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# UV-C Up-Conversion in $Li_2Ca_{1-2x}SiO_4:Pr_xNa_x$


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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.
For the characterization of the concentration dependent behavior, the solid solutions $Li_2Ca_{1-2x}SiO_4:Pr_x,Na_x$ with x = 0.001, 0.002, 0.005, 0.01, 0.02, 0.05, 0.07, and 0.1 were synthesized via a solid state method and the photoluminescence of the down conversion and the up conversion properties were investigated.

## Measurement Setup

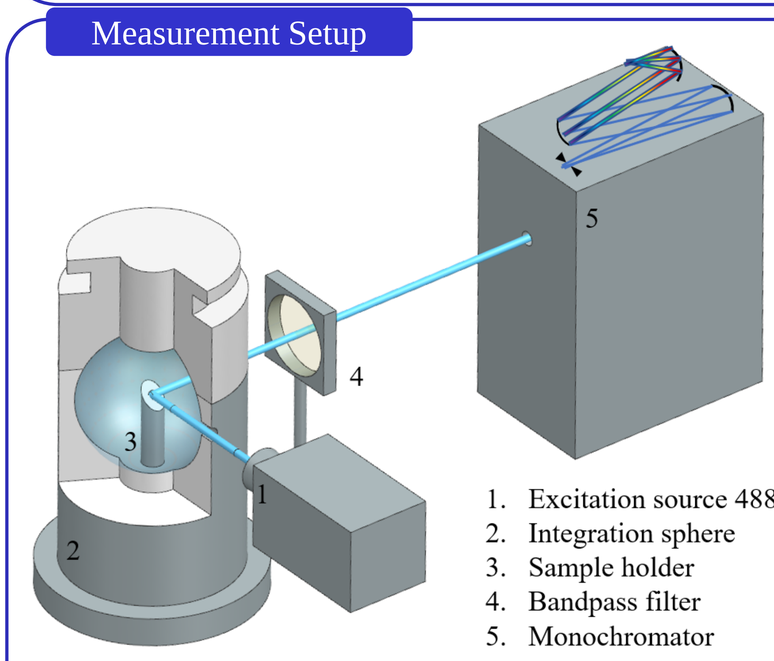



**Fig. 1: Sketch of the measurement equipment**

## Up-Conversion Process

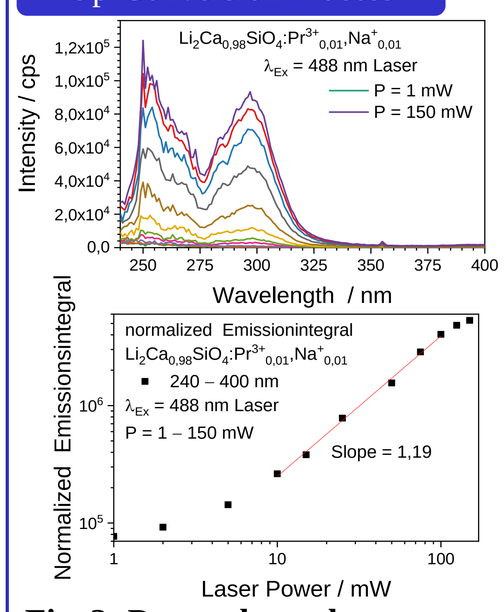



**Fig. 2: Power dependent measurements**

Power dependent measurements for $Li_2CaSiO_4$:Pr,Na showed that the corresponding up-conversion mechanism is due to excited state absorption (ESA). An ESA process means that after excitation of the ground state the obtained excited state is subsequently excited by a second photon with same energy.

Alternative to the ESA mechanism there are the Electron Transfer Up-conversion (ETU) and the Photon Avalanche (PA processes.

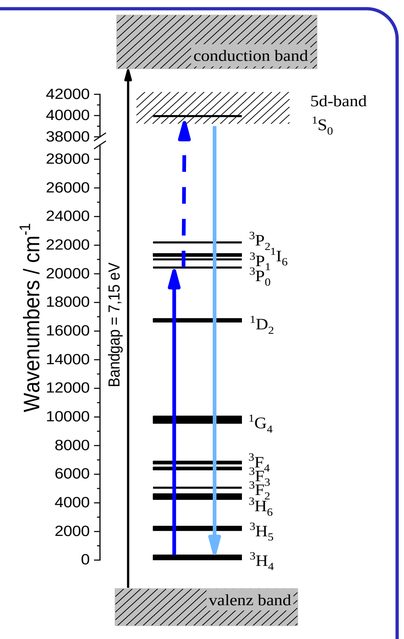



**Fig. 3: Schematic ESA process**

## Results of down-Conversion Measurements

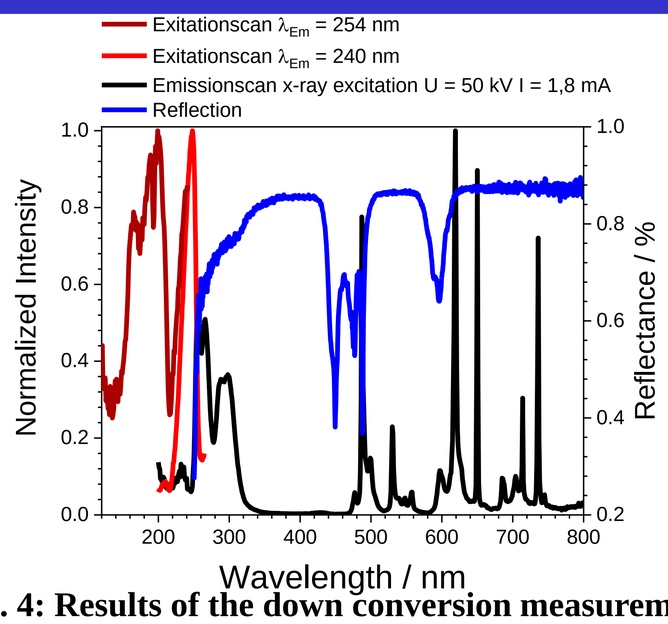



**Fig. 4: Results of the down conversion measurements of $Li_2Ca_{0,9}SiO_4:Pr_{0,05}.Na_{0,05}$**

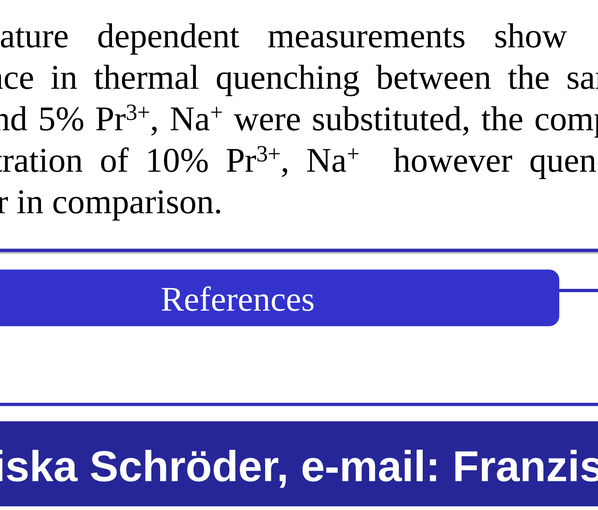



**Fig. 5: Relative excitation- and emission integral of the solid solutions as a function of the concentration**

## Results of up-Conversion Measurements

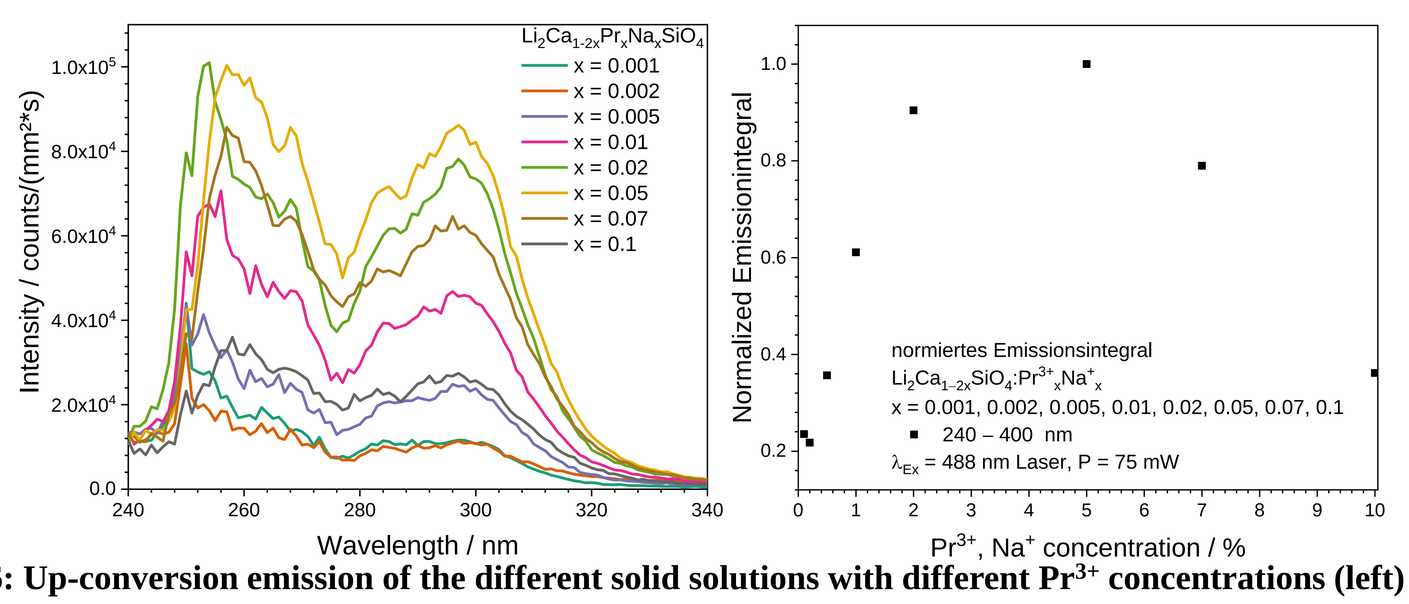
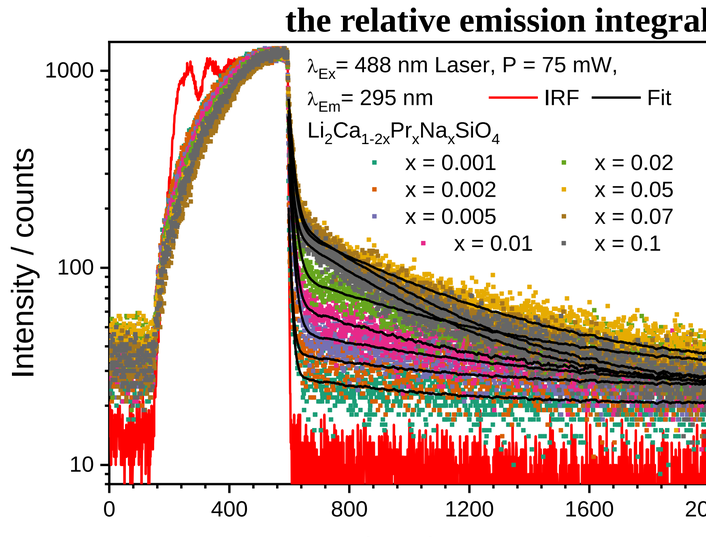



**Fig. 6: Up-conversion emission of the different solid solutions with different $Pr^{3+}$ concentrations (left) and the relative emission integral of the measurements (right)**




| $Pr^{3+}$ concentration [%] | $\tau_1$ [ns] | $\tau_2$ [ns] | $\tau_1$:$\tau_2$ |
|---|---|---|---|
| 0.1 | 8.49 | 436.64 | 95:5 |
| 0.2 | 8.39 | 522.80 | 93:7 |
| 0.5 | 13.14 | 750.82 | 86:14 |
| 1 | 14.52 | 575.01 | 86:14 |
| 2 | 15.57 | 557.91 | 82:18 |
| 5 | 15.57 | 460.59 | 74:26 |
| 7 | 15.02 | 365.05 | 73:27 |
| 10 | 12.74 | 361.58 | 71:29 |

**Fig. 7: Time dependent measurements of the $[Xe]4f^15d^1 \rightarrow {}^3H_4$ transition excited via up-conversion. As well as the corresponding decay times evaluated by reconvocation**

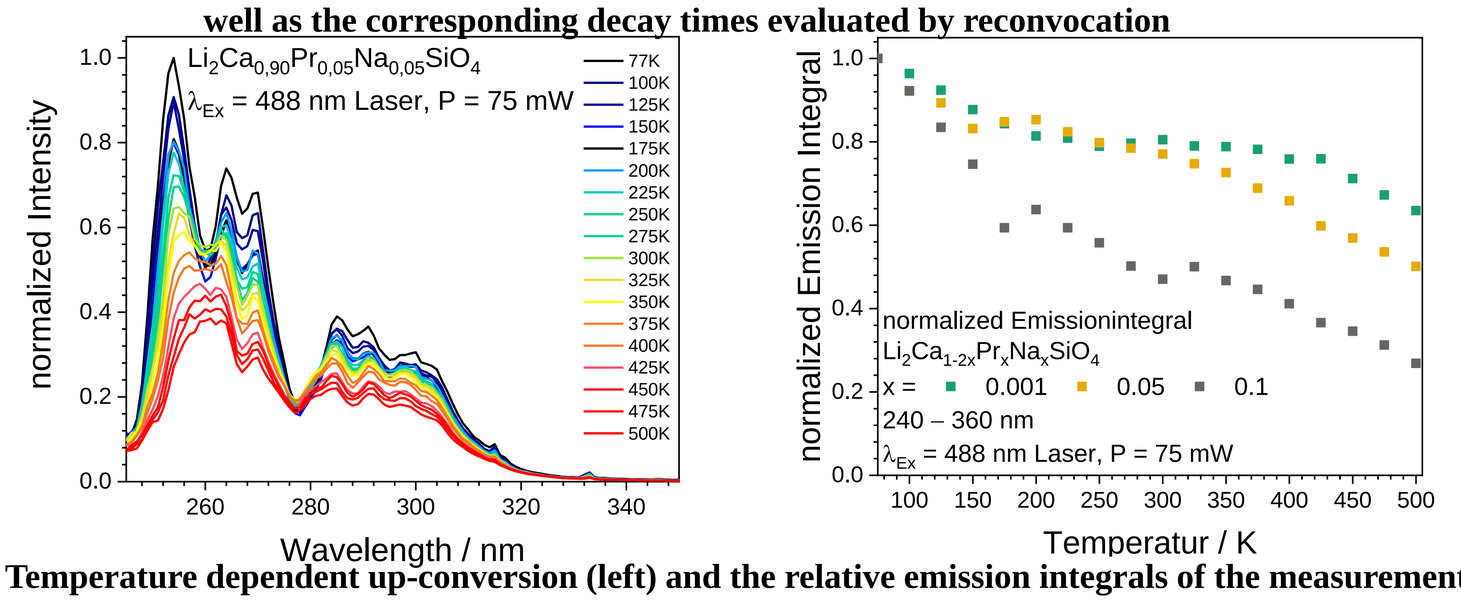



**Fig. 8: Temperature dependent up-conversion (left) and the relative emission integrals of the measurement for the compounds $LiCa_{1-2x}SiO_4:Pr_xNa_x$ with x = 0.001, 0,05 and 0.1 (right)**

## Conclusions

Optical spectroscopy demonstrates that the concentration quenching of the up-conversion occurs at higher concentration compared to the down-conversion luminescence.
The decay curves of the transition from the $[Xe]4f^15d^1$ band show a bimodal behavior, with a long component that increases with increasing concentration. The determined decay times agree with the emission integral of the up-conversion emission.

Temperature dependent measurements show almost no difference in thermal quenching between the samples where 0.1% and 5% $Pr^{3+}$, $Na^+$ were substituted, the compound with a concentration of 10% $Pr^{3+}$, $Na^+$ however quenches slightly stronger in comparison.

## References


## Acknowledgement

The authors are grateful to Evonik Operations GmbH, Essen, Germany for financial support and to research group „Tailored Optical Materials“.



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