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Tailored Optical Materials

Effect of Ga^{3+} Doping on the up-Conversion of $Lu_3(Al,Ga)_5O_{12}:Pr^{3+}$

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Background

Blue to UV up-conversion is currently attracting a high level of attention because up-converters can be used to generate UV radiation from daylight or indoor lighting. Even though, the intensity is rather low and the up-converter is not working in the shade when covered, there is despite of the low intensity a long-term effect concerning the inactivation of microorganisms on surfaces or for radiation therapy.
Upon the replacement of Al^{3+} by Ga^{3+} the emission wavelength of 4f5d emission bands located in the UV range can be adjusted, since the covalent character increases, while the band gap of the host declines at the same time.

Up-Conversion Process

For up-conversion measurements, the excitation photon energy is lower than the energy of emitted photons. Since the energy cannot simply be produced, it has to be a process involving at least two photons. Up-conversion can be caused by the processes “Excited state absorption” (ESA), “Energy transfer up-conversion” (ETU), or “Photon avalanche” (PA).

In the ETU process, two adjacent ions are excited simultaneously. Through an energy transfer, one electron is excited twice to a higher level while the other relaxes radiation less to the ground state.

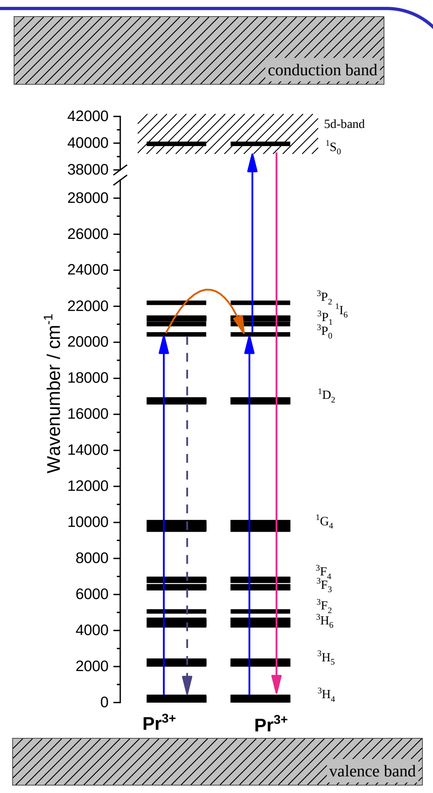


Fig. 1: Schematic representation of the ETU process

Results of down-Conversion Measurements

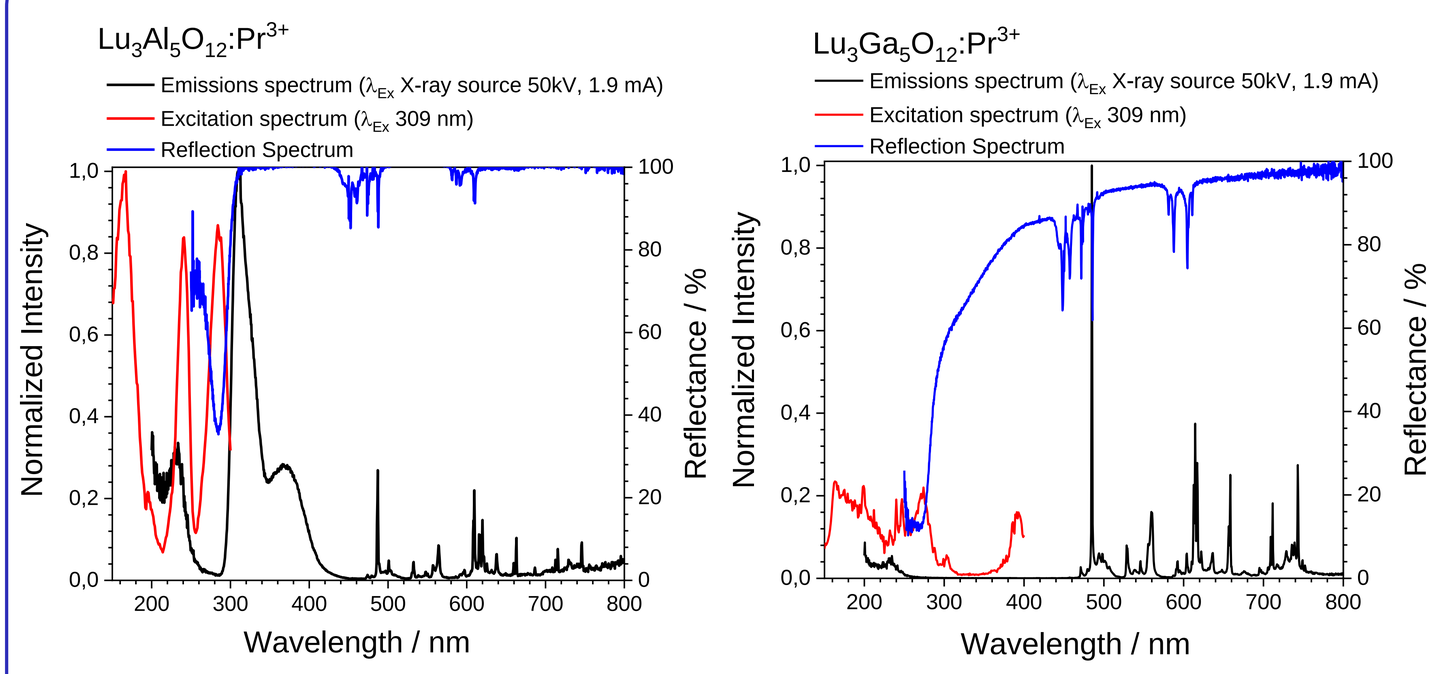
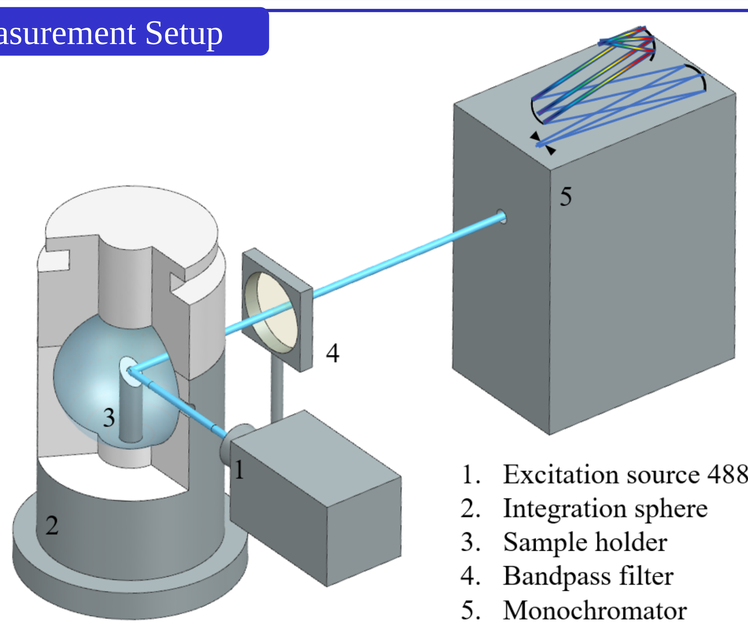


Fig. 2: Excitation, emission and reflection spectra of $Lu_3Al_5O_{12}$:Pr (left) and $Lu_3Ga_5O_{12}$:Pr (right)

Measurement Setup



1. Excitation source 488 nm Laser
2. Integration sphere
3. Sample holder
4. Bandpass filter
5. Monochromator

Fig. 3: Schematic representation of the measurement setup

Results of up-Conversion Measurements

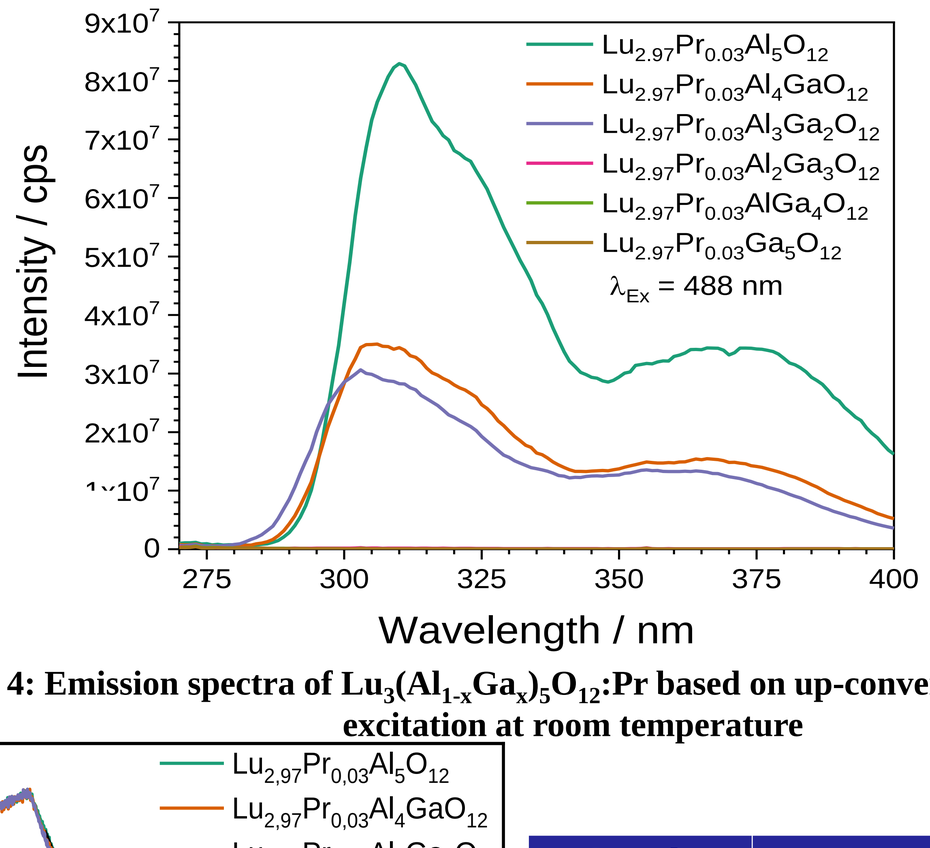


Fig. 4: Emission spectra of $Lu_3(Al_{1-x}Ga_x)_5O_{12}$:Pr based on up-conversion upon 488 nm excitation at room temperature

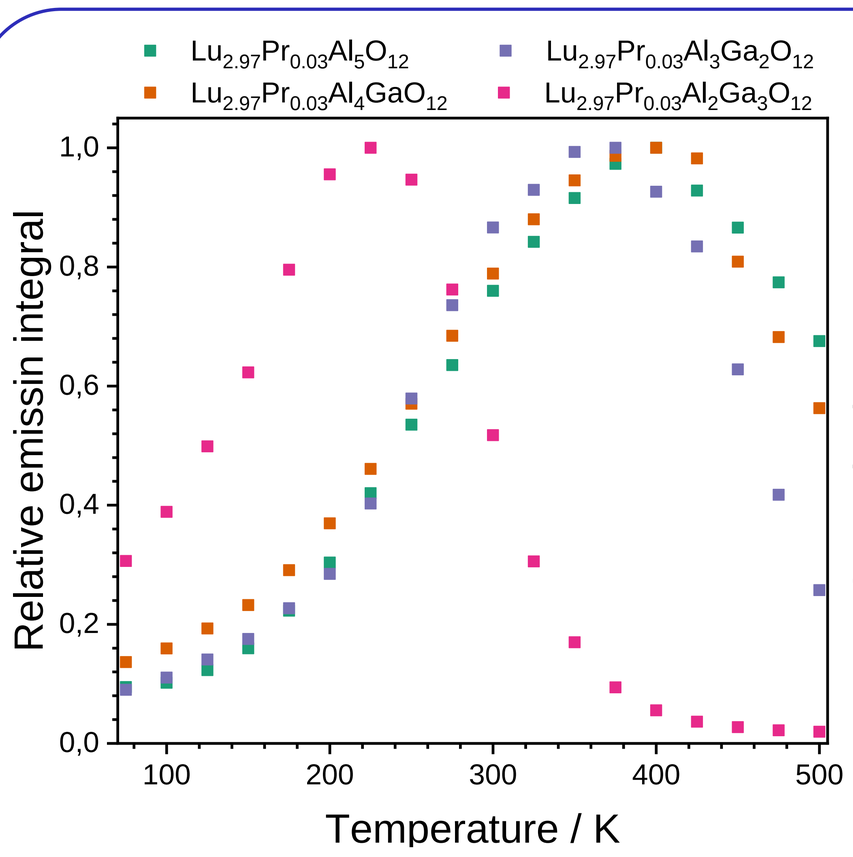


Fig. 5: Emission integrals of the temperature dependent up-conversion emission measurements

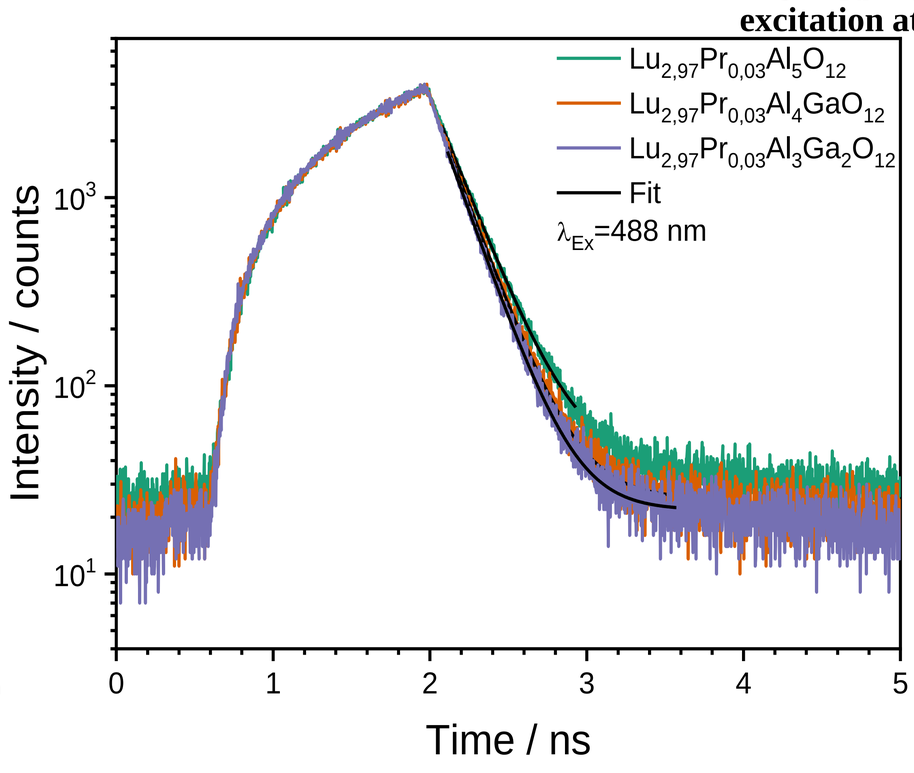


Fig. 6: Time dependent measurements of the up-conversion process

Sample	Up-Conversion Decay time / ns	Down-Conversion Decay time $[Xe]4f^15d^1 \rightarrow {}^3H_4$ / ns
$Lu_3Al_5O_{12}$	21	20
$Lu_3Al_4GaO_{12}$	19	18
$Lu_3Al_3Ga_2O_{12}$	15	16

Reference

F. Schröder, T. Jüstel, (2021) Optical Material X, 12, 100117

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