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

In 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 (CH3NH3+, MA) PbBr3 and MAPbI3 as visible-light sensitizers in photoelectrochemical cells, opening a fruitful worldwide field of research. Halide perovskites, generally are represented as AMX3, where A is an alkyl ammonium cation, such as MA, dimethyl-ammonium ((CH3)2NH+, DMA), formamidinium (CH3(NH2)2 +, FA), or Cs; M is Pb2+, 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 Cs2AgBiBr3 (Cl6) 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 Cs2AgBiBr6 (Cl6) 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 Cs2AgBiBr6 and Cs2AgBiCl6 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 Cs2AgBiBr6(Cl6) 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 Cs2AgBiBr6(Cl6) perovskites-based band alignment, with both electron- and hole-transporting layers.

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[1] A. Kojima et al., Organometal Halide Perovskites as Visible-Light Sensitizers for Photovoltaic Cells, J. AM. CHEM. SOC. **2009**, 131, 6050–6051.
[2] D. Zhao et al., Four-Terminal All Perovskite Tandem Solar Cells Achieving Power Conversion Efficiencies Exceeding 23% ACS Energy Lett., **2018**, 3, 305–206.
[3] E. T. McClure, et al., Cs2AgBiX6 (X = Br, Cl): New Visible Light Absorbing, Lead-Free Halide Perovskite Semiconductors, Chem. Mater, **2016**, 28, 1348–1354.
[4] A. H. Slavney, et al., Bismuth-Halide Double Perovskite with Long Carrier Recombination Lifetime for Photovoltaic Applications, J. Am. Chem. Soc. **2016**,1 38, 2138–2141.
[5] M. R. Filip, et al., Band Gaps of the Lead-Free Halide Double Perovskites Cs2BiAgCl6 and Cs2BiAgBr6 from Theory and Experiment. J . Phys.Chem. Lett., **2016**, 7, 2579–2585.
[6] F. Igbari et al., Composition Stoichiometry of Cs2AgBiBr6 Films for Highly Efficient Lead-Free Perovskite Solar Cells, Nano Lett. **2019**, 19, 2066–2073.
[7] E. Greul et al., Highly Stable, Phase Pure Cs2AgBiBr Double Perovskite Thin Films for Optoelectronic Applications. J. Mater. Chem. A, **2017**, 5, 19972–19981.

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