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$MAPbI_3$ Perovskite Solar Cells Employing Flexible n-Type Graphene Transparent Conducting Electrodes

Metal halide-based organic-inorganic hybrid perovskite solar cells (PSCs) have been actively studied in recent years due to the rapid increase in their efficiency [1]. Integrating graphene into PSCs has especially attracted much attention because graphene provides promising flexibilities in device designs due to its excellent structural, electrical, and optical properties [2]. In addition, graphene is very useful as a flexible transparent conductive electrode (TCE) that can replace brittle transparent conductive oxides (TCOs) such as indium tin oxide and F-doped tin oxide [3]. Despite successful application of graphene TCEs for PSCs [4], no use of n-type graphene as a TCE has been reported until now. However, most of the active scaffolds are based on n-type metal-oxide electron transfer layers such as TiO_2, Al_2O_3, and ZnO because they play an important role in achieving high efficiency in PSCs. Therefore, studies on n-type graphene TCEs are very important for PSCs. Here, we fabricate *n-i-p*-type $MAPbI_3$ PSCs by employing Ag nanowires (Ag NWs)-doped graphene with high transmittance (T) and low sheet resistance (R_s) as an n-type graphene TCE. With increasing the doping concentration (n_A) to 0.3 wt%, the R_s monotonically decreases to ~ 52 Ω/sq whilst the T decreases by about 10%. Due to the n_A-dependent trade-off correlation between the R_s and T, the ratio of DC conductivity/optical conductivity is the highest (~ 62) at n_A = 0.1 wt%, resulting in 15.80 and 13.45% power conversion efficiencies for the PSCs on rigid and flexible substrates, respectively.

References

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Figures

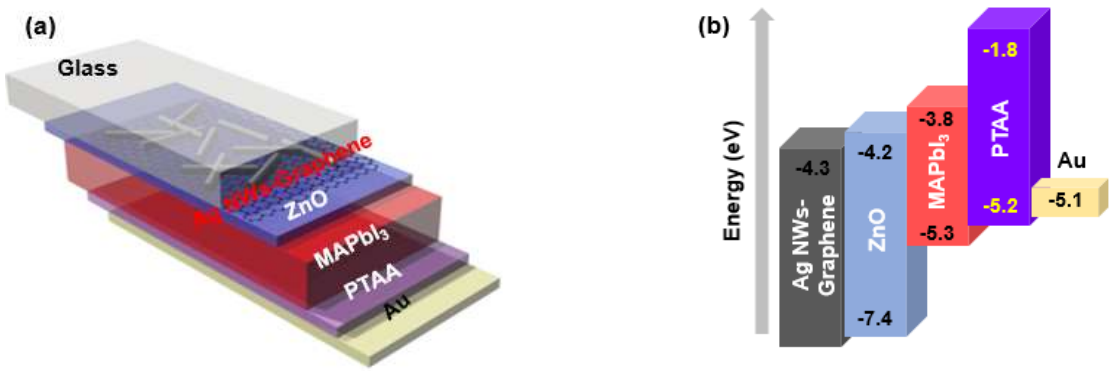

Figure 1: (a) A schematic of a typical TCO-free *n-i-p*-type planar PSC with a structure of glass/Ag NWs-doped graphene/ZnO/$MAPbI_3$/poly[bis(4-phenyl)(2,4,6-trimethylphenyl)amine] (PTAA)/Au and (b) its band diagram.