Crystal Growth of Differently Doped Mixed Oxides Compounds of Perovskite, Garnet and Olivine Structures

The crystals of $YAlO_3$ (YAP) $Y_3Al_5O_{12}$ (YAG) and $LiMgPO_4$ (LMP) differently doped with rare-earth (RE) elements were investigated within this work. The crystals were grown from the melt using micro pulling-down method at the Research Laboratory on Advanced Crystal Engineering, Yoshikawa Laboratory, Tohoku University, Sendai, Japan. Luminescence and energy–storage properties of the obtained crystals were studied at the Institute of Nuclear Physics Polish Academy of Sciences, Krakow, Poland using different spectroscopic methods.

The RE-doped LMP compound is nowadays considered as very promising dosimetric material, as its luminescent properties are comparable or in a few aspects even better as compared to LiF or Al_2O_3.

In turn, the RE-doped YAP and YAG are rather known as fast and efficient scintillators and thus the investigation of the energy-storage properties of such materials remains rarely seen. Therefore, within this work, we want to indicate that the RE-doped YAP perovskite can be also applied as very promising energy-storage phosphor for dosimetric applications. This topic is also very actual nowadays because the evidence of energy-storage by mixed oxides compounds of perovskite and garnet structures was recently reported by our research group from Krakow. Moreover, the infra-red stimulated luminescence (IRSL) emission in Ce^{3+} doped YAP, YAG and $Lu_3Al_5O_{12}$ (LuAG) crystals was also investigated [1-3].

The investigated crystals were grown from the melt by the micro pulling-down (MPD) method. The detailed description of this method can be found in our previously published papers [1-3]. The luminescence properties were investigated by different spectroscopic techniques, such as Thermoluminescence (TL(T)), TL(λ) spectral measurements, the Infra-red-light stimulated luminescence (IRSL) and Cathodoluminescence (CL).

For TL measurements the semiautomatic Risø reader model TL/OSL-DA-20 has been utilized. The reader is equipped with $^{90}Sr/^{90}Y$ beta source and ^{241}Am alpha particle source that were used for samples irradiations. All samples were read out with the same temperature regime, namely from room temperature (RT) to 400 °C at the constant heating rate of 2 °C/s.

For spectrally resolved TL(λ) measurements, a high-sensitive Ocean Optics QE PRO grating spectrometer was connected to the Risø reader instead of the standard photomultiplier tube. This device allows to record luminescence emission in the range from 200 to 1000 nm with a 4 nm resolution. The signal is delivered from the sample to the spectrometer via optical fiber of a core diameter of 400 µm. Its flat spectral characteristic causes that the measurements can be done without any additional optical filter. Therefore, the measured data are not affected by the spectral characteristics of the applied photomultiplier and optical filters as it is in the case of the measurements performed with the standard reader. On the other hand it should be noted, that sensitivity of the spectrometer is much lower than that of the photomultiplier.

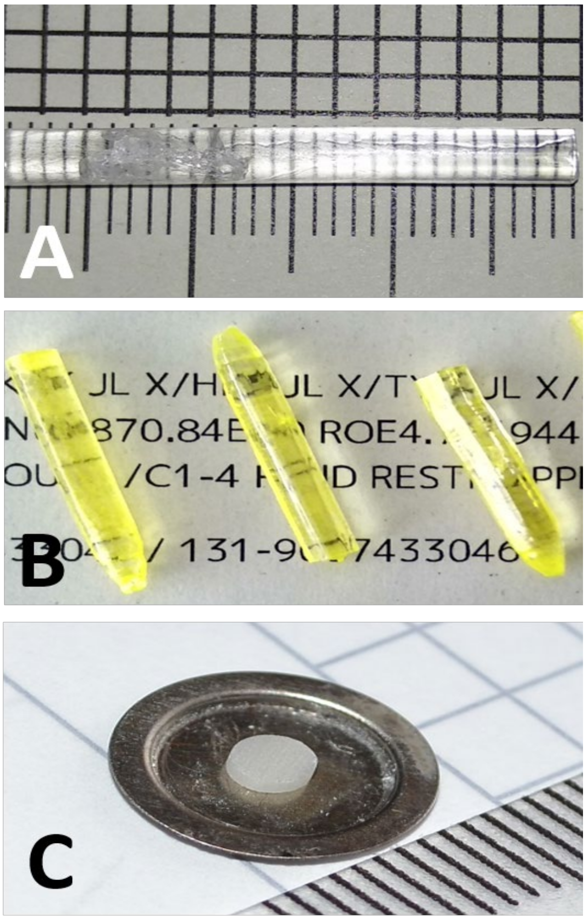

Fig. 1 shows the studied crystals: $YAlO_3$ (panel A), $Y_3Al_5O_{12}$:Ce (panel B) and $LiMgPO_4$:Tb,B (panel C).

CL measurements were done in cooperation with the Institute of Physics Kazimierz Wielki University in Bydgoszcz, Poland. The CL spectra were measured at RT using 10 keV electron beam excitation from electron microscope SEM JEOL coupled with a Stellar Net grating spectrometer with TE-cooled CCD detector working in the 200–1100 nm range with a 1 nm resolution. It should be mentioned that e-beam excited CL and X-ray excited RL well imitate scintillation phenomena in the crystals under study. It is worth noting that 10 keV electrons are unable to produce new host defect centers due to high displacement energy for knock-out mechanisms in binary and complex oxide.

We have also checked the different preheating temperatures before the IRSL measurements to correlate the signals measured using TL and IRSL phenomena for investigated the obtained YAP crystals. The results are shown in Fig. 2 (left). Fig. 2 (right) shows the differences in the IRSL emission intensities for YAG:Ce crystals of different Ce^{3+} concentration.

It was also shown that the IR stimulation mostly affects the low-temperature peak (100-160 ◦C) while the high-temperature peaks remain less affected. Finally, due to highest radio-sensitivity and lowest fading, we concluded that both YAG and YAP crystals seem promising for dosimetric applications.

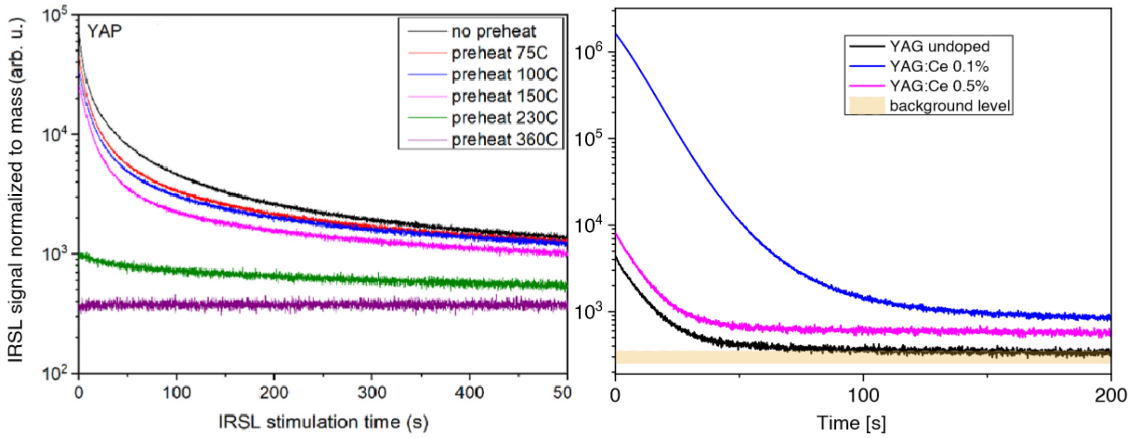

Fig 2. Comparison of the IRSL signals measured for YAP investigated samples (panel left) and YAG investigated samples (panel right)

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