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ITO Free Flexible OLEDs

[1]D.Shanmuga sundar, [2]A.Sivanantharaja
[1,2] Alagappa Chettiar College of Engineering and Technology, Karaikudi, Tamilnadu, India.

ABSTRACT

Due to the demand in data communication and hazardous nature of existing wireless communication paves a path for the existence of Visible Light Communication (VLC). Flat panel displays and wall mounted displays are mainly used as the source for the VLC. For efficient communication in VLC, efficiency of the source also plays a major role. However use of Indium Tin Oxide (ITO) based flexible devices results in reduced efficiency due to the refractive index mismatch between the ITO and flexible substrate. In this review, the recent progress (modification) in the anode layer for OLEDs is discussed and also the best suitable candidate for the same is also reported.

Keywords: *Polymers, Flexible substrate, Organic Light Emitting Diode (OLED), Polymer Anode, Refractive index.*

1. INTRODUCTION

Organic light-emitting devices (OLED) have attracted researchers due to its delightful advantages such as ultra-thin thickness, light weight, and environment protective nature which insist to use them in flat panel displays and interior lighting source [1]. OLEDs also plays a major role as a transmitter in the field of Visible light communication, a recent trend in the field of communication in which the information is transferred by use of visible lights [2]. In order to achieve the efficient data communication in the field of VLC, flexible panel OLED displays with high efficiency are identified as a perfect candidate [3].

The simple structure of flexible OLEDs consists of flexible substrate, anode, emitting layer and the cathode. The anode layer is in contact with the flexible substrate which also plays a major role in the efficiency of the device. Because of the transparency and moderate electrical conductivity, ITOs are preferred to be a best anode for glass substrate [4, 5]. However being a best anode in glass, ITO fails to perform a same role in the flexible substrate due to large refractive index mismatch between the anode and the plastic substrate and brittleness nature [6, 7].

Also the efficiency of the device increases after the surface annealing of ITO at high temperature which is impossible in plastic based OLEDs. It is also reported that use of ITO as anode, the various species from it will enter it the organic layers which will degrade the performance of the device [8, 9].

In this review, best replacement candidate for the ITO in flexible substrate opto-electronic devices is discussed and also the properties to be considered for the best anode to overcome the challenges in the flexible displays are also reported.

2. METAL ANODES

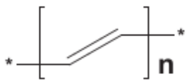
Due to high processing temperature, brittleness nature and refractive index mismatch of ITO in plastic substrate make researchers to start finding a best alternative for ITO. *Scott et al.* had reported that the gold is a good anode for the replacement of ITO [10] and that motivates to have a continuous interest in the alternate findings [11, 12, 13]. Table-1 shows the electrical properties of Au and ITO.

Table-I: Electrical Properties of Au anode and ITO

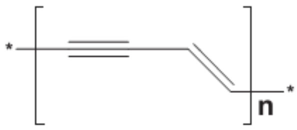
Film	Sheet Resistance (Ω)	Thickness (nm)	Resistivity (Ω cm)
Au	2.7	20	$5.4x10^{-6}$
ITO	16	120	$1.9x10^{-4}$

Sijin Han et al. extended the use of gold (Au) with fullerene as anode (Au/C60) and reported the device performance had increased twice that of Au based device. Also reported that the device's current efficiency is about 4.6cd/A, which is approximately five times higher than the Au-anode based device [14]. Furthermore it is also concluded that the Au/C_{60} device performance is similar to that of the reported ITO based devices [15]. *Ha et al.* had reported the use of Aluminum-doped zinc oxide (AZO) as anode and the sheet resistance and transparency of AZO are 1.94x10-$^{4}\Omega$cm and 81.47% respectively [ref-81gupta].

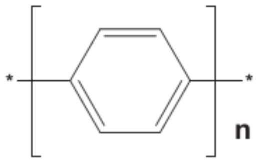
Zinc oxide (ZnO) films with different doping materials such as Zr, Ti and gallium-doped zinc oxide films [16, 17, 18]. Other materials including transparent electrodes such as antimony doped tin oxide films [19, 20] and multi oxide combination as In_2O_3-ZnO films and Cd-In-Sb-O films were also reported [21, 22].



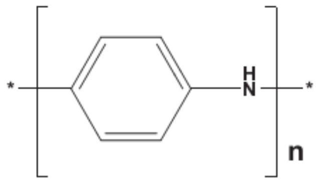
Polyacetylene



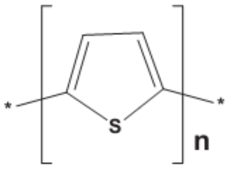
Polydiacetylene



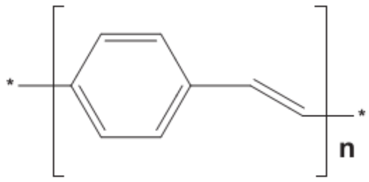
Poly(p-phenylene)



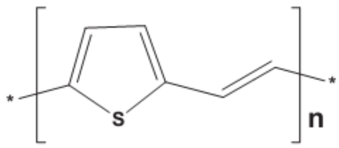
Polyaniline



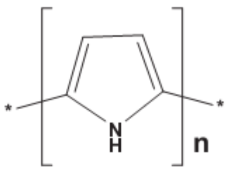
Polythiophene



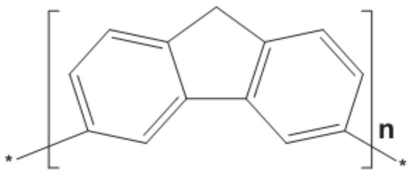
Poly(phenylene vinylene)



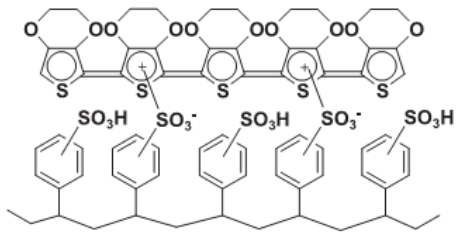
Poly(thiophene vinylene)



Polypyrrole



Polyfluorene



PEDOT/PSS

3. CONDUCTING POLYMER

After the invention of polyacetylene, a conducting polymer by Heeger et al in 1976 had motivated all the researchers in the world to start working on conductive polymers [23]. Their research extended to discover the polymers such as polyacetylene, polyaniline, polypyrrol, polyphenylene, poly(p-phenylene viny-lene), and polythiophene due to its low cost processing and stable conducting state.

Among these polyaniline and polypropol have been commercialized for its applications such as for corrosion protection, antistatic materials and fiber sensors and Polyphenylene and poly(p-phenylene vinylene) have been used as an emitting material for OLEDs. Polythiophene, more specifically poly(3,4-ethylenedioxythiophene) (PEDOT), has preferred a best candidate for the replacement of ITO due to its high conductivity of about 300S/cm, which is also transparent, high stability in the oxidized state [24,25]. But the use of PEDOT is limited due to its water insoluble property which have been overcome by poly(styrene sulfonic acid) PSS to form PEDOT:PSS [electronic properties].

4. CONCLUSION

Flexible displays will be the ultimate choice in the future in the display industry due to its convenience, portability, and large-size applications as well as low-cost production through RTR processes. However there are many challenges are still to overcome for the effective use of flexible substrates. OLEDs requires best configuration of anode, cathode, ETL, HTL and polymers for high efficiencies. Due to the drawbacks of ITO in flexible substrate had motivated us to proceed this review article. In this article, the best candidate for the replacement of ITO had been reported.

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