ORGANIC MATERIALS FOR MICROSENSOR APPLICATIONS : A BRIEF REVIEW

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Abstract

Organic electronics has evolved in these years and now-commercial aspects are slowly coming up. A lot of researches were done to use polymers and their nanocomposites as gas sensing materials. Review of literature gives glimpses of various domains connected to the polymer nanocomposites.

Keywords:- Organic electronics, polymer nanocomposite, conducting polymers.

I. INTRODUCTION

The importance and potential impact of conducting polymers, a new class of materials, was recognized by the world scientific community when Hideki Shirakawa, Alan J. Heeger and Alan G. MacDiarmid were awarded the Nobel Prize in Chemistry in 2000 for their pioneering research in this field [1-4]. Although these materials are known as new materials in terms of their properties, the first work describing the synthesis of a conducting polymer was published in the nineteenth century. Flexible electronics circuits, displays, and sensors based on organic active materials will enable future generations of electronics products that may eventually enter the mainstream electronics market. Organic / plastic electronics will, on the whole, become a winning technology platform not by 'beating' silicon but by complementing silicon technologies or by facilitating the development of new products (like rollable displays) where silicon just cannot be used. The global market for plastic electronics is under \$2 billion now, but is forecast to grow at an astonishing rate to as much as \$330 billion in 2027.

The motivations in using organic active materials come from their ease in tuning electronic and processing properties by chemical design and synthesis, low-cost processing based on low-temperature processes and reel-to-reel printing methods, mechanical flexibility, and compatibility with flexible substrates [5-7]. Resulting technologies will include ultra thin television sets delivering crisper pictures than today's LCDs, inexpensive RFID tags, chemical and biosensor, OFET, OLED, low-cost solar panels integrated into buildings, cars, clothing fabrics etc.

II. CONDUCTION IN POLYMERS / TYPES OF POLYMERS

An organic polymer that possesses the electrical and optical properties of a metal while retaining its mechanical properties and processability, is termed an 'intrinsically conducting polymer' (ICP). The conductivity of ICPs lies above that of insulators and extends well into the region of common metals; therefore, they are often referred to as 'synthetic metals.' The common feature of ICPs is the presence of alternating single and double bonds along the polymer chain, which enable the delocalization or mobility of charge along polymer backbone [8]. There are two types of organic semiconductors based on the type of majority charge carriers: p-type (holes as major charge carriers) and n-type (electrons as major charge carriers). To facilitate charge transport, the organic semiconductor layer usually consists of π-conjugated oligomers or polymers, in which the π–π stacking direction should ideally be along the current flow direction. The conductivity is thus assigned to the delocalization of p-bonded electrons over the polymeric backbone.

III. DEPOSITION TECHNIQUES

Materials can be deposited in the form of thin film (up to a μm thick) on a substrate by a variety of methods such as physical vapour deposition, chemical vapour deposition, wet-chemical processes such as sol-gel and electrochemical deposition, thermolysis and flame spray pyrolysis etc. Structural properties and composites of the nanocomposite films are strongly dependent on deposition techniques and deposition parameters. There are many more challenges to deposit composite films consisting of materials of very different nature such as a metal with a polymer or a metal oxide with a metal, than to deposit films of only one type of material. Any deposition process that can be used to prepare nano-composite films should be able to simultaneously vaporize or coat materials of different nature onto the same substrate to form the composite films. To deposit composite materials of different natures by precisely controlling their chemical composition surface morphology, microstructure, and phase, remains a challenge.

IV. APPLICATIONS OF POLYMERS

In order to improve and expand the use of organic materials in devices like organic field-effect transistors (OFET) and to implement new technologies, not only new materials and manufacturing processing have to be developed, but also a fundamental understanding of the properties of organic interfaces is needed. Organic interfaces formation process is rather complex and no reliable interface-design criteria are available yet.

Organic electronics is a multidisciplinary field, where complementary knowledge form the sources is necessary and combined efforts from chemists, physicist, material scientists and engineers can truly make a difference. Nanotechnology has revolutionized the various areas of existing technologies. Development of nano-materials and integrating those materials into functional nano-devices along with organic materials is highly demanding and involves cutting-edge technologies.

In recent years, there has been growing interest in research on conducting polymer nanostructures (i.e., nano-rods, -tubes, -wires, and -fibers) since they combine the advantages of organic conductors with low-dimensional systems and therefore create interesting physicochemical properties and potentially useful applications [9-14].

Nano-composite films are thin films formed by mixing two or more dissimilar materials having nano-dimensional phase(s) in order to control and develop new and improved structures and properties. The properties of nano-composite films depend not only upon the individual components used but also on the morphology and the interfacial characteristics. Nano-composite films that combine materials with synergetic or complementary behaviors possess unique physical, chemical, optical, mechanical, magnetic and electrical properties unavailable from that of the component materials and have attracted much attention for a wide range of device applications such as gas sensors. Design of the nano-composite films for gas sensor applications needs the consideration of many factors, for example, the surface area, interfacial characteristics, electrical conductivity, nano-crystallite size, surface and interfacial energy, stress and strain, etc., all of which depend significantly on the material selection, deposition methods and deposition process parameters [15-23].

Nowadays Graphene is also coming up as one of the promising materials due to its outstanding physical properties and its practical applications such as field-effect transistors, chemical sensors and composite reinforcement [24-33]. There is tremendous importance of development of transparent electrodes, which can withstand bending, and in flexible displays, these days graphene-based organic photoelectrical devices have come up and graphene is in its early stage to replace ITO as a transparent electrode.

Recently, several reports have been made on incorporating graphene into polymer matrices to produce novel nano-composite materials. It was found that a homogeneously dispersed graphene nanofiller in a polymer matrix provided nano-composites with enhanced mechanical, electrical, thermal, and other properties due to the high aspect and surface-to-volume ratios of the nanofiller. It was also suggested that graphene nano sheets can provide more active nucleation sites for polyaniline as well as excellent electron transfer pathways [34-35].

Polymer and polymer nano-composites have also shown to have applications in the area of organic resistive memory devices [36]. The reviews by Scott et al. [37] and Ling et al. [38] offer excellent discussions on various organic resistive memory devices based on polymer and their nano-composites.

Miniaturization of portable systems creates unique opportunities to expand the microsensor technologies to polymer microsystems. The integration of a polymer MEMS device and organic electronics has open new avenues. Traditionally, microsystems have been fabricated using silicon-like semiconductor substrates by micromachining techniques. Silicon (or thin-film in general) may be the ideal substrates for semiconductor devices, but they may not be suitable for all microsystem applications. Polymer / polymer nanocomposite is known as a good sensing material and is a key element in microsensor developments. Attempts are being taken for the integration of conductive polymer/nanomaterials technologies with MEMS processes for sensing and other applications. This type of integration has mainly two advantages (i) CMOS-compatible material deposition process for large-scale integration and (ii) multi-functional and site-specific detection utilizing different nanocomposite materials at different detection positions on a single chip.

In particular, silicon-based wafer level technology may not be suitable for cost effective manufacturing and packaging of microsystems for large-area and large-volume applications. The driving force for developing organic field-effect transistor (OFET) or organic thin-film transistor

(OTFT) based electronics is in fact that they are flexible, light weight and have the prospect of low-cost manufacturing. Major barriers in the practical realization of OTFT-based electronic systems are the need for larger power supplies, lower gain, lower switching speeds and reliability problems. New directions leading to changes in the design of transistors, materials used in the fabrication, and processing techniques are warranted for developing processes and equipment that can lead to the manufacturing of OTFT based electronics. OTFTs are being investigated in utilization of OTFTs to control polymer MEMS actuators [39]. They are currently controlled manually. Silicon-based transistors do not have the capability to withstand the high actuation voltages [40-43]. Polymers are also attracting material for RF applications as they have low insertion losses [44-46]. The low dielectric constants, high resistivities and low dissipation factors [47-48] are very attractive for high quality-factor RF applications. Processing polymer does not involve toxic materials nor high thermal budget for annealing. The high thermal stability, high degree of planarization and chemical resistances are compatible with existing IC processing technologies [47-48]. Polymers can also be conformal reducing processing complexity. Many polymers have versatile micromachining abilities which are very attractive for MEMS applications. 3-D microstructures can be realized by photolithography, deep reactive ion etching (DRIE), plasma etching [49] or hot embossing processes. Organic electronics is still under development and new concepts are continuously being tested all over the world.

V. CONCLUSION

Based on literature, the exploration of organic electronics is slowly maturing. Applications of conducting polymers in biosensing, chemical/gas sensing and Solar cell applications, micro devices are being explored worldwide and in future some proven technology will come up.

VI. REFERENCES

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