Light-Soaking, Photo-Damage and Self-Healing in Halide Perovskites

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Light-soaking, photo-damage and self-healing are intriguing phenomena widely reported in halide perovskites. Yet, their origin is still not understood even if they strongly influence the stability of the material. We discussed recently which could be the chemical origin of various phenomena connected to these effects revealing how the stability of the interstitial Br defects (associated with photodamage) in $MAPbBr_3$, $FAPbBr_3$, $CsPbBr_3$ is inversely related to the kinetic of self-healing of photodamage after intense illumination. In this talk, I will extend the description of the effects of intense illumination to $MAPbI_3$ showing how this material can also self-heal from photodamage with kinetics in the order of (several) minutes. I will reveal the presence of multiple (chemical) pathways activated by intense illumination some of which cause an increase of the photoluminescence (light-soaking) and some of which decreasing it (photodamage). All of these are, at least partially, reversible and proceed from what can be called the “high entropy” of the halide perovskites. I will also show how water, even in conditions that do not cause the degradation of the material, strongly influences all the mentioned processes actually “protecting” $MAPbI_3$ from photodamage but also substantially impeding light-soaking. This causes the measurements performed over a short time in an inert atmosphere to provide better results because of transient light-soaking effects which, eventually, disappear over time in both humid and inert atmospheres.

The talk will conclude with a panoramic over the literature trying to identify any other critical experimental condition inducing variations on the photodamage, light-soaking, kinetics and extent of self-healing. I will relate these to an overall evaluation of the stability of the perovskites and identifying all the possible, alternative, chemical equilibria in which the perovskite can exist with their equilibrium-dependent set of properties (i.e. defect density). I will also show how the ability to self-heal is a unique characteristic of the perovskites with the potential to maintain their elevated photoconversion efficiency for long times possibly beyond the limits of other more well-known photovoltaic materials.