Invited

Semiconductor nanowires for energy harvesting and conversion

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Despite the fact that solar radiation accounts for most of the available renewable energy, only a small portion of it is currently being harnessed, mostly due to the production and installation costs of commercial photovoltaic (PV) devices. Emerging PV devices based on solution-processable conjugated polymers offer opportunities for the production of low-cost solar cells. To obtain high efficiencies of exciton dissociation and high photocurrent, it is desirable to have an interpenetrating network of electron-donor and electron-acceptor components within the device, referred to as a bulk heterojunction (BHJ). However, current limitations of the all-organic PV devices are inefficient hopping charge transport through the discontinuous percolation pathways in the BHJ films, and therefore modest power conversion efficiencies or non-competitive cost.

We have developed an alternative type of nanowire-based solar cells that are based on organic/inorganic hybrid device structures and demonstrated two distinct hybrid BHJ architectures with enhanced power conversion efficiencies. Furthermore, we have developed a simple method to grow high-quality ZnO nanowires on graphene via the hydrothermal method. Our method is enabled by an interfacial modification that preserves the structural and electrical properties of both the nanowires and the graphene. Based on the graphene/ZnO nanowire structure, we have demonstrated graphene cathode-based hybrid solar cells by using two different solution-processed photoactive materials – PbS quantum dots (QDs) and poly(3-hexylthiophene) (P3HT) conjugated polymers – and ZnO nanowires as hole and electron transport layers, respectively.We have also identified several critical parameters to further boost the device efficiency and enable scalable, cost-efficient production, and these will be discussed.