COMPOSITIONAL DESIGN APPROACH FOR pe-LED PRODUCTION BASED ON 3D LEAD-FREE HALIDE DOUBLE PEROVSKITES

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The perovskite structure holds immense potential for intelligent synthesis, enabling the creation of new materials grounded in the fundamental science of crystal chemistry. The tuneable crystal structure and variable chemical composition of perovskites position them as promising candidates for fuel cells, memory devices, and photovoltaic applications. Experimental results show that in this case, the halide double perovskites (HDPs) can transform the bandgap from indirect to direct states and alter the photoluminescence quantum yield (PL QY), which characterizes their photoluminescence properties. More importantly, HDPs can emit efficient white luminescence as self-trapped excitons (STEs), making them suitable as inexpensive white phosphors. The STEs can transfer excitons to dopants like Sb^{3+} or RE^{3+}, further tuning the emission from visible (Vis) to the near-infrared (NIR) region.[1-2]
In our case, we investigated various compositions of HDPs: $Cs_2NaInCl_6$, $Cs_2Na_{0.6}Ag_{0.4}InCl_6$, and $Cs_2AgInCl_6$ doped with Sb^{3+}, Er^{3+}, Ho^{3+}, and Yb^{3+}. The samples were obtained by using solid-state, hydrothermal, and precipitation techniques. Additionally, HDPs with the general formula $Cs_2NaRECl_6$ (RE – La, Ce, Pr, Nd, Eu, Tb, Ho, Er, Tm, Yb) were synthesized. The X-ray diffraction and Raman spectroscopy were used to analyse the crystal structures and vibrational characteristics of the samples. The compositions of the samples were checked using the energy-dispersive X-ray spectroscopy (EDS) method, and some X-ray photoelectron spectra (XPS) spectra were measured. The luminescent properties in the range of 250-1600 nm were investigated for the first time, revealing significant potential for advanced applications. Upconversion was also fixed in the investigated samples, which makes them suitable candidates for the transformation of the sunlight from the NIR region to the Vis region.
Some prototypes of the LED, based on the UV chip (320 nm) and synthesized HDPs powder samples as the luminophore material, were prepared. The emission spectra were measured under 4.4-5.0 V bias voltage, and the prepared LED emitted blue, green and white light (depending on the HDP composition). It was possible to obtain efficient, stable multimodal emission in Sb^{3+}/RE^{3+}-codoped HDP samples using down-conversion to cover the Vis-NIR spectral range. The LED prototypes were stable and showed similar characteristics after six months.

Acknowledgements**:** *This research is part of the project No. 2022/47/P/ST5/01816 within the POLONEZ BIS programme co-funded by the National Science Centre and the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No. 945339.*

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