

Metal-halide perovskites are recently a hot topic in the field of optoelectronics. This new class of materials has made a spectacular career especially in photovoltaics, showing an unprecedented growth of photon conversion efficiency, from 12 % to 25 % within only a decade of development. Besides competitive efficiency, these materials offer easy and inexpensive fabrication methods, allowing also possibility of designing flexible devices. However, limited stability of these compounds for long hampered the performance of perovskite optoelectronics, preventing it from unveiling the full potential. One of such problems is the phenomenon of phase segregation, a process occurring in compounds which are halide mixtures under external stimuli (light or electric field), which causes material de-mixing and formation of monohalide domains, efficiently capturing photocreated carriers from the entire film. These inclusions are characterized by reduced value of critical parameter – the bandgap, which results in reduced voltage and energy losses. In photovoltaic race for efficiency every percent counts, therefore, a great research effort has been undertaken to significantly reduce phase-segregation phenomena. This has been recently successfully achieved by meticulous tuning of chemical compositions.

Good light harvesters are usually good light emitters – and this is true also for metal halide perovskites. However, the technology of perovskite- based light emission is on much earlier stage of development when compared to photovoltaics. In a nutshell, light-emission devices in operational condition need to deal with larger energy density than light-harvesting counterparts, which, is too much to handle for today's perovskites and associated materials. However, a nightmare for photovoltaics turns out to be a great emitter, as after undergoing phase segregation, perovskite films emit up to 15 times more light. This emission occurs through low- bandgap domains, which forming only near illuminated area and constituting less than 2% of the total volume of perovskite film, are responsible for more than 90% of the overall light emission. If such an effect could be used in a device, certain level of performance could be maintained with reduction of emission-driving stimuli, which would improve the lifetime of devices.

The aim of this project is to overthrow a paradigm of “always-parasitic” role of phase segregation phenomenon in perovskites, exploiting it now to improve the performance of perovskite light sources. We will thoroughly investigate the phenomenon, especially for the emission in visible, green spectral range, important for everyday applications. We will explore which chemical and processing methods can be used for better control over phase segregation process and its long-term stabilization without stimuli, in order to bring it closer to real-life applications. We will also manufacture devices - lasers in which only low-bandgap domains will be used as the emitters. We expect that high concentration of carriers within the phase-segregated area would contribute to lowering the lasing threshold, which could lead to longer lifetime and operational stability of the devices. Thus, the phenomenon previously associated with energy losses in solar cells will gain a new life as a potential way to commercialize perovskite light sources.