Use of doped-graphene transparentconductive electrodes for optoelectronic devices

Suk-Ho Choi [1]

[1]*Kyung Hee University, Korea, Republic of*

Even asmall increase in efficiency could significantly lower the operating costs oflight-emitting diodes (LEDs) or solar cells in their multibillion-dollarmarket. We first employ graphene (GR) transparent conductiveelectrodes (TCEs) for Si quantum dots (SQDs)-based solar cells, showing amaximum power conversion efficiency (PCE) of 16.6%, much larger than ever achievedin SQDs solar cells with metal TCEs as well as in bulk-Si solar cells with GRTCEs. The GR TCEs are doped with several kinds of materials such as $AuCl_3$,Ag nanowires, and bis(trifluoromethane sulfonyl)–amide (TFSA) for efficientcollection of the carriers photo-induced in SQDs. The encapsulation of thedoped-GR TCE with another GR layer prevents the doping elements from beingdesorbed, thereby making the PCE higher, its doping dependence more evident,and the long-term performance more stable. In the similar device structure, thephotoresponse is remarkably enhanced in the near-ultraviolet range compared tocommercially-available bulk-Si photodetectors (PDs). Especially, the stabilityof the solar cells and PDs are greatly improved with the use of TFSA-doped GR TCEs.We also report that the plasmon-induced lightcoupling amplifies emitted light by ~2.5 times in doped-GR. This coupling behavior alsoappears in GaN-based LEDs. With $AuCl_3$-doped GR on Ga-doped ZnO filmsthat is used as TCEs for the LEDs, the average electroluminescence intensity is1.2 ~ 1.7 times enhanced depending on the injection current. The chemicaldoping of GR may produce the inhomogeneityin charge densities (i.e., electron/hole puddles) or roughness, which can playa role as grating couplers, resulting in such strong plasmon-enhanced lightamplification.