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Perovskite solar cells characterization using synchrotron light-based techniques

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The effects of global warming have evidenced the need for developing environmentally friendly energy sources such as solar cells. Among the new photovoltaic technologies, perovskite solar cells (PSCs) have received attention due to their high-power conversion efficiency close to silicon solar cells (25.7 vs 26.1%), low cost of preparation, and versatile properties. In hybrid organic-inorganic perovskites (HOIP), used in solar cells, site A is occupied by a monovalent cation, such as methylammonium ($CH_3NH_3^+$, MA), formamidinium ($CH(NH_2)_2$, FA), or cesium (Cs^+), B site is occupied by a divalent metal, such as lead (Pb^{2+}) or tin (Sn^{2+}), and X is a halide anion, bromide (Br^-) or iodide (I^-). Besides the high performance achieved, many aspects need to be better understood, such as the crystallization and nanoscale heterogeneities. In this context, synchrotron-based techniques are great tools for deeper investigations. Perovskite formation is a complex process that depends on the composition and solvents. *In situ* grazing incidence wide-angle X-ray scattering (GIWAXS) during spin coating reveals the formation of different intermediates that impacts directly on properties and consequently on device performance.[1,2] The incomplete conversion of the intermediates to perovskite leads to the formation of heterogeneities in perovskite films. The nano-FTIR technique was used to map and identify these heterogeneities in different perovskite compositions.[3] Besides that, simultaneous XRD and X-ray excited optical luminescence (XEOL) characterization reveals the complexity of the effects of the light and X-ray on optoelectronic properties of perovskites under dry and humid atmospheres. In addition, the first result obtained from the new synchrotron light source, Sirius, at the Carnaúba beamline will be presented. The beam dose is a critical parameter for perovskite characterization and causes ion migration depending on the experimental conditions. The X-ray beam also affects the structural and optoelectronic properties, which becomes a challenge during

the experiments. The perspectives for in situ and operando characterization of perovskite solar cells will also be discussed.

Keywords: Perovskite solar cells, synchrotron radiation, in situ GIWAXS, nano-FTIR

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References

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