

LUMINESCENCE OF KLuP_2O_7 DOPED WITH Pr^{3+} IONS UNDER DIFFERENT TYPES OF EXCITATION

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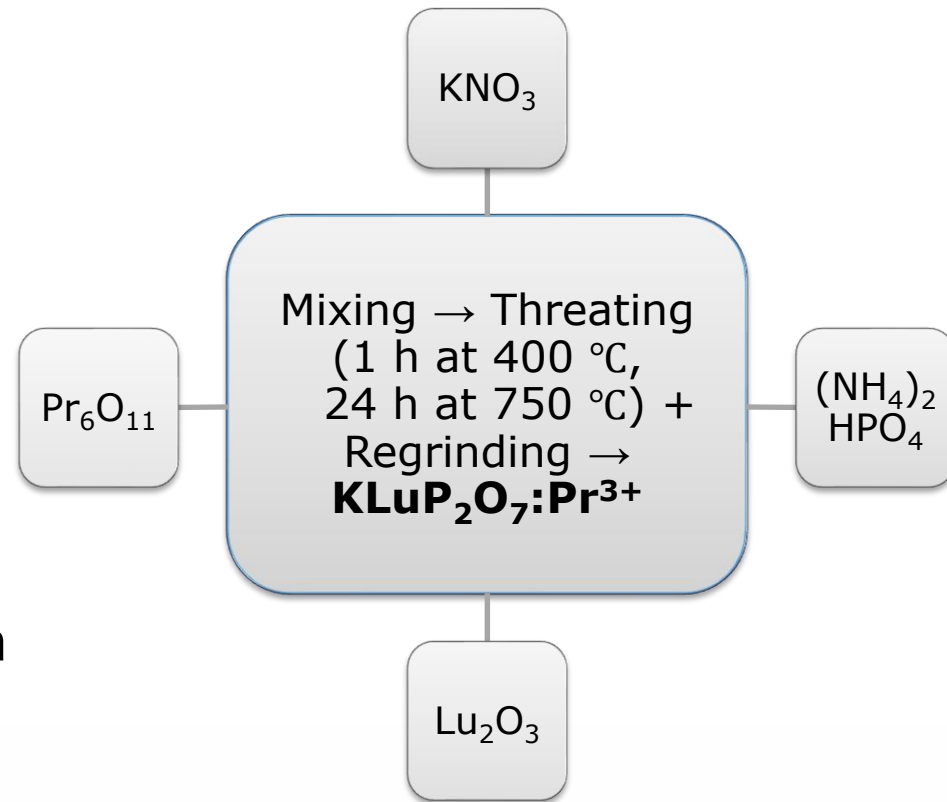
Introduction

- ❑ Praseodymium-ions doped luminescent materials are recently being actively investigated due to demonstration of fast interconfigurational $5d - 4f$ optical transitions.
- ❑ KLuP_2O_7 with Ce^{3+} and Pr^{3+} is one of the most promising materials among fast energy converters transformers.
- ❑ Previous researchers have proposed application potential of this material based only on VUV-spectroscopy (emission and excitation spectra, its kinetic measurement).
- ❑ In this report we examine spectroscopic properties of luminescence under different types of excitation: photo-, X-ray-, pulse cathode-, X-ray synchrotron radiation.

- Inorganic scintillator materials with improved characteristics in terms of light output and timing are widely required in modern technologies such as nuclear physics, security, chemistry, space physics, medical imaging, etc.
- Pr³⁺-doped hosts are doubly demanded in systems working at higher count rate – they are characterized with short wavelengths and fast decay time.

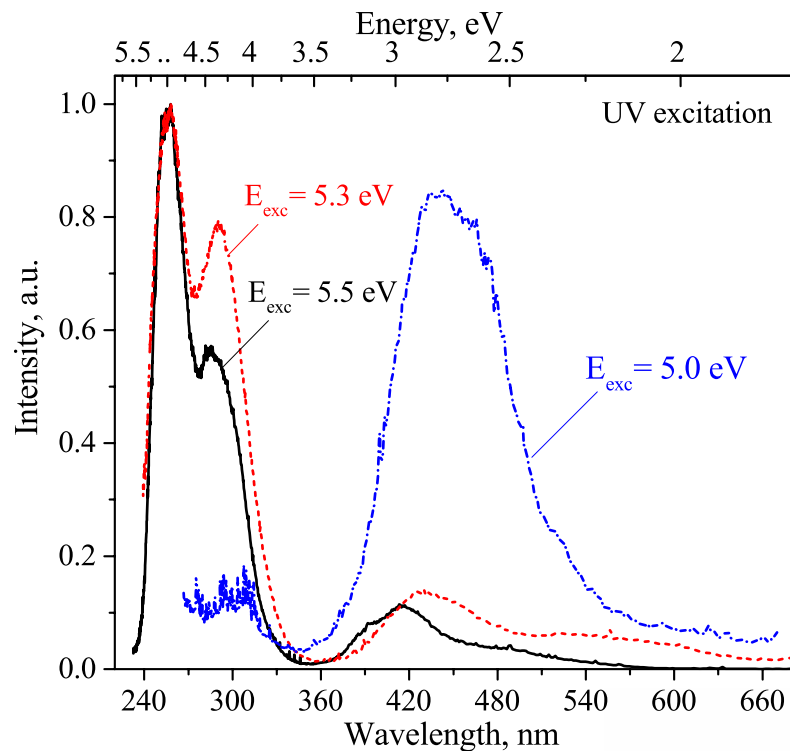
Object and experiment details

- ❑ KLuP₂O₇ powders were synthesized using solid-state reaction at Laboratory of Luminescent Materials, University of Verona.
- ❑ Obtained powder was controlled with X-ray powder diffraction (PXRD) method.
- ❑ Confirmed measurements:
 - ✓ photoluminescence upon UV-VUV excitation;
 - ✓ PL excitation;
 - ✓ X-ray excited luminescence;
 - ✓ pulse cathodoluminescence;
 - ✓ decay kinetics.



Flowchart of powders' synthesis

UV photoluminescent spectroscopy



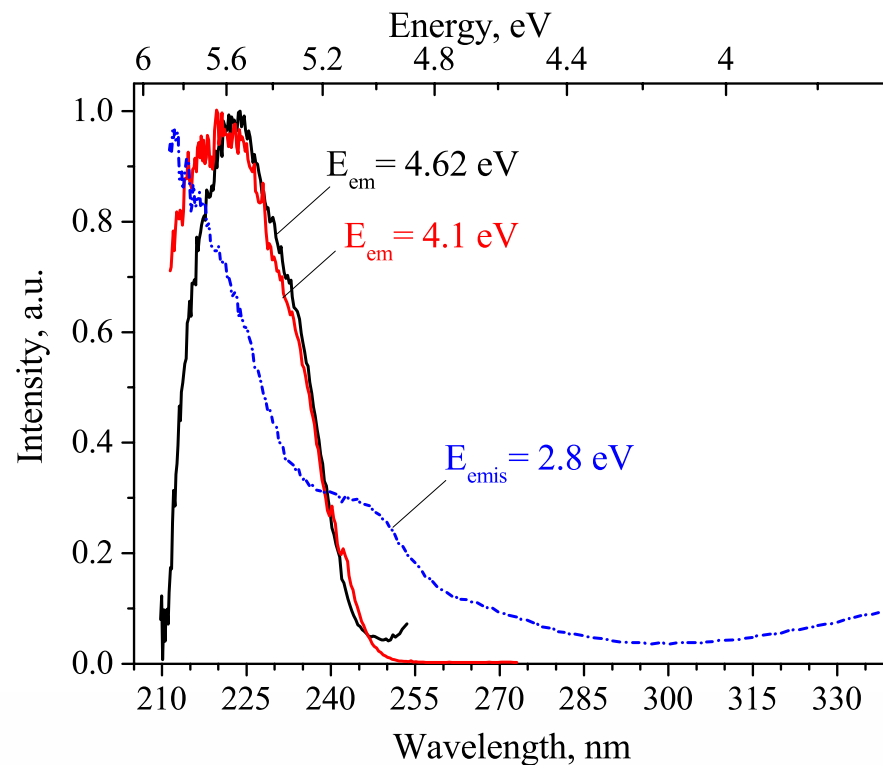
Photoluminescence spectra
of $\text{KLuP}_2\text{O}_7:\text{Pr}^{3+}$ upon
different excitation energy
 E_{exc} , $T=295 \text{ K}$

The broad emission bands with maxima near 290 nm are dominating in spectra. They correspond to the parity-allowed interconfigurational radiative transitions from the lowest excited $4f^15d^1$ state to the multiplets of the ground $4f^2$ electronic configuration of the Praseodimium three plus ion. With excitation at 5.0 eV we observe a broad emission band with maximum near 450 nm. We suppose that this band is related to defects in the crystal structure.

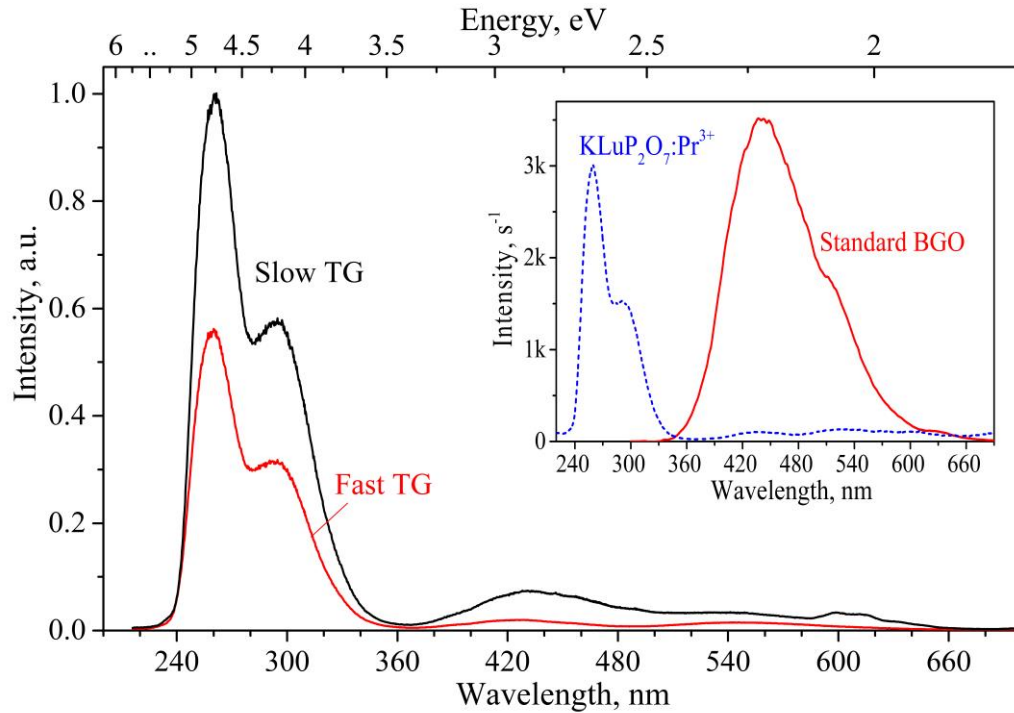
UV photoluminescent spectroscopy

PL excitation spectra were measured for the main emission bands of $d - f$ and defect-related luminescence. Spectra contain broad complex band in the UV region between 200 and 250 nm corresponding to intracenter transitions.

As it can be concluded from PL and PL excitation spectra, there are two dominant channels of emission: besides $d - f$ transitions active defect-related luminescence is a serious competitive channel of capturing charge carries. The contribution of $4f^2 \rightarrow 4f^2$ is very low due to a small Stokes shift.



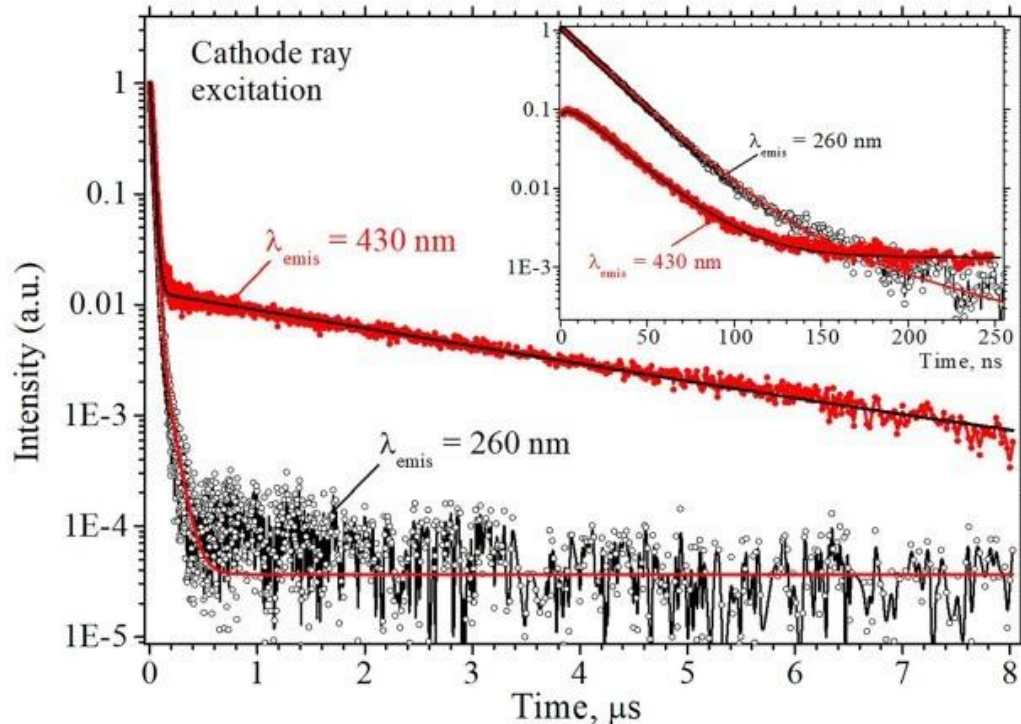
PL excitation spectra of KLuP₂O₇:Pr³⁺ of different emission energy E_{emis}, T = 295 K



PCL spectra also demonstrates interconfigurational bands in 250 nm region. Inset shows the comparison of light output of KLuP_2O_7 and standard BGO powder made in same conditions. Integral area under operating region of our powder contains about 40 % of BGO output.

Time-resolved PCL spectra of $\text{KLuP}_2\text{O}_7:\text{Pr}^{3+}$, $T = 295 \text{ K}$. Inset shows the comparison output of $\text{KLuP}_2\text{O}_7:\text{Pr}^{3+}$ and BGO powder

Luminescence decay kinetics

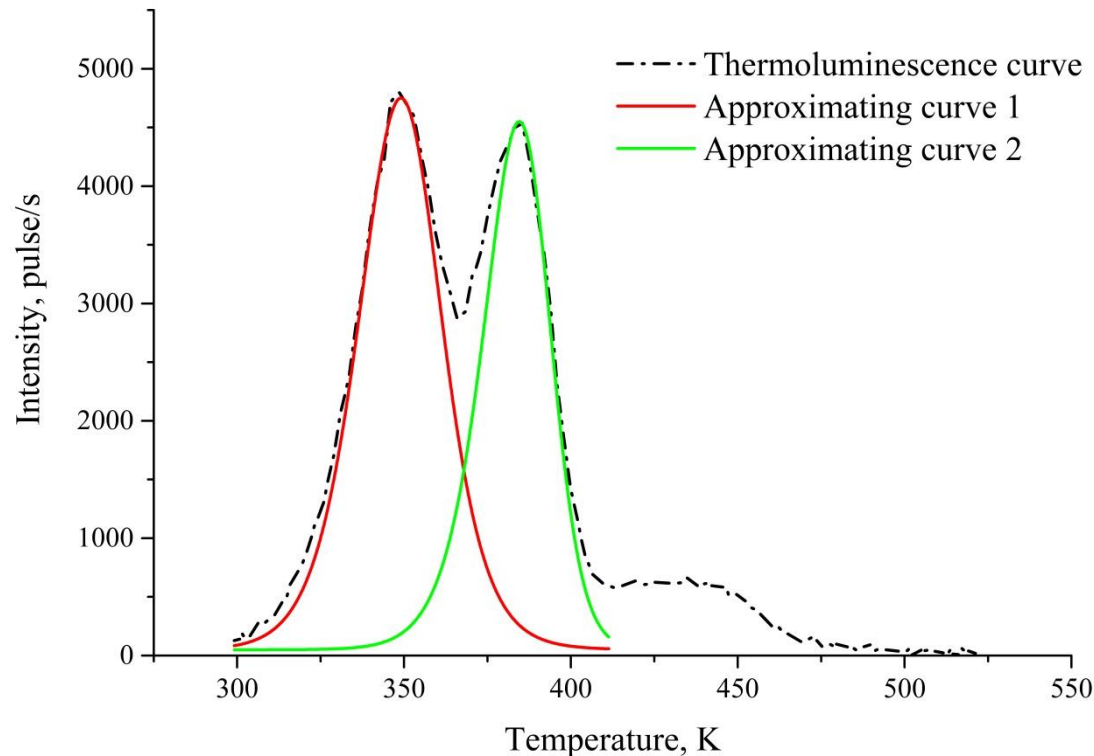


Decay kinetics recorded monitoring $\text{Pr}^{3+} 4f^{15}d^1 \rightarrow 4f^2$ emission and defect-related emission in $\text{KLuP}_2\text{O}_7:\text{Pr}^{3+}$ upon cathode ray excitation in μs scale and sub- μs scale (Inset) at $T = 295 \text{ K}$

PCL decay kinetics of UV-emission bands shows no build-up stage; this indicates a prompt population of the $\text{Pr}^{3+} 4f^{15}d^1$ levels by host electronic excitations, which is a typically beneficial result of recombinational mechanism of energy transfer.

The PCL decay kinetics recorded for 430 nm line of defect-related luminescence contains a well-observed built-up stage characterized with rise time of 4.8 ns. The build-up stage may indicate the presence of shallow traps which act as intermediate trapping centers for thermalized charge carriers; this is approved in thermally stimulated luminescence measurements.

Thermoluminescent measurements



Thermoluminescence curve and approximating curves of X-ray irradiated powder at $T = 295$ K $\text{KLuP}_2\text{O}_7:\text{Pr}^{3+}$

TSL spectra prove the presence of defect-related traps, where the recombination of charge carriers takes place. The features of XRL and TSL spectra indicate an efficient transport of energy from the impurity center to the defects.

- Peak 1 ($T_{\text{max}} = 352\text{K}$):
 - $\Delta E = 1.1$ eV
 - $p_0 = 2.7 \cdot 10^{13} \text{ s}^{-1}$.
- Peak 2 ($T_{\text{max}} = 388\text{K}$):
 - $\Delta E = 1.3$ eV
 - $p_0 = 1.4 \cdot 10^{16} \text{ s}^{-1}$.

Conclusion

- $\text{KLuP}_2\text{O}_7:\text{Pr}^{3+}$ powder was obtained by solid-state reaction; phase purity was controlled with PXRD analysis.
- Photoluminescent (PL), PL excitation, XRL, PCL and thermoluminescence spectra of the samples were measured.
- Upon both UV intra-center and band-to-band excitation with ionizing radiation, the emission spectra of $\text{KLuP}_2\text{O}_7:\text{Pr}^{3+}$ are dominated by Pr^{3+} interconfigurational $4f^15d^1 \rightarrow 4f^2$ radiative transitions.
- Luminescence decay kinetics measurements established decay time $\tau \approx 19$ ns.
- Parameters of charge carriers' traps were calculated: $\Delta E_1 = 1.1$ eV (for peak at $T_{1\text{max}} = 352$ K) and $\Delta E_2 = 1.3$ eV (for peak $T_{2\text{max}} = 388$ K).

Thank you for attention!

Acknowledgements

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