Enhancement of power conversion efficiency along with reduction in cell and installation cost are necessary for photovoltaic (PV) devices to achieve significant market penetration. We report on the use of highly aligned and nanostructure of dot black heterojunction (DBH) PV devices as emerging solar cells, which benefit from high absorptivity of organic-semiconductor quantum dot and high mobility of crystalline inorganic material. Also, their fabrication is compatible with low-cost solution-based fabrication techniques, which reduces the overall cost of the PV device significantly. However, their low efficiency (below 1%) has limited their applications. One of the reasons, which is responsible for lowering power conversion efficiency in these types of solar cells, is inorganic material’s density (e.g. highly dense ZnO nanowires grown using low temperature solution-based method). The pitch between inorganic nanostructure must be controlled to have high exciton dissociation and charge collection efficiency. This work investigates two strategies for controlling the density of hydrothermally grown ZnO nanowires: (1) Block copolymer patterning, which separates nanowires in the order of organic materials exciton diffusion length (~40 nm) and (2) electron-beam lithography, which provides the ability to further increase the pitch between wires and to optimize their interdistance according to quantum dot minority carrier diffusion length (~300 nm). Through a systematic study, we have demonstrated that block copolymers can effectively mask the hydrothermally grown ZnO nanowires nucleation and eventually reduce the density of the wires. Also, we were able to show a general approach, regardless of the substrate, to grow separated and well-aligned ZnO nanowires using a beam lithography. The pitch between wires was controlled from 100 nm to 1 μm. Furthermore, we were able to fabricate a quantum dot BHJ PV device based on the nanowires with optimum pitch.

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