GaN/polymer nanostructures for hybrid photovoltaic applications

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In this work we present results on fabrication and characterization of novel hybrid solar cells with popular π-conjugated polymer poly(3-hexylthiophene-2,5-diyl) (P3HT) acting as electron donor and self-assembled n-type GaN nanowires as acceptor. Controlled morphology of GaN acceptor leads to creation of organized bulk heterojunction between P3HT and GaN with potentially improved charge collection ability. Si-doped nanowires are used for the purpose of enhancing carrier transport between electrodes of the photovoltaic structure due to superior electrical properties of GaN compared to organic acceptor materials. Methanofullerene derivative (PCBM) is used as intermediate agent helping in charge carrier transfer between P3HT and GaN.

Self-assembled GaN nanowires were grown using Plasma-Assisted Molecular Beam Epitaxy (PAMBE) technique. Bottom contact (solar cell cathode) to GaN nanowires was provided either through n-type Si (111) substrate or through nucleation layer which is an amorphous material of metallic electrical conductivity deposited on silicon substrate. P3HT/PCBM solution was put on the array of nanowires by spin-coating resulting in a layer of p-type polymer with embedded n-type nanowires. Semi-transparent metal layers deposited on top of active layer were used as anode.

Electric and photoelectric measurements show that the optimal length of NW is about 300 nm. Photocurrent spectroscopy measurements were made in the range 1–4 eV (see Fig. 1.) on structures with different thickness of polimer layers and different doping of GaN. The results show that structure exhibits photogenerated current maxima at 1.9 eV and 3.4 eV incident light energies which correspond to bandgap edge of P3HT and GaN respectively. The observed direction of photocurrent confirms that P3HT acts as a donor and GaN as an acceptor in this heterostructure. As shown in Fig. 1, when P3HT layer is too thin, light excites also Si/GaN junction generating opposite photocurrent. Solar cell performance was studied under AM1.5 simulated solar radiation and results are discussed.

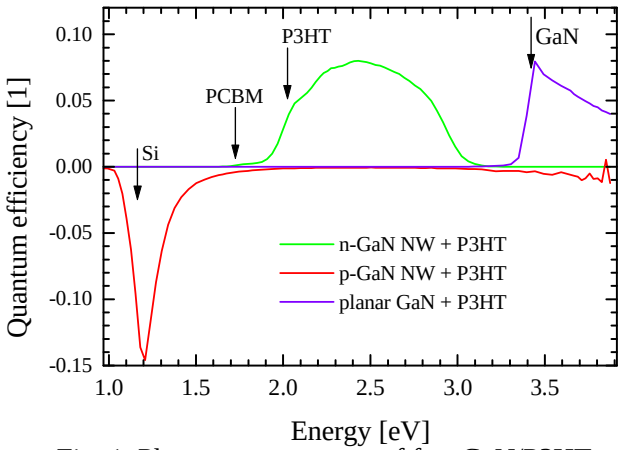

Fig. 1. Photocurrent spectra of few GaN/P3HT samples.

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