Achieving Stable and High Performance Perovskite Solar Cells using High-Working-Pressure Sputtered ZnO Electron-Transporting Layer

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The photovoltaic community has witnessed a rapid development of perovskite solar cells (PSCs) in recent years, owing to their high power conversion efficiency. ZnO as the electron transporting layer (ETL) in PSCs has been investigated by many researchers as an alternative to most widely used TiO_2. This is because ZnO has a unique feature of being printable onto flexible substrates, due low sintering temperature. Also, ZnO has electron mobilities one order of magnitude higher than those of TiO_2. However, ZnO in PSCs has not been the preferred over TiO_2 as it leads to a faster degradation of perovskite layer. It was found that residual chemicals, ZnO interstitials, and the basicity of ZnO contribute to a fast degradation of the perovskite layer. Recently, sputtering ZnO has been reported to serve as a solution, and demonstrated facile and stable PSCs. Contrary to the general perception, ZnO sputtering does not impose a substantial increase on the fabrication cost, because the step is a continuation of the indium tin oxide (ITO) electrode, which is also sputtered. Furthermore, stabilizing ligands, which exacerbate the degradation of the perovskite layer, are not present in sputtered metal oxides. However, sputtered ZnO still contains interstitial defects at its surface, which leads to the formation of hydroxyl groups and trigger the degradation of the perovskite layer.

One year ago, we reported ZnO film with higher conductivity and crystallinity in organic solar cells by controlling the working pressure of ZnO sputtering.[1] High working pressure (HWP) condition during the sputtering reduced the energy of high-energy particles, resulting in ZnO films with more balanced Zn to O stoichiometry. In this work, we used the HWP-ZnO films in PSCs and demonstrated not only the record high efficiency (17.0%) among the reported ZnO ETL-based PSCs, but also showed improved stability compared with the conventionally sputtered ZnO-based PSCs. Various analyses were conducted to demonstrate less defects and less hydroxyl groups on HWP-ZnO.

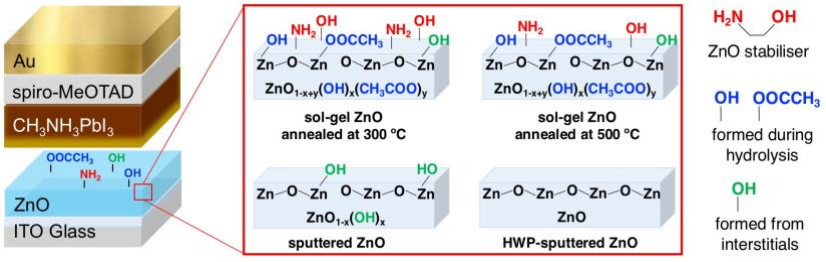

Figure 1. Illustration of four different ZnO ETLs and their contribution to the PSC degradation.

[1] I. Jeon, et al., *J. Mater. Chem. A*, 2016, **4**, 18763-18768