Charge transport in hybrid OPV with group III nitride nanostructured cathode

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Hybrid bulk heterojunction solar cell has been demonstrated using with poly (3-hexylthiophene) (P3HT) doped with Phenyl-C71-butyric acid methyl ester (PCBM) fullerene derivative as an active layer with gallium nitride (GaN) nanowires as the electron selective layer. Nanostructured GaN cathodes were synthesized by plasma-assisted molecular beam epitaxy (PA-MBE) and is electrically integrated with silicon substrate. Fabricated by common spin-coating method, devices with P3HT:PC71BM/GaN/Si layer sequence were compared with analogous planar structures i.e., without nano-morphology, and show increased light sensitivity with significant enhancement of photovoltaic parameters. Short circuit current density increase of three orders of magnitude was demonstrated, while open circuit voltage increased more than three times.

Photovoltaic behavior of devices assembled on GaN/Si layers synthesized in various morphologies differs significantly. After cathode morphology optimization, maximal open circuit voltage and short circuit current enhancement were achieved on cathodes with nanowire length equal to 150 nm with active volume fraction occupied by nanowires equal 0.4. Analysis of dark volt-ampere characteristics and Mott-Schottky measurement results indicate the formation of space charge region. Built-in voltage was found to be equal 0.45 V. Impedance spectroscopy results give lifetime of electrons in the range of 1-10 msec and mobility equal 2⋅10-3-5⋅10-2 cm-2Vs.