Conference

High Efficiency Lead-Free Perovskite Solar cells for indoor-outdoor Applications.

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n 2009 Kojima et al.,[1] reported the first hybrid organometal halide perovskites as visible-light sensitizers for photovoltaic cells. They studied the photovoltaic function of the organic-inorganic lead halide perovskite compounds methylammonium ($CH_3NH_3^+$, MA) $PbBr_3$ and $MAPbI_3$ as visible-light sensitizers in photoelectrochemical cells, opening a fruitful worldwide field of research. Halide perovskites, generally are represented as AMX_3, where A is an alkyl ammonium cation, such as MA, dimethyl-ammonium ($(CH_3)_2NH^+$, DMA), formamidinium ($CH_3(NH_2)_2+$, FA), or Cs; M is Pb_2^+, and X is a halide ion (I^-, Br^-, Cl^-).

Although the efficiency of hybrid perovskite solar cells is today competitive with Si, achieving power conversion efficiencies exceeding 23%,[2] some drawbacks regarding these systems are the environmental toxicity of water-soluble Pb, and their air/humidity stability. In order to solve these disadvantages a fervent research is currently going on, and in 2016, materials with complete replacement of lead in the perovskite structure, by other cations such as nontoxic Ag+ and Bi3+ , leading to the double perovskite $Cs_2AgBiBr_3(Cl_6)$ structure,[3,4] were synthesized. Amazingly, very soon, in 2019, these new perovskites exhibited increasing power conversion efficiencies up to 2.5%.[5–7]

This work aims to present the HELFO (High Efficiency Lead-Free Perovskite Solar cells for indoor-outdoor Applications) project and the preliminary results on fully-inorganic lead-free $Cs_2AgBiBr_6(Cl_6)$ double-cations perovskites. HELFO is a challenging interdisciplinary project, which involves three Institutions of CNR from both fundamental condensed matter (CNR-ISM-Roma) and applied physics (CNR-IMM-Lecce) fields up to plant biology (CNR-ISPA-Lecce) field, aiming to combine different competences intrinsically belonging to CNR. Semitransparent lead-free $Cs_2AgBiBr_6$ and $Cs_2AgBiCl_6$ perovskites are synthesized by using both in-situ ultra-high vacuum molecular beam epitaxy deposition and ex-situ solution-processing, and investigated by XRD, SEM/AES/PL and UV-Visible optical techniques. Furthermore, these materials will be applied in green-houses for investigating, indoor-and-outdoor, the influence of solar light radiation shielding, through the $Cs_2AgBiBr_6(Cl_6)$ perovskites, on seed germination and plant metabolic profiles at a molecular level of *Artemisia annua* and *Solanum lycopersicum* plant species. Photovoltaic devices will be assembled by matching the $Cs_2AgBiBr_6(Cl_6)$ perovskites-based band alignment, with both electron- and hole-transporting layers.

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