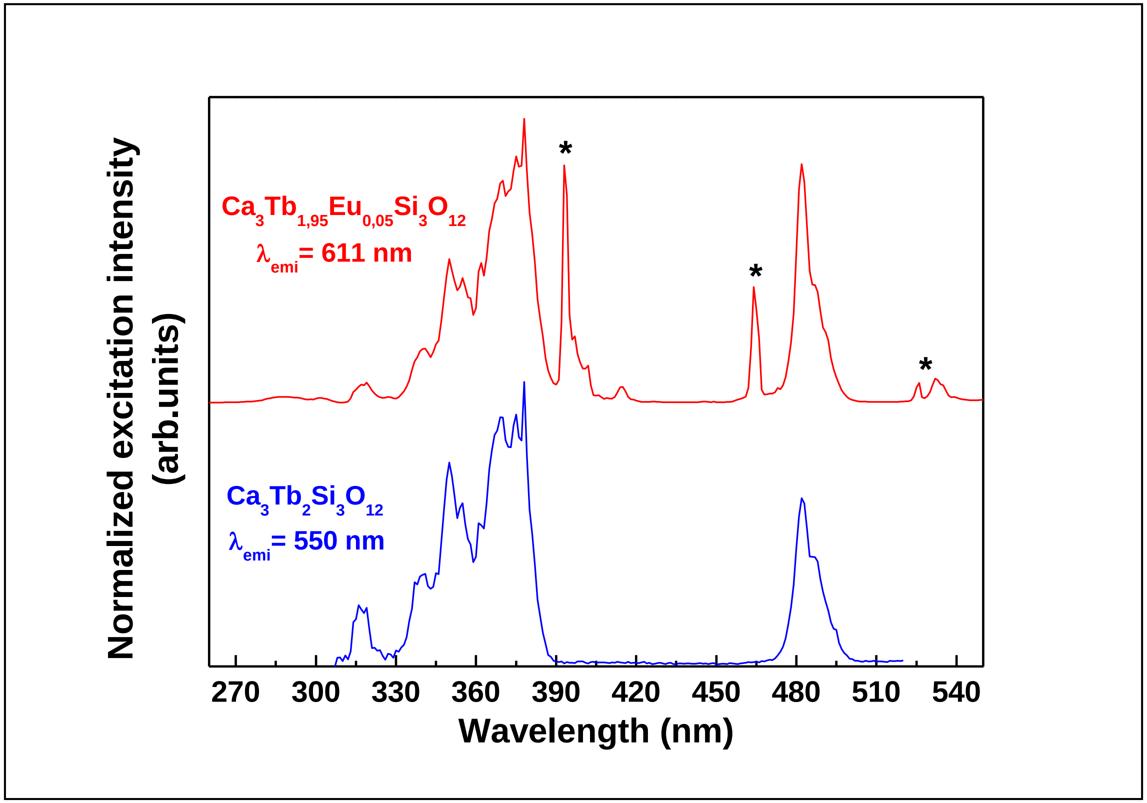


$$\frac{I_{\,^7F_2}(Eu^{3+})}{I_{\,^7F_5}(Tb^{3+})} = \mathbf{123} \qquad \frac{I_{\,^7F_4}(Eu^{3+})}{I_{\,^7F_5}(Tb^{3+})} = 55$$

Very efficient energy transfer from Tb^{3+} to Eu^{3+}

LUMINESCENCE RESULTS

RT EXCITATION

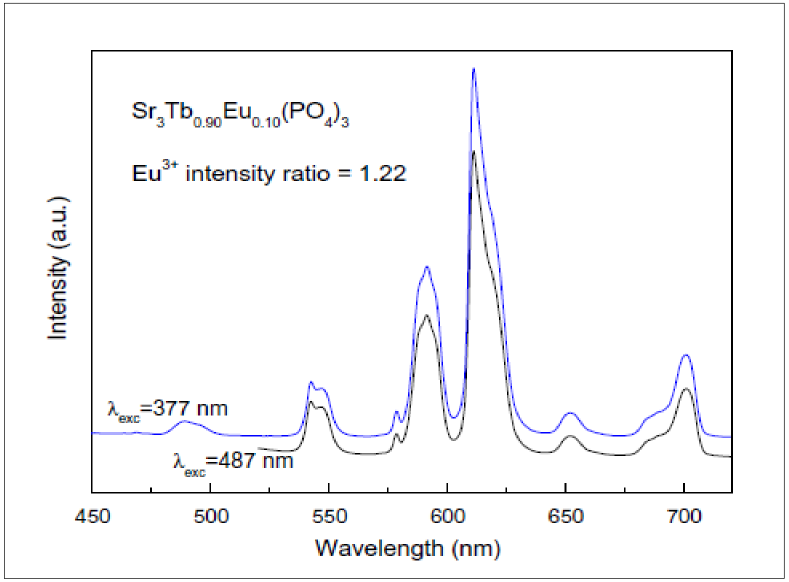


Only a few Eu^{3+} excitation bands are observed (labeled with *)

These results confirm the $Tb^{3+} \longrightarrow Eu^{3+}$ energy transfer

LUMINESCENCE RESULTS

$Sr_3Tb(PO_4)_3$: Eu^{3+} (10%)



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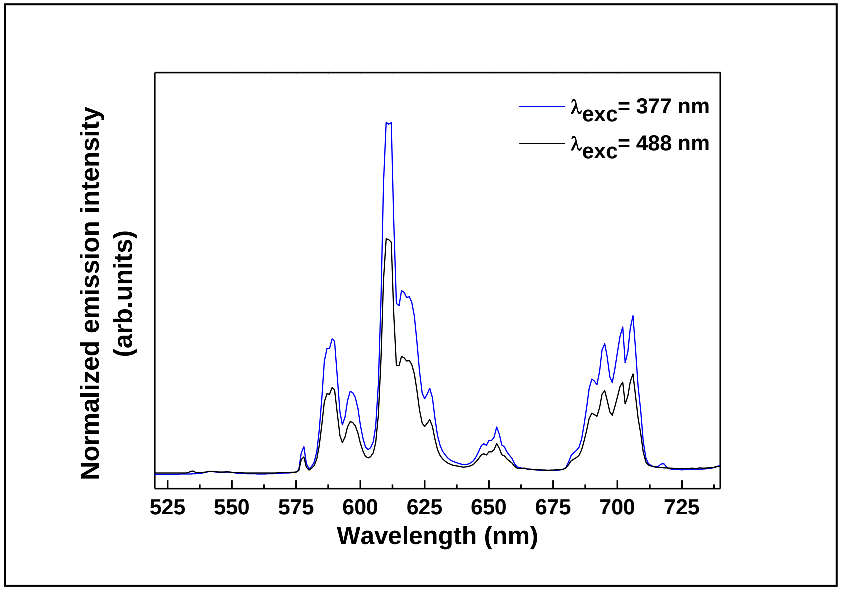
Relative intensity of Eu^{3+} $^5D_0$ bands with respect to Tb^{3+} $^5D_4$ ones, depends on excitation pathway

Same behaviour observed In $Ca_3Tb_2Si_3O_{12}$:Eu^{3+} (5 mol%)



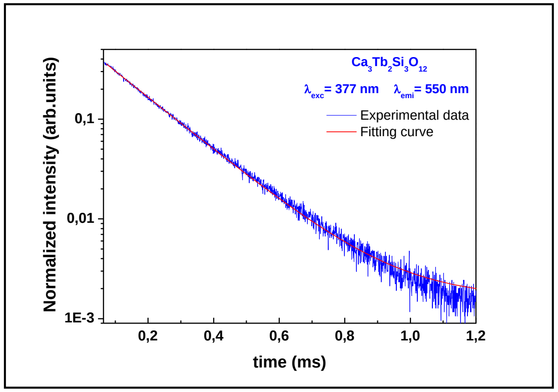
In the 570-720nm range:

$$\frac{I_{em}(\lambda_{exc} = 377nm)}{I_{em}(\lambda_{exc} = 488nm)} = 1.53$$

LUMINESCENCE RESULTS
RT DECAY CURVES

$Ca_3Tb_2Si_3O_{12}$

$^5D_4 \rightarrow {}^7F_5$

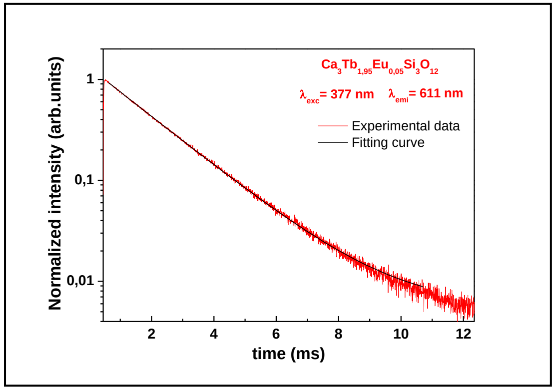


Exponential decay

Short time constant: τ = 164 μs

$Ca_3Tb_2Si_3O_{12}:Eu^{3+}$ (5 mol%)

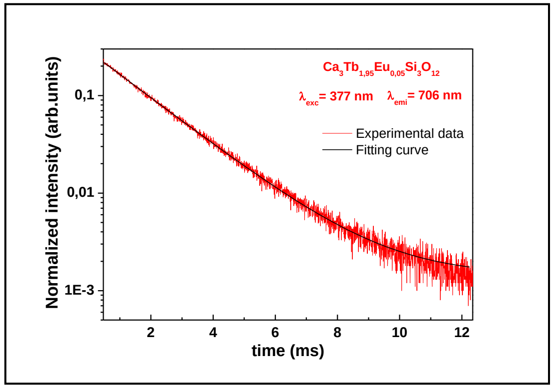
$^5D_0 \rightarrow {}^7F_2$



Exponential decay

Time constant: τ = 1.78 ms

$^5D_0 \rightarrow {}^7F_4$



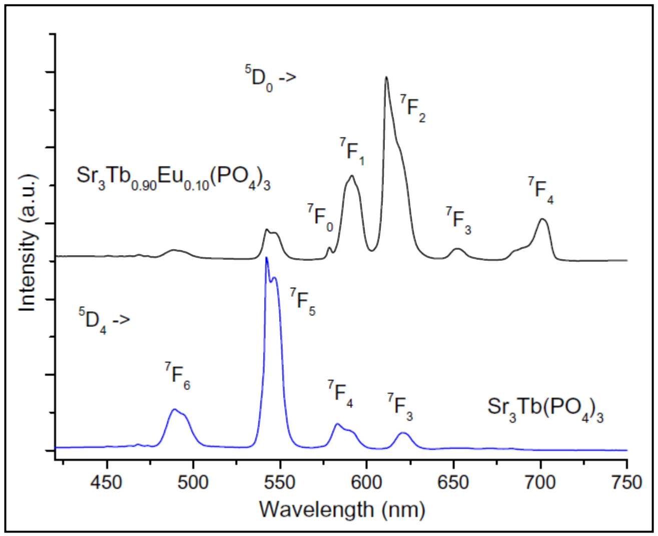
Exponential decay

Time constant: τ = 1.80 ms

No data for Tb^{3+} $^5D_4 \rightarrow {}^7F_5$ transition in $Ca_3Tb_2Si_3O_{12}:Eu^{3+}$ due to its very low intensity

LUMINESCENCE RESULTS
EFFICIENCY OF THE PROCESS

$Sr_3Tb(PO_4)_3$: Eu^{3+} (10%)



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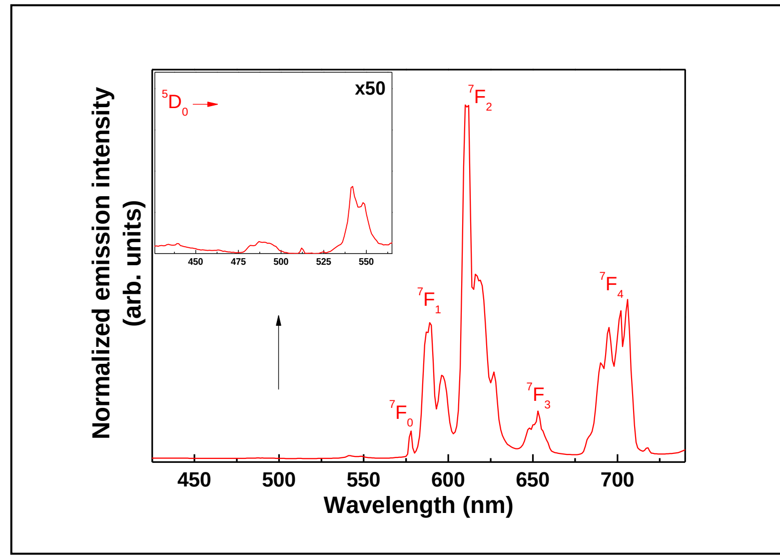
$$\eta_T = 1 - \frac{\tau_{Tb-Eu}}{\tau_{Tb}} = 0.93$$

$Ca_3Tb_2Si_3O_{12}$:Eu^{3+} (5 mol%)



Efficiency of the energy transfer η_T > 0.93

CONCLUSIONS

Clear evidences of energy transfer from Tb^{3+} to Eu^{3+}

Tb^{3+} emission almost quenched
⟶ very strong Eu^{3+} emission

Efficient changes in the emission colour of the material by the addition of 5 mol% Eu^{3+}

CURRENT WORK

Synthesis of samples with various Eu^{3+} doping concentration under 5 mol%

FUTURE WORK

VUV luminescence experiments

Study of diluted Tb^{3+} compounds

Nanosized materials

Thank you for your attention

LUMINESCENT MATERIALS LAB