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STUDY ON TRANSPARENT ELECTRONICS FOR REALIZATION OF INVISIBLE CIRCUITS AND ITS APPLICATION

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Abstract : Transparent electronics is an developing science and technology field focused on producing 'invisible' electronic circuits, which its applications include consumer electronics, energy sources and transportation. Transparent Conductive Oxides (TCO's) and Thin Film Transistors (TFT's) are the two technologies involved in the development of transparent electronics. TCO's possess two physical properties- high optical transparency and high electrical conductivity. This specific combination of physical properties can be achieved only if the material has a sufficiently large energy band gap so that it is transparent to visible lights and also possesses high concentration with large mobility then the material can be considered as a good conductor of electricity. In conventional Si/III-V based electronics, the device structures are based on semiconductor junctions and transistors, by using transparent electronics in place of normal electronic components performance of that particular device can be improved.

***IndexTerms* - TCO's, TFT's, Si/III-V.**

I. INTRODUCTION

Transparent electronics are replacing usual semiconductor materials with transparent materials in electronic devices. This is the process of combining optical transparency with electrical conductivity. The materials available for transparent electronics have grown drastically over the years. Two technologies that holds the brand of transparent electronics are TCO's-Transparent Conducting Oxides and TFT's-Thin Film Transistors. Basically -transparent materials act as an insulator and contain empty conduction band. Whereas TCO's are an unusual class of materials containing two physical properties, high optical transparency and high electrical conductivity. The conduction of TCO depends on number of oxygen vacancies (Vo) in the metal. Most commonly used TCO's are SnO2, ZnO and In2O3. In addition, TCO's are applied to transparent optoelectronics because it has unique feature of optically transparent in visible light region.[1][2]

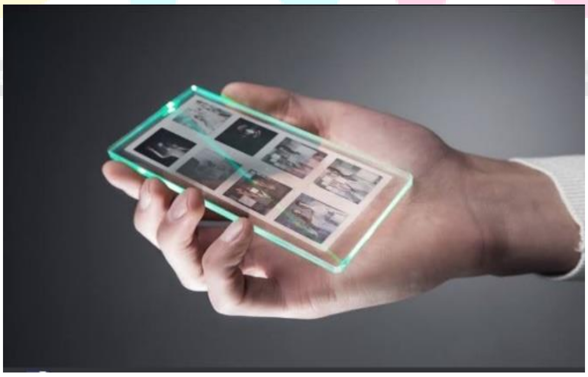

fig1.Transparent Electronics

II. METHODOLOGIES

2.1 Invisible Circuits

The difficulty in producing Invisible circuits is that the semiconducting materials must be transparent to visible light and also have good carrier mobility. These materials require special class of materials having "contra-indicated properties" because the combination of transparency and conductivity is Contradictory [3].

In invisible electronic circuits, we need active components like diodes and transistors, to make them, we need invisible conductors of two different types of charge carrying conductors. Some with the charge carriers as electrons (n-type), and others with holes (p-type). Invisible (n-type) conductors are easy to make when compared to p-type conductors. So, there is only an invisible thin film p-type conductors for real applications.[4]. According to our study we believe that invisible circuits will be applied in optoelectronic applications. Without this invisible circuits the concept of transparent electronics is impossible.

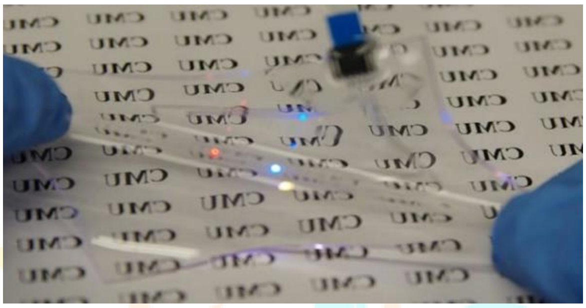

fig 2. Invisible Circuits

2.2 Transparent Conductive Oxides

Transparent conductive oxides (TCO) are doped metal oxides used in transparent and optoelectronic devices for flat displays and photovoltaics. Most of these films are fabricated with polycrystalline or amorphous microstructures. These electrode materials have greater than 80% transmittance of incident light as well as electrical conductivity higher than 10^3 S/cm for efficient carrier transport. Normally these TCO's should have low resistivity and a band gap greater than 3.2eV to avoid absorption of light over most of the solar spectra.[5] Current transparent conducting oxides used in industry are primarily n-type conductors, means their primary conduction is as donors of electrons. This is because electron mobility is typically higher than hole mobility, making it difficult to find shallow acceptors in wide band gap oxides to create a large hole population, this is for n-type whereas suitable transparent p-type conducting oxides are still being under study, though the best of them are still orders of magnitude behind n-type TCO's.

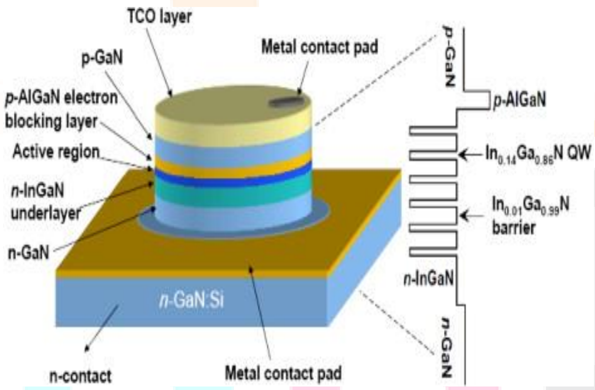

fig 3. Transparent Conductive Oxides

Metal oxides without any intentional impurity doping have also developed for use as TCO's. These are basically n-type with a concentration on the order of 10^20 cm^-3, with interstitial metal ions and oxygen vacancies which both act as donors. But still this type of simple TCO's have not found practical use due to their high dependance on their electrical properties on temperature and oxygen partial pressure.[5]

According to our study, currently labs are looking to observe the electrical and optical characteristics of certain TCO's. These transparent conductive oxides play's a major role in the field of transparent electronics.

2.3 Transparent Thin Film Transistors

The Thin Film Transistor is another technology underlying transparent electronics, it acts as a bridge between passive electrical and active electronic applications. But this does not fully evolve as a transistor. It acts as a special kind of field effect transistor made of thin films of an active semiconductor layer and a dielectric layer and metallic contacts deposited over a supporting substrate. A common substrate is glass, since the primary application of TFT's is in liquid=crystal displays. According to our study in the past few years, the research on transparent thin transistors with channels made from oxide semiconductors has seen some significant progress. [6-12] Devices based on [11] single crystalline materials show high channel mobilities but require either high deposition temperature or some high temperature post growth treatment. Recently an intense search has undergone for new materials and new fabrication techniques that might improve the performance, lower manufacturing cost and also to enable new functionality. All of those materials have something to offer but none is entirely without technical problems, so there are some limitations for thin film transistors.[13]

fig 4. Transparent Thin Film Transistor

III. APPLICATION

3.1 OLED Display

OLED display is a display which works without backlight because it emits visible light. OLED stands for Organic Light Emitting Diode. They are of many type's Transparent OLEDs, Top-emitting OLEDs, Foldable OLEDs, White OLEDs, PMOLEDs and AMOLEDs.

Transparent OLEDs have only transparent components, when the transparent OLED is turned on it allows light to pass in both directions. It can either be active or passive matrix. These transparent OLED lighting panels have more immediate applications like embedded in windows and etc. [14]

fig 5. OLED Display

Top-emitting OLEDs are OLEDs that are best suited for Active-matrix design. They have a substrate that is either opaque or reflective. These OLEDs are used in the manufacture of smart cards. These OLEDs aren't efficient in passive matrix designed displays.[14]

Foldable OLEDs have substrate made of plastics or any other flexible foils. They are very light weighted and durable. GPS receiver, integrated computer chip, and many other devices can be attached or sewn into the foldable OLED display.[14]

Fig 6. Foldable OLEDs

White OLEDs emit white light even brighter that the light emitted by fluorescent lights. According to our study there is a major area of research under the development of white OLED devices for use in solid-state lighting applications. Their use could surely reduce the energy costs for lighting.[14]

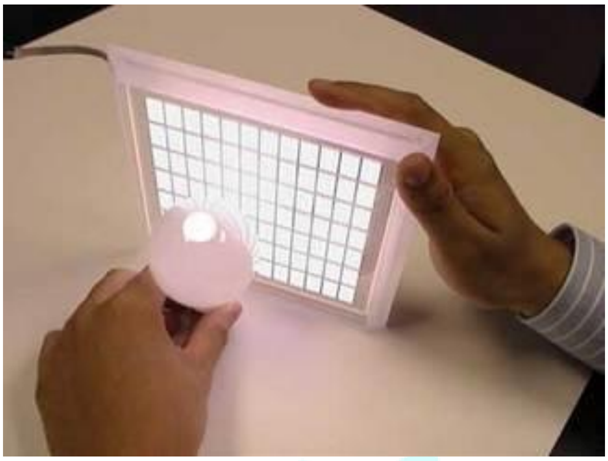

Fig 7. White OLEDs

PMOLEDs stands for passive-matrix OLED. They have strips of cathode, organic layers and strips of anode in which the anode strips are arranged perpendicular to the cathode strips. The intersection of these strips makes the pixels where light is emitted.[14] PMOLEDs are usually small and are used to display character data or small icons. They can also be used in small wearable gadgets and sub displays. PMOLEDs consume very less battery power than the LCDs that currently power the devices nowadays.

fig 8. PMOLED Display

AMOLEDs stands for active-matrix OLED, they have full layers of cathode, anode and organic molecules. But unlike PMOLED the anode layer overlays a thin film transistor (TFT) array that forms a matrix. The TFT array acts as the circuit itself and determines which pixels turns on to form the image.[14] AMOLEDs consumes less power when compared with PMOLEDs because TFT array requires less power than external circuits. AMOLEDs are used in very large displays, with the help of TFT energy can be transferred quickly across a very wide display.

Fig 9. AMOLED Display

3.2 Transparent Solar Panels

The technology that is about to transform the global solar energy concept. Transparent solar panels or photovoltaic glass is also termed as cutting-edge solar panel. These panels can be setup in any sort of buildings or skyscrapers with large windows. These panels can be used in place of our regular windows in offices or homes, if applied this will eventually turn every building in a locality into a solar energy producer.

Solar cells are designed to absorb sunlight and convert them into power. When a solar glass is transparent, the sunlight will pass through the glass and defy the purpose of utilizing sunlight. But this panel completely changes the way of solar cells absorbing light. The cell harnesses a portion of solar spectrum that is invisible to the naked eye, while allowing the visible light to pass through the medium. According to the recent study once the mass production begins these panels should be able to deliver an efficiency of about 10%, meanwhile they're affordable too. Transparent solar panels are of two types based on their transparency, fully transparent solar panel and partially transparent solar panel.

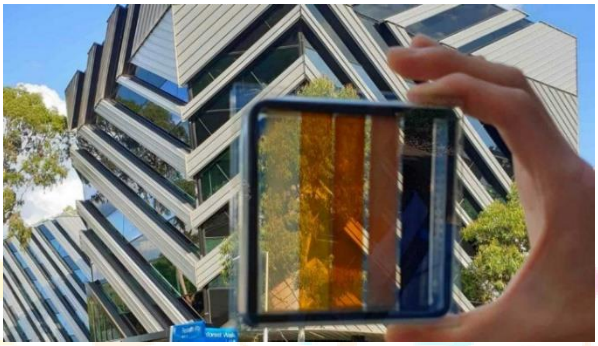

fig 9. Transparent Solar Panel

IV. ADVANTAGES AND DISADVANTAGES

4.1 Advantages

1. Visible transparency.
2. Less temperature effects on devices.
3. Low cost.
4. Passive availability of materials.
5. Stable inorganic materials are used.
6. No toxic materials are used during synthesis.

4.2 Disadvantages

1. High resistance in TCO's.
2. Lack of complementary devices.
3. Low frequency during operation.
4. Technological immaturity

V. CONCLUSION

Started as a mere electrical device technology during World War 2, transparent electronics in the meantime will be the most efficient way of utilizing energy. The concept of combining two properties, optically transparent and electrically conductive is contradictory but when applied those semiconductors gives us lots of advantages such as higher mobility, high performance, less power consumption and many more. Transparent electronics application in solar panels is another developing idea set to replace the existing traditional solar energy consumption and usage. The concept of invisible circuitry plays a major role in the field of transparent electronics, by reasoning the meaning of the word transparent. This technology is very efficient than the existing technology and also the manufacturing process of transparent electronic components are eco-friendly. With this we have studied that this new class of electronics is more advantageous than conventional electronics.

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