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Multilayer graphene/conducting polymer/Si nanowires/Si/TiO_x hybrid solar cells

Over the past decade, many researchers have focused on organic materials/Si hybrid solar cells (HSCs) to reduce the production cost of Si-based solar cells [1,2], but several problems such as big reflective index of Si, low aperture ratio of the mesa-type metal transparent conductive electrodes (TCEs), and large recombination loss at Si rear contact should be solved for the practical applications. Especially, poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS), a conducting polymer, is not only a antireflective layer for HSCs but also a hole transporting/optical window that serves as a passivation layer [3]. As one approach for further increase of the power conversion efficiency (PCE), it is necessary to find a method of enhancing the light absorption of Si, for example, by lowering the refractive index. Si-based nanostructures such as Si nanowires (NWs) and porous Si are useful for reducing the reflectivity, resulting in higher light absorption than bulk Si [4]. Here, we report a HSC structure of multi-layer graphene (MLG) TCE/ PEDOT:PSS/Si NWs/n-Si/TiO_x (back surface passivation layer) to cope with aforementioned problems. Resulting maximum PCE is 12.10 %, much larger than that of the planar-Si-type HSC (10.11 %) as a control sample, mainly due to the lowered reflectance (increased absorption) and recombination loss. As the active area increases from 14 to 50 mm^2, the PCE decreases by only 2.5 % from 12.10 to 9.60 %, possibly resulting from the area-dependent change in the uniformity of the Si NWs. The PCE shows only a 10% decrease for 30 days under 25 °C temperature and 40% humidity.

References

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Figures

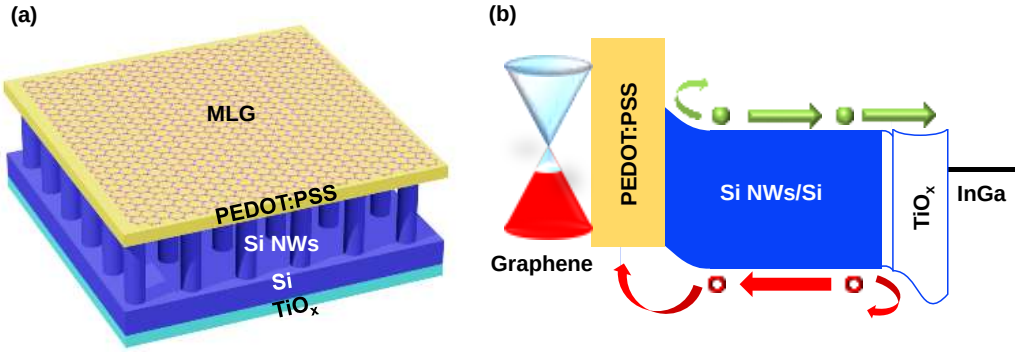

Figure 1: (a) Schematic and (b) energy band diagram of a typical MLG/PEDOT:PSS/Si NWs/n-Si/TiO_x HSC.