

Synthesis and Optical Characterisation of Pr³⁺ Doped UV Emitting Luminescent Ceramics

Julian Plewa, Thomas Jüstel

University of Applied Sciences Münster, Stegerwaldstraße 39, 48565 Steinfurt, Germany

UV emitting luminescent materials are of strong interest for UV emitting fluorescent lamps driven by a Hg low-pressure or a by Xe excimer discharge. Pr³⁺ doped host lattices exhibit efficient UV emission upon deep UV excitation, if the site of the host lattice, where Pr³⁺ is located, is suitable for this purpose.

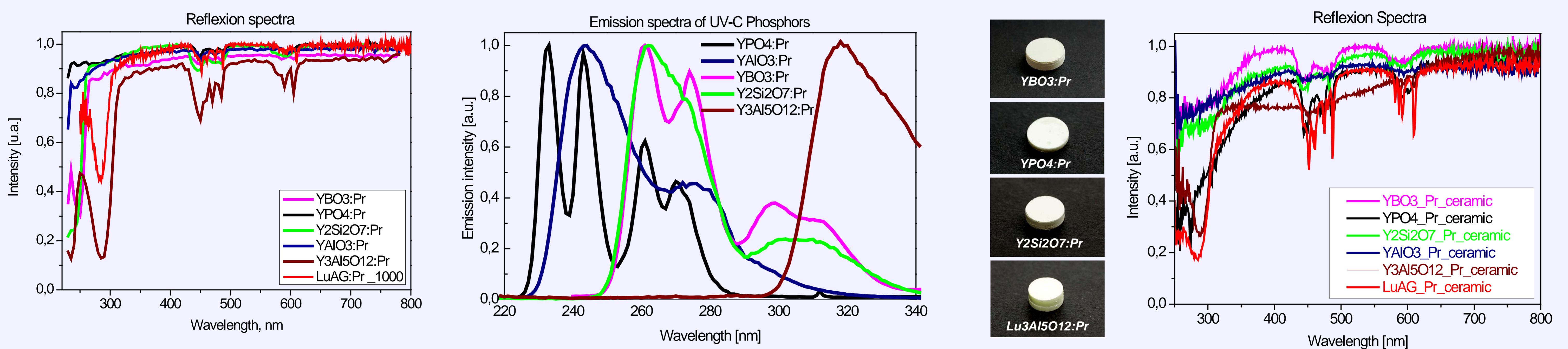
Rare earth doped yttrium comprising compounds found many application areas, e.g. as scintillators, as crystals for solid state LASER, and as visible or UV emitting luminescent powders for fluorescent lamps. Pr³⁺ activated luminescent materials show UV, visible or IR emission, which is a sensitive function of the crystal field strength and covalent character of the environment of the lattice position, where Pr³⁺ is located.

This work deals with Pr³⁺ activated VUV ceramic luminophores, i.e. materials, which show efficient luminescence upon 160 nm excitation. As host lattices for the potentially UV emitting Pr³⁺ ion aluminates and silicates have been studied.

All samples were prepared by conventional mix and fire synthesis techniques with metal oxides as starting materials. Firstly, powder samples were annealed between 1000 and 1700°C and secondly, ceramic samples were repeatedly thermally treated at similar temperatures after pressing.

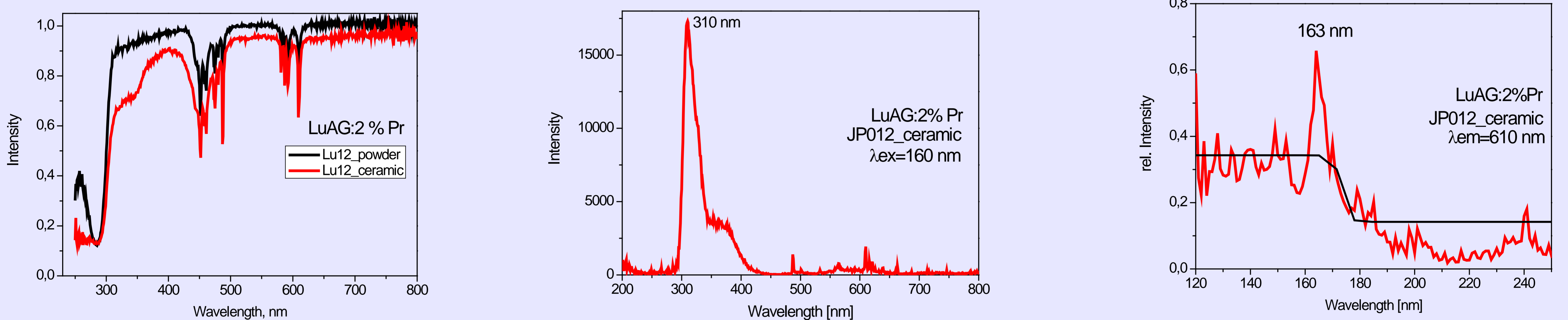
We have demonstrated that translucent ceramics show mainly UV luminescence upon deep UV excitation, while excitation by a blue 450 nm LED results in green to red luminescence with a similar decay time as observed for single crystals.

Reflexion and Luminescence Spectroscopy of the Yttrium compounds doped with Pr³⁺



Reflection and Emission spectra of YBO₃, YPO₄, Y₂Si₂O₇, YAlO₃, Y₃Al₅O₁₂ and Lu₃Al₅O₁₂ doped by 2% Pr³⁺ (upon 160 nm excitation).

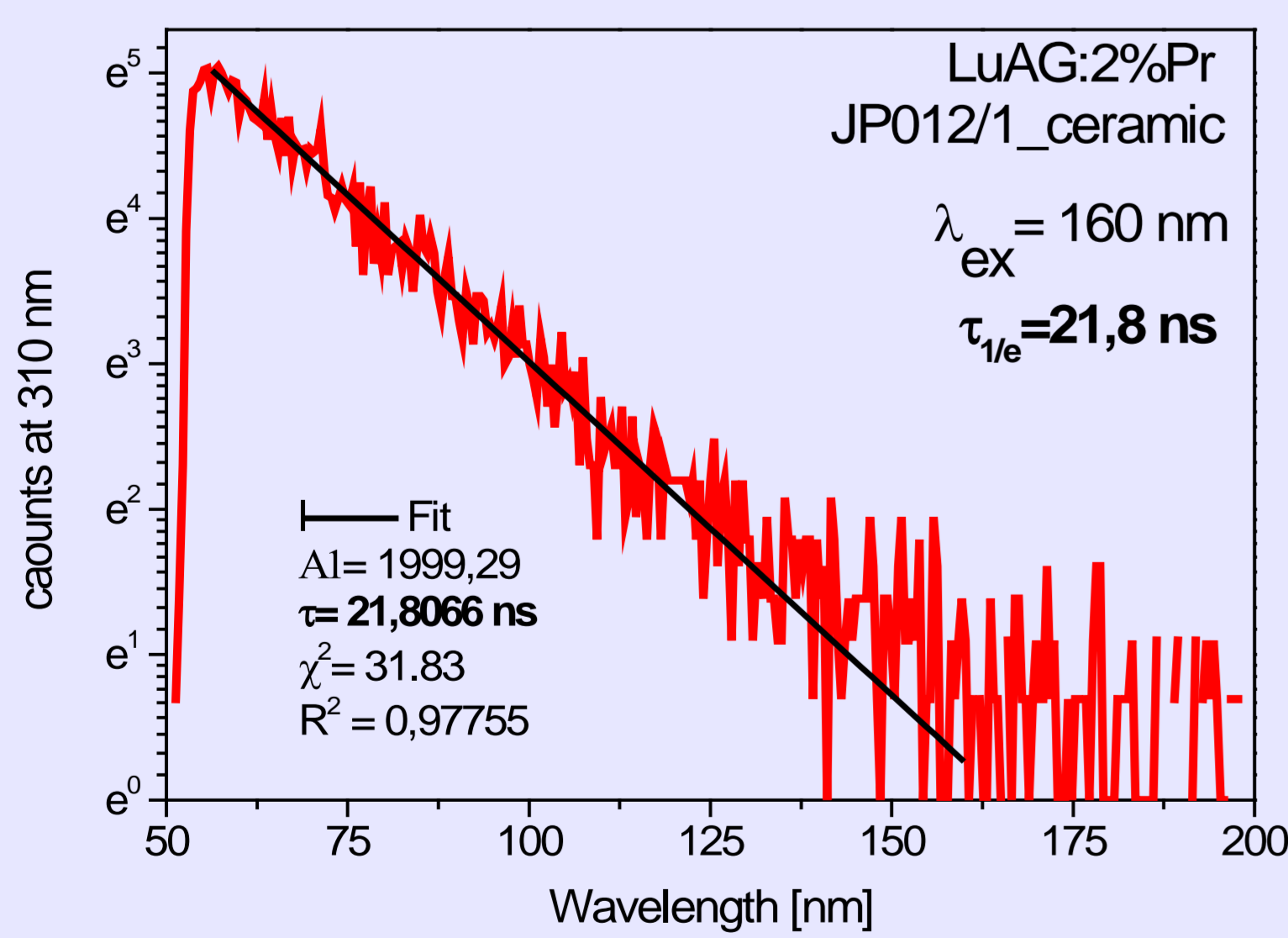
Reflexion, Luminescence and Excitation Spectroscopy of Lutetium Garnet ceramic LuAG:Pr³⁺



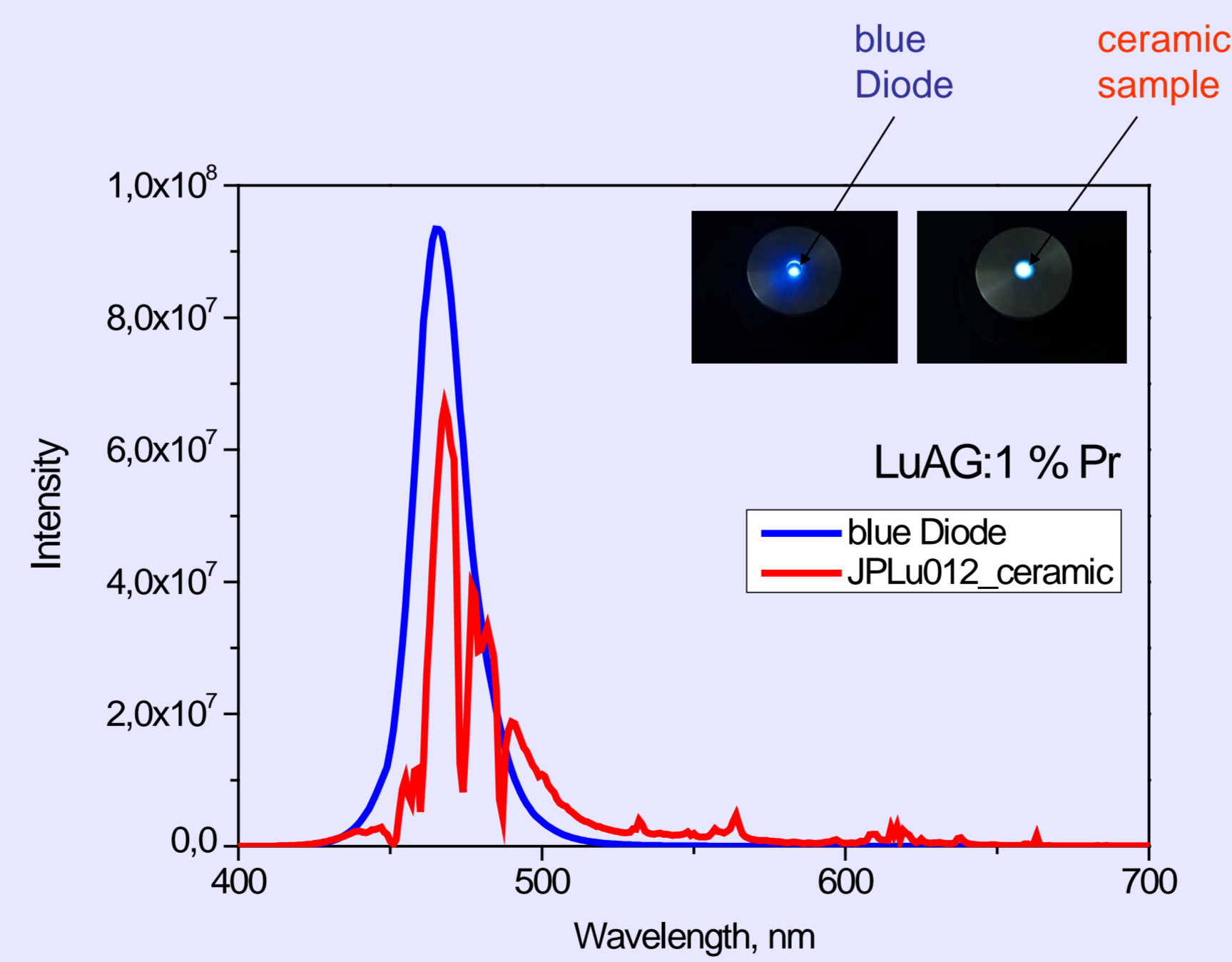
The reflection spectra show absorption bands in the UV range due to the interconfigurational [Xe]4f² to [Xe]4f¹5d¹ transitions, which energetic position is dependent on the host.

Emission spectrum for 160 nm excitation of a LuAG:Pr³⁺ ceramic

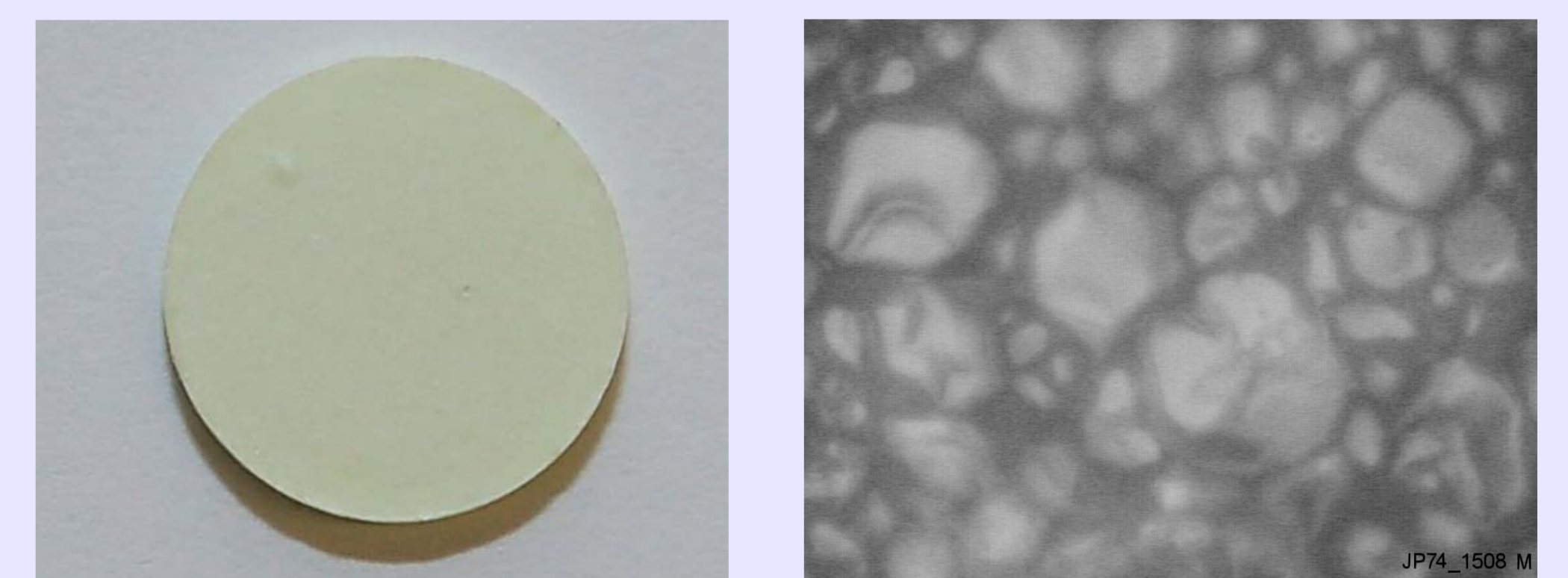
Excitation spectrum monitored at 610 nm of a LuAG:Pr³⁺ ceramic



Decay curves upon 160 nm excitation.



Emission spectra in transmission of LuAG:Pr³⁺ ceramics



Photographs of samples subsequently annealed at 1650°C in air for 48 h with a MgSiO₃ flux (1000x) (thickness of the tablets ~ 1.2 mm).

Conclusions

The observed five transitions between the [Xe]4f¹5d¹ configuration and the levels ³H₄, ³H₅, ³H₆, ³F₂ and ³F₃ of the [Xe]4f² configuration of Pr³⁺ are located in the UV-C or UV-B range. The spectral position of the observed bands is governed by the energetic position of the lowest crystal field component of the [Xe]4f¹5d¹ configuration and thus shifts to lower energy by increasing the crystal field strength.

In host lattices with a very strong crystal field, e.g. YAG:Pr³⁺, the [Xe]4f¹5d-4f² transitions are located in the UV-A range. Consequently, transitions from the ³P₀ levels to the ³H_J and ³F_J states of Pr³⁺ are also present and become dominant by further increasing the crystal field strength

LuAG:Pr³⁺ ceramic show mainly UV luminescence upon deep UV excitation, while excitation by a blue 450 nm LED results in green to red luminescence. The decay time of our LuAG:Pr³⁺ ceramics upon 160 nm excitation is 22 ns, which is perfectly in line with the decay time of LuAG:Pr³⁺ single crystals.