Organic Semiconductors

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Until recently all functional semiconductor materials originated from the semiconductor series of periodic table (see www.semi1source.com/materials). They are available as bulk wafers or thin films deposited on the mechanically stable substrates. In both cases semiconductor material maintains its properties and ability to produce functional devices only as long as its mechanical rigidity is maintained. This restriction is a reason for which some very attractive applications, for instance flexible displays, are not possible using "conventional" semiconductors. A new bread of very cheap to process semiconductor materials, known as organic semiconductors (because they consist primarily of carbon, hydrogen, and oxygen), is bound to overcome these limitations. This is because some types of thin film organic semiconductors maintain their properties even if drastically flexed.

From the point of view of physical properties organic semiconductors differ in several ways from the conventional, non-organic semiconductors. Just like other semiconductors, however, they do allow control of charge distribution using external electric field and they do have capability of emitting radiation. Consequently, several semiconductor device structures both photonic and electronic (LEDs, lasers, solar cells as well as Thin-Film Transistors, TFTs) can be implemented using select organic compounds.

In terms of chemical composition two types of organic semiconductors are: (i) small molecule compounds in which limited number of atoms are covalently bonded into stable molecular units (monomers) and (ii) long, high molecular weight chains comprised of covalently bonded monomer segments (polymers). Small-molecule organic semiconductor films are formed by means of vacuum deposition while polymeric, or plastic, semiconductor films are typically formed by spin-on deposition.

The best promise for a breakthrough application organic semiconductors show in flexible displays. Hence, organic LEDs (OLEDs) and TFTs, both needed to engineer high quality full-color display, are in the center of attention. In OLEDs (Fig.1) light generation is based on different physical effects than in conventional LEDs (decay to the ground state of excitons formed through interactions between electrons and "holes" rather than band-to-band recombination). In organic TFT, however, similarly to conventional TFTs, transistor action is based on the field effect in which potential applied to the gate contact changes conductivity of organic semiconductor between source and drain (Fig. 2).

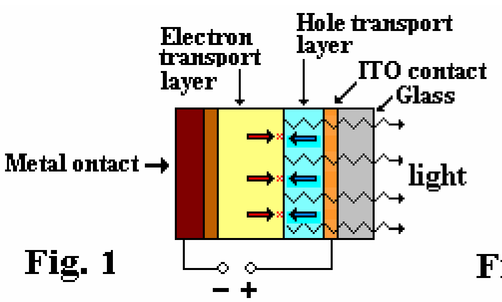

Fig. 1

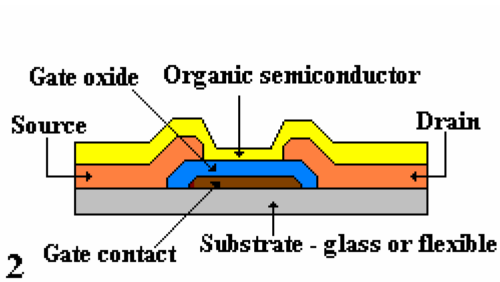

Fig. 2

Despite great promise, undeniable successes, and significant interest organic semiconductors are attracting these materials are still lagging behind typical non-organic semiconductors in terms of several basic properties. Their electron mobility is still very low (about 2 cm^2/V sec) and due to sensitivity to oxygen and water their stability is still insufficient. Also, variety of process related issue will have to be resolved before organic semiconductors will reach their full potential.

For additional information go to:

* http://www.spectrum.ieee.org/publicfeature/aug/00/orgs.html ,
* http://physicsweb.org/article/world/15/12/4 ,
* http://jerg.ee.pdu.edu .