Bilayered Solar Cells with >1% Power Conversion Efficiency Arising from Carbon Nanotube Excitons

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Semiconducting single-walled carbon nanotubes (s-SWCNTs) are promising photoabsorbers for photovoltaics due to their strong optical absorptivity (> 10^5 cm^{-1}), tunable bandgaps (0.8-1.4 eV), ultrafast charge transport (> 10^4 cm^2 V^{-1} s^{-1}), stability, and solution processability. Previously, we have shown that electrons can be extracted from photogenerated excitons in s-SWCNTS by pairing them with electron acceptors such as C_{60}, with internal quantum efficiency (QE) > 85%. Here, we demonstrate bilayered s-SWCNT/C_{60} heterojunction devices with >1.0% AM1.5G power conversion efficiency, in which the photoresponse is primarily derived from the s-SWCNT photoabsorption, for the first time. We have achieved high performance by optimizing the electronic-type purity of the s-SWCNTs, implementing highly monochiral (7, 5) s-SWCNTs, and tailoring the device stack in order to optimize the exciton collection efficiency and tune the spectral response. External QE > 35% and > 20% are achieved at the E_{11} bandgap of the s-SWCNTs at 1055 nm and the E_{22} transition at 655 nm. More than 50% of the AM1.5G photoresponse is derived from the s-SWCNTs, substantially exceeding previous s-SWCNT hybrid devices in which the photoresponse has mostly originated from the organic phase. This work, in conjunction with future work on tailoring the morphology of s-SWCNTs and blending them directly with acceptors, has the potential to make semiconducting carbon nanotube-based solar cells a viable means for photovoltaic energy conversion