This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under grant agreement No 101035813

Boron doped Zinc Oxide thin film as ETL alternative candidate in Perovskite single-junction solar cell

Fiorella Tringali[1,2,3], Lorenzo Sirna[3], Virginie Brizé[3], Noëlla Lemaitre[3], Malek Benmansour[3], Giuseppe Bengasi[4], Diego Di Girolamo[4], Giuliana Giuliano[4], Marina Foti[4], Antonio Terrasi[1,2]

[1] Dipartimento di Fisica, Università di Catania, via S. Sofia 64, 95123, Catania, Italy. [2] IMM-CNR, Sede Catania-Università, via S. Sofia 64, 95123 Catania, Italy. [3] Univ. Grenoble Alpes, CEA, LITEN, Campus INES, 73375 Le Bourget du Lac, France. [4] 3SUN s.r.l., Contrada Blocco Torrazze, 95121 Catania, Italy.

The development of innovative and better-performing materials that fulfil device's requirements and overcome limiting factors is crucial to improve the performance of future solar cells. Therefore, our research aims to contribute on reducing the recombination rate of photo-generated carriers by investigating C60/BZO (Fullerene/Boron doped Zinc Oxide) as innovative Electron Transport Layer (ETL) combination on the back side of single junction p-i-n perovskite solar cells. Optimal ETL material should combine a low minority carrier recombination rate with low resistivity and high optical reflectance, which is essential to ensure efficient light trapping and absorption. To pursue these requirements, an in-depth examination of the properties and characterization of low-concentration Boron doped Zinc Oxide thin films, deposited via Magnetron Sputtering, was carried out. Sputtering deposition is a widely employed technique in microelectronics and photovoltaics industries, due to its versatility and higher throughput as compared to thermal evaporation. Moreover, this technique allows for depositions under highly controlled conditions, enabling the reproducible growth of films with optimal purity, good quality and strong adhesion to substrates. BZO (2 at.% of Boron) was deposited by RF, DC and Pulsed DC magnetron sputtering, using a 4-inches BZO target (99.99% purity), using different sputtering powers (150W, 200W) and a range of Argon working pressures (from 5.0·10-3 mbar to 9.0·10-3 mbar). Additionally, more sets of samples were deposited in either Ar-O2 or Ar-H2 atmospheres. XRD analyses revealed a polycrystalline structure in all the deposited samples. Further results showed that samples deposited at lower sputtering power (i.e. 150W) and high working pressure (9.0·10-3 mbar) exhibit low absorbance and high optical reflectance. Conversely, the high-power (i.e. 200W) and low-pressure (5.0·10-3 mbar) deposited samples demonstrated more prominent electrical properties but poorer optical performances. These results could be attributed to differences in the growth kinetics within the sputtering chamber, i.e. different mean free path of sputtered atoms in relation with the working pressure, yielding films with different structure. Given the promising properties of BZO deposited by sputtering, a new single-junction perovskite solar cell was designed, incorporating C60 combined with a ~30 nm BZO thin film as ETL, replacing the standard C60/BCP (Bathocuproine) employed in the analogue reference cell. Despite BZO not being a conventional material for this application, several tests showed optimal results, indicating a Power Conversion Efficiency (PCE) of ~10% and Voc of ~1000 mV– results that are comparable with the performance of the established reference cells. These preliminary findings are both innovative and encouraging, suggesting that C60/BZO could be a viable alternative as ETL in single-junction perovskite solar cells.