Green Electronics & Application of OFETs in Device Displays

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Abstract - The objective of this paper is to highlight the advancements in the domain of Green Electronics & Biodegradable Technology and design Bio-Compatible Display System using OFETs (Organic Field - Effect Transistors) . This technology proves to be crucial in the modern society as with the revolution in electronics, the necessity of eco-friendly materials in the design and manufacture of consumer products with display devices such as Smart Phones, Television, etc. are increasing in demand. Hence Non-Toxic & Sustainable components of natural origins are desired. Device Display is a current potential application area for sustainable component such as OFETs.. To reduce the number of contacts in displays and increase field contrast & selection ratio, introduction of elements such as transistors is highly desirable. Organic Field - Effect Transistors on plastic substrates including a mechanically flexible polymer dispersed liquid crystal display and displays containing e-Ink are used.

Key Words: Green Electronics, Display, OFET, Transistor, Bio-compatible technology.

1. INTRODUCTION

Green Electronics is the integration of electronics and environment friendly technology aimed at distinguishing the sustainable compounds which are of natural origin and non-toxic/biodegradable/bio-compatible. The main aim of this technology is to fabricate efficient substitute of synthetic compounds used extensively. "Green" electronics is oriented to deliver efficient energy consumption materials and low-cost devices and energy efficient materials and devices hence reducing E-waste.

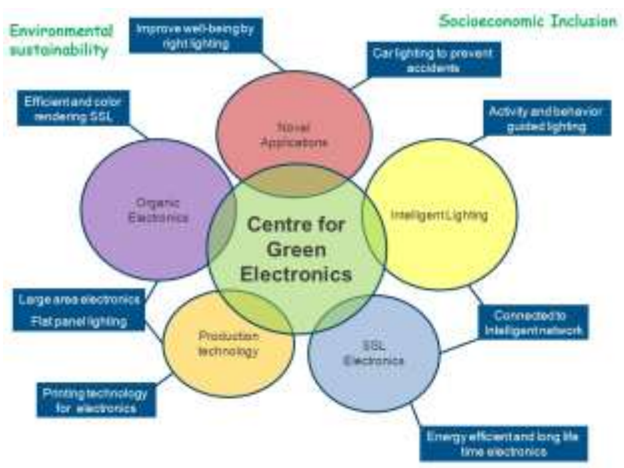

Fig 1: Green Electronics and its research domains

2. OFET (ORGANIC FIELD-EFFECT TRANSISTOR)

Transistors are the elementary foundation of any circuitry, and are used as switches or signal amplifiers. In field effect phenomenon the conductivity of a semiconductor changes due to the application of an electric field normal to its surface. The electric field is applied through a metallic gate in the device. OFETs are composed of three terminals i.e the source, drain, and gate, a semiconductor layer and an insulating layer between the semiconductor and gate. The OFET is similar to TFT (Thin-Film Transistor) in nature. A thin film deposited on a semiconductor, lies on non-conducting substrate.

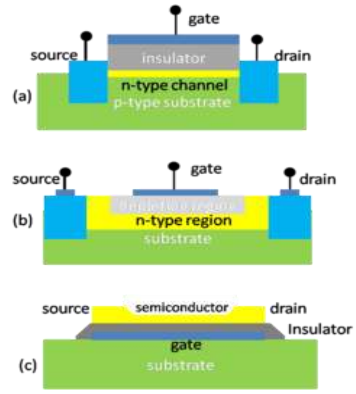

Fig 2: Types of configurations in OFETs

2.1 WORKING OF OFETs

Conduction of current through the OFET depends on the charge carriers at dielectric and organic semiconductor interface. Some holes accumulate in the organic semiconductor when a small negative gate to source voltage is applied, thus increasing the conductivity of the material. As it can operate in two regions (saturation or linear region). The drain current in saturation region is given as

$$I_{Dsat} = \frac{W}{2L}\mu C_{gd}(V_G - V_T)^2$$

Fig 3: Mathematical equation for drain current in Saturation Region.

Where W is the channel width, L is the channel length, μ is the mobility, C is the capacitance of the dielectric, VG is the gate voltage and VT is the threshold voltage.

Similarly, for Linear region the drain current is given as

$$I_{Dlin} = \frac{W}{L}\mu C_i (V_G - V_T) V_D$$

Fig 4: Mathematical equation for drain current in Linear Region.

Where W is the channel width, L is the channel length, μ is the mobility, C is the capacitance of the dielectric, VG is the gate voltage, VT is the threshold voltage and VD is the drain voltage.

3. DRAIN CURRENT-VOLTAGE CHARACTERISTICS

Drain current±voltage characteristics of a doped OFET.

The insulator is Polymethyl methacrylate) (PMMA) and the semiconductor Dihexylsexithiophene (DH6T). Note that a substantial current flows at zero gate voltage. The geometrical parameters of the device are L = 50 mm, Z = 5 mm, and C i = 10 nF/cm.

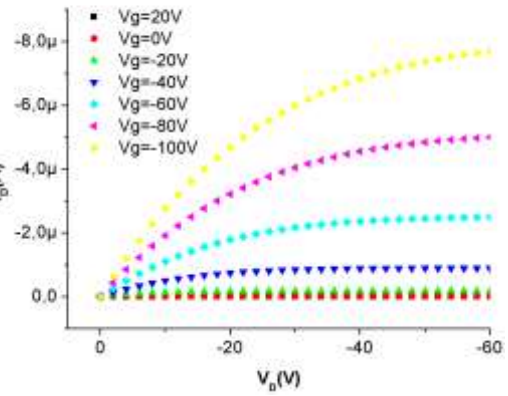

Fig 5: Drain I/V characteristics of doped OFET.

4. MATERIALS & METHODS

Most OFETs contain a high density of aromatic rings due to the electron delocalization inherent in aromatic structures. Aromatic rings contain alternating single and double bonds that lead to overlapping p orbitals, which form π-bonds. In π-bonds, electrons delocalize and are shared between the atoms on the ring's backbone similar to "sea of electrons"in metals depicting free movement of electrons. Examples of materials shown in figure as

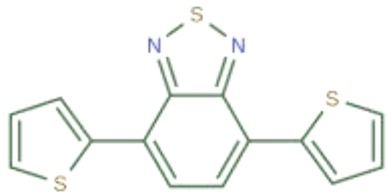

Fig 6: 4,7-Di(thiophen-2-yl)benzo[c][1,2,5]thiadiazole

Hence organic structures are used in semiconductors such as OFETs because of the advantage of their properties as such they satisfy Van Der Waals properties for solids. They do not require epitaxial templating, the growth of a layer which continues the crystal structure of a substrate.

Most OFETs are compatible with wide range of substrates and characterize simple manufacturing and low thermal budget.

5. OFETs & DEVICE DISPLAYS

The active matrix OLED displays require thin-film transistors (TFT) hence for the practical realization of flexible displays organic field-effect transistor is used and fabricated on plastic at low temperatures. Mechanically field-driven displays using organic field effect transistors on plastic/metal substrates including flexible polymer LCD and displays containing E-Ink.

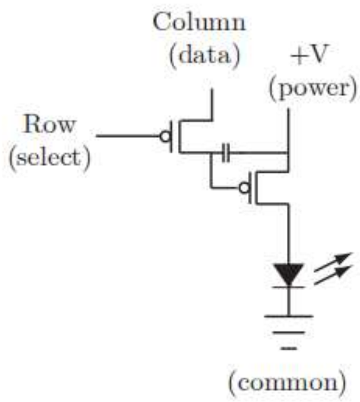

Fig 7: Shows the two transistor voltage-programmed current driver circuit in which OFETs can be implemented.

6. ADVANTAGES & CHALLENGES

6.1 ADVANTAGES

- The substrates used are low in cost thereby reducing budget.
- They are flexible, light weight, and environmentally-friendly, so there s scope of reducing electronic waste.

6.2 CHALLENGES

- Notable issue is the poor electron mobility which limits the effectiveness of n-type OFETs.
- One of the challenges faced during the production is also the instability of radical anions in the air and anisotropy property.

7. CONCLUSION

The revolution in the electronics industry has brought about a necessity for sustainable and eco-friendly technology. Green electronics can solve the modern world problem of E-waste (Electronic waste) and prove to be more economical. Traditionally, the use of synthetic components in a large demand sector such as smart phones, computers etc. can be reduced and substituted with the help of organic components such as OFETs. It finds wide applications in displays of any commercial devices and hence proves to be efficient and cost effective step towards a sustainable future in electronics.

8. FUTURE IMPLEMENTATIONS

The scope of research in the domain of green electronics is vast which can cover various domain such as “Green Computing” and production of biodegradable components where in particularly OFETs are the crucial area of studies. Organic field-effect transistors have advance research scope in their use as Bio sensors, Gas sensors and Chemical sensors. Alternatively, they appear to be beneficial in Bio-Medical Sciences applications in Artificial Electronic Skin and Electronic Nose.

The scope of research on Ambipolar OFETs, Light-Emitting OFETs is vast and may add to crucial development in this domain. Another area of related research is into the design of fully-organic FETs, in which all parts of the transistor are composed of organic materials, not just the semiconductor. Overcoming the existing challenges in the implementation and design of n-type OFETs is an important aspect of research studies.

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