

Flexible/ ITO-free organic optoelectronic devices based on versatile multilayer electrodes

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Abstract:

Transparent electrodes (TE), which are essential elements in displays and solar cells, have so far relied heavily on transparent conductive oxides (TCO) such as indium tin oxide (ITO) or indium zinc oxide (IZO). While these technologies are currently fulfilling requirements for many kinds of applications, some futuristic applications such as flexible electronics demand the additional properties that are difficult to realize using today's TCO technologies. In addition, organic photovoltaic (OPV) cells, which are targeting inexpensive solar technologies, should find a low-cost alternative to ITO electrodes with a comparable performance. Another thing to note is that use of TE technologies in many demanding applications such as organic light emitting diodes (OLEDs) and transparent thin-film transistors (TTFTs) often require an Ohmic injection to transporting or emissive layers. In such case, the capability of tuning the effective injection barriers would be very important in order to have a larger degree of freedom in choosing active materials and device structures.

Here we present the results of our work on hybrid multilayer TEs based on an ultrathin metal layer combined with additional dielectric or semiconducting layers. With a careful selection of dielectric/ semiconductor materials and metal layers and engineering of their structure, ideal balance can be achieved between optical transparency and cell electrical properties such as carrier injection and collection. OLED cells with the optimized multilayer electrode structure not only show the device performance comparable to ITO or ITO/PEDOT:PSS-based reference cells but also exhibits an excellent flexibility that is far superior to that of ITO electrodes. Systematic study on the optical/ electrical properties and bending-induced degradation is presented from the perspectives of flexible OLED displays. We also present such multilayer electrode can be used in OPV applications to result in OPV devices with desirable characteristics such as high fill factor. Effect of using inexpensive metals in multilayer structure as well as its optimization is explored both theoretically and experimentally in an effort to realize ultra-low cost solar cells.