PhD Thesis Defense NADIA FORMICA 'Mechanically Flexible Transparent Conductors based on Ultrathin Metallic Layers'

NADIA FORMICA

May 18, 2015

Monday, May 18, 11:30. ICFO Auditorium

NADIA FORMICA

Optoelectronics

ICFO-The Institute of Photonic Sciences

Transparent Conductors (TCs) are essential components in many applications, such as light emitting diodes, solar cells, rigid and tactile displays and smart windows, since theyallow efficient light transmission while electric signals are applied or collected. To date, Indium doped Tin Oxide (ITO) exhibits the best trade-off between high optical transparency and low electrical resistance, making it the first choice as TC for the most optoelectronics applications. However, ITO has several important drawbacks such as high cost, p000r mechanical flexibilityand incompatibility with organic compounds, all of which prevent its use in future flexible and cost-effective high-performance devices. A potential alternative avoiding these restrictions are Ultrathin Metal Films (UTMFs), thanks to hteir large mechanical flexibility, the possibility of low temperature-processing, and their low cost. Thier low potential durability under oxidizing and corrosive conditions maybe a majorn concern for several applications. In this Thesis, various combinations of UTMFs have been investigated and optimized, to demostrate that they can serve as an effective alternative to conventional ITO. MOst importantly, several designs and methods have been developed for improving the stability of UTMFs, while at the same time still maintaining high optical and electrical characteristics. Aiming at flexible devices, the newly developed TC structures have also been deposited on flexible substrates, namely Polyetheylene therephtalate (PET) and the recently developed Corning Willow ultrathin glass, and their high transparency, electrical conductivity, and stability have been demonstrated. Furthermore, to obtain improved UTMFs, the proposed UTMFs have been combined with several indium-free transparent conductive oxides, e.g. Aluminum doped Zinc Oxide (AZO). Also, two different approaches have been proposed to improve the stability of UTMFs and AZO layers at high temperature and in harsh ambient conditions. In first approach, an ultrathin oxidized Ti layer was found to greatly enhance the stabilityof AZO film without affecting the electro-optical properties. In a second approach, it was demonstrated that a single sheet of Graphene works as protection layer against degradation both for AZO and UTMFs. The search of proper barrier layers for TCs against oxygen and water vapor was thus addressed without compromising the mechanical flexibility, demonstrating the superioir mechanical strenght of UTMFs unlike the ITO. Finally, the Thesis demonstrates potential for technological applications by incorporating UTMF based TCs in organic solar cells with efficiencies comparable to those with state-of-the-art ITO. The research and results of the thesis open new routes for low cost and large scale manufacturing of flexible optoelectronic devices.

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