Highly Conductive and Environmentally Stable Organic Transparent Electrodes Laminated with Graphene

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Abstract

Highly conductive and transparent electrodes based on conjugated-conducting polymers have been commercially utilized in various organic optoelectronic applications such as organic light-emitting diodes, thin-film solar cells and energy storage systems. However, organic compounds are soft and fragile and can easily degrade when exposed to unfavorable environmental agents such as moisture, ultraviolet light, and high mechanical and thermal stress. In this light, improving the lifetime and the operational and thermal stability of organic thin-film materials while maintaining high conductivity and mechanical flexibility is critical for organic electronics applications. Here, we report that highly conductive and environmentally stable organic transparent electrodes (TEs) can be fabricated by mechanically laminating poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) films containing dimethylsulfoxide and Zonyl fluorosurfactant (PDZ films) with a monolayer graphene barrier. The proposed lamination process allows graphene to be coated onto the PDZ films uniformly and conformally with tight interfacial binding, free of wrinkles and air gaps. The laminated films exhibit an outstanding room-temperature hole mobility of ~ 85.1 $cm^2\ V^{-1}\ s^{-1}$ since the graphene can serve as an effective bypass for charge carriers. The significantly improved stability of the graphene-laminated TEs against unfavorable environmental agents is particularly promising. Furthermore, the incorporation of the graphene barrier increases the expected lifetime of the TEs by more than two orders of magnitude.