Use of Graphene in Photovoltaics

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Graphene, with its outstanding properties such as high electrical conductivity, carrier mobility, and optical transparency, has been an attractive material to be integrated in solar cells for various applications. As a 2D material, graphene matches the current focus in research on developing highly efficient, low-cost thin-film solar cells. One application for graphene in solar cells is its role as an emitter in graphene/Si Schottky barrier solar cells, where it collects the photogenerated holes and transports them to the top electrode. Our work focused on enhancing the performance of this type of solar cell by improving the interface between graphene and Si through the addition of interfacial layers. Al2O3, and HfO2 layers were grown with optimized thickness on the n-type Si substrate using the atomic layer deposition (ALD) technique before transferring the graphene layer to form the junction. Adding Al2O3, and HfO2 layers increased the power conversion efficiency from 7.2% to 8.7% and from 3.9% to 9.1%, respectively. The main reason for this improvement is the increase in Schottky barrier height after adding the interfacial layer, which facilitated the hole transport to graphene and helped reflecting the generated electrons back to the Si, reducing the carrier recombination. At the same time, these interfacial layers has passivated the Si, limiting the native oxide growth that can reduce the hole tunnelling, resulting in hole accumulation and recombination at the interface. Graphene has also been an interesting material to test in the third-generation solar cells like the organic solar cells (OSCs), where it can be applied as a transparent conductive electrode and as a dopant for different layers of the cells, due to its unique properties. Our work focused on investigating doping the PEDOT:PSS layer with graphene. PEDOT:PSS is a conductive polymer commonly used as a hole transport layer in OSCs due to its high work function of 5.0–5.2 eV, which is preferred for hole extraction. It also has high mechanical flexibility and transparency, allowing more light to reach the absorber layer in the p–i–n OSCs. Although PEDOT:PSS is conductive, its performance can still be enhanced through doping with Graphene due to its high conductivity and transparency, which can retain the transparency of the PEDOT:PSS.