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A Study on Transparent Electronic Devices

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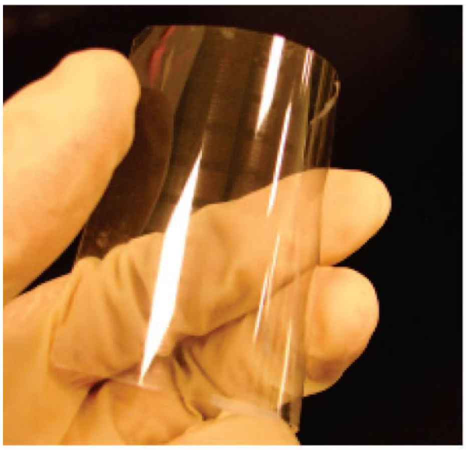
ABSTRACT: Transparent Electronics is a newly emerging area of Semiconductor Technology. It is the next generation of opto-electronic devices and wide-band gap semiconductors, which are generally, used to realize the invisible circuits. The Transparent conducting oxide (TCO) thin films having greater conductivity are highly desirable for optoelectronic devices. Flexibility, Transparency, Light weight, Lower power consumption and operating voltage are the most important characteristics of these opto-electronics devices.

KEYWORDS: Transparent conducting oxides, Optoelectronic devices, Wide-band gap semiconductors, Thin films.

I. Introduction

The basic transparent device structure is based on semiconductor junctions & transistors. However, in the device, the electric contacts and the dielectric layers must now be transparent, which is very difficult to make.



But, in transparent electronic semiconductor technology, the plastic substrate has opened up the possibilities of a wide range of new devices for various applications including sensors, solar cells and even artificial skins also! Such consumer electronic devices will find wide use in biosensors, military applications. However, this technology is facing some manufacturing problems. The direct deposition of transparent electronic material may cause damage to the flexible substrate layer on which they are deposited. Also, it is very difficult to etch the small dimension oxide multilayers of the device during fabrication. This problem in transparent electronics can be solved by using nanofabrication techniques.

II. Literature Survey

Fumiaki N. Ishikawa et al. [1] have been fabricated a fully transparent thin-film transistor on rigid as well as on flexible substrate by using low temperature processing. The low temperature processing allows device fabrication on a flexible substrate. They used nanotubes as a channel and indium-tin-oxide as a drain, source and gate electrodes. Yanfei

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Xu et al. [2] have been produced transparent, conductive grapheme filmsby using spin-coating method. By using this grapheme films they fabricated a bulk heterojunction polymer organic photovoltaic device. As the grapheme solution is used to fabricate grapheme film for electrodes the process becomes cost effective and simple. The films can be used as electrode in polymer OPVs by replacing ITO electrodes. J.F. Wager [3] has reviewed and gave a information about the interface formation theory. This theory is applied to the problem of indium tin oxide (ITO) – zinc oxide and ITO – tin oxide interfaces for source-drain contacts in transparent thin-film transistors. The ideal interface information theory originates from Fermi level mediated charge transfer giving rise to a macroscopic interfacial dipole.

As the battery electrodes are not transparent and have to be thick to store energy they are not suitable for transparent devices. Yuan Yang et al. [4] demonstrated a grid-structured electrode to solve this problem. They fabricated this electrode by using microfluidics-assisted method. The fabricated electrode is below the resolution limit of human eyes, and, thus, the electrode appears transparent.

III. MATERIALS USED IN TRANSPARENT ELECTRONICS

First of all, the transparent conducting oxides are used for the formation of transparent electronic devices as they are both electrically conductive and optically transparent too. And also, because of their wide use in solar cells, touch display panels, flat panel displays, heaters, 'smart windows' and optical coatings. Oxide plays a Key role in formation of transparent electronic devices. Zinc Oxide and Amorphous Oxides are the most widely used transparent materials with heavy metal content, such as amorphous $InGaZnO_4$ (a-IGZO). Both pass visible light and are almost completely transparent.

The conventional *n*-type TCO hosts In_2O_3, SnO_2, CdO and ZnO share similar chemical, structural and electronic properties. To become a transparent conducting oxide (TCO), these TCO hosts must be degenerately doped to displace the Fermi level up into the conduction band. Degenerate doping then provides both (i) the high mobility of extra carriers (electrons) due to their small effective mass and (ii) low optical absorption due to the low-density of states in the conduction band. The high energy dispersion of the conduction band also ensures a pronounced Fermi energy displacement up above the conduction band minimum, the Burstein–Moss (BM) shift. The shift helps to broaden the optical transparency and keeps the intense optical transitions from the valence band out of the visible range. This is critical in oxides like CdO which are not transparent throughout the entire visible spectrum. Recently, scientist had developed new active materials for functional transparent electronics. Transparent conducting ZnO films have been prepared by doping with Group III (Al, Ga, In and B), Group IV (Si, Ge, Ti, Zr and Hf) and a Group VII elements.

In 1997, a transparent *p*-type conducting material CuAlO2 with high mobility in transparent thin film is invented by Kawazoe *et al.* of the Tokyo Institute Technology. Organic Semiconductors also exhibits *p*-type conductivity, but they have several times lower carrier mobility than those of typical inorganic semiconductors.

Presently, the Indium tin oxide (ITO) is used for making of transparent electrodes. But, as the Indium is limitedly available in earth's crust, many of the researchers have been concentrated on a simple solution based way to fabricate a cost effective transparent electrodes. Grapheneis the best suitable material for this. A single-atom-thick sheet of carbon called graphene. It has some amazing properties: like Hardness, flexibility, transparency and also it is highly electrically conductive material which makes it a promising material to make flexible touch screens and super strong structural materials.

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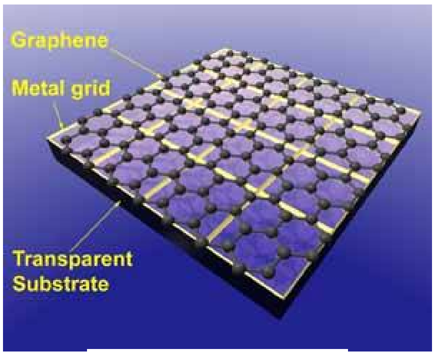

Fig. Graphene Solar cell

Graphene fibers are used for making carbon nanotubes (CNT). The transparent electrode materials are the essential components of Photo voltaic cells (OPV's) that are used for the conversion of solar energy into electricity.

IV. TRANSPARENT ELECTRONIC DEVICES

The Transparent Electronic Devices can be divided in to two basic categories:

i) The field effect transistor (FET) made with thin film technology, offend called thin film transistor (TFT). Also called as transparent thin film transistor (TTFT).

ii) Junction type devices (*p-n* junction and their other types)

The TTFTs are fabricated by all TSO wide band gap materialswhether binary or ternary oxides. The key performances of TTFT are its high device mobility and low-temperature fabrication. The high-device mobility enables fast device operation and low power consumption which broadens the area of TTFTs. On the other hand, the lower temperature fabrication enables novel applications such as wearable display, e-paper, artificial skin etc. It also reduces the fabrication cost of TTFTs.The making of *p-n* Junction devices (and all its variations) of transparent oxides becomes possible now due to recent inventions of *p*-type conducting transparent materials. Several transparent oxide *p-n* junctions are made up till date now.

V. APPLICATIONS & FUTURE SCOPE

The transparent electronic devices and transparent electronic circuits have wide range of applications. Almost every glass setting can be modified in to electronic device; windows could also be used as power generator, automobile windshields, consumer electronics, security systems, in military for real-time wearable displays.

Researchers in Germany have been developed the transparent material that could act as Solar cell. The research scientist Wolfgang Korner (at IWM Fraunhofer Institute for Machine of Materials) said that, "If transparent p-conductors with adequate conductivity could be produced, it would be possible to realize completely transparent electronics". In consumer electronics LCD displays, iPad and smart-phone touch screens, and organic light-emitting diode (OLED) displays for televisions and computer monitors could be fabricated by using transparent electronic devices.

The transparent electronic founds very useful in medical field also. The flexible silicon sensors are put in the body's salty fluid. The researchers build circuits from ultrathin, single crystal Si on a flexible or stretchy substrate like a sheet of plastic. The nanometer thickness of Si layer makes it possible to bend and fold the normally rigid semiconductor.

In future, it may be possible now to replace all the glass windows and shields by the transparent solar cell. Even though by using the advance researches in nanotechnology, it is possible to make paints which acts like a solar cell

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when placed on the wallsthat can convert solar energy into electrical energy & full fill our need of electricity in very effective & economical way. One another emerging application of Flexible display is e-paper which uses pixel array that can be possible to make now by nanowire transistors.

VI. Conclusion

It has been impossible to develop fully transparent circuits up till now due to metal or silicon electrodes and other electronic components but, if the transparent electronic circuits are fabricated on integrated circuit then it will be possible to embed them in to the large area applications.Today's transparent electronic circuits cannot be said as complete electronic product to start with and come in to market but, after when Industries will experienced in using these transparent devices, commercially it might be possible in the future that we could see smart transparent systems working with us.

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