ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
Vol 5, Issue 1, January 2018

Review on Flexible Electronics and Intelligent Sensors

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Abstract: Flexible electronics is a new trend in the electronics industry for dealing with the increasing chip burden. It is a technology in which electronic circuits are assembled by mounting electronic devices on flexible plastic substrates. Increasingly, this technology is being used in a number of applications that benefit from their light weight, favorable dielectric properties, robust, high circuit density and conforming nature. If not required, flexible circuits can be rolled away Plastic substrates have to offer properties such as clarity, dimensional stability, low thermal expansion coefficient, elasticity etc. to replace glass. Recent advances in organic and inorganic based electronics are based on flexible substrates, offering substantial rewards for developing displays that are thinner, lighter and can be rolled when not in use Thin-film electronics in its myriad forms has underpinned much of the technological innovation over the past four decades in the fields of displays, sensors and energy conversion. This technology forms also the basis for flexible electronics. Here they review the current status of flexible electronics and try to predict the future promise in healthcare, environmental monitoring, display and human-machine interactivity, energy conversion, management and storage, and communication and wireless networks of these pervading technologies.

Keywords: Displays, Devices, Flexible electronics, Sensors, Thin film technology, Substrates, Circuits.

INTRODUCTION

Flexible electronics have attracted considerable attention recently as they allow many promising applications such as RFID tags, solar cells, bio-sensors, wireless power and signal transmission sheets, e-skin, e-paper and flexible display [1]. Flexible electronics ' characteristic is not only reduced cost, they have light weight, thinner, non-breakable & new forms to create many new applications It is an attractive candidate for consumer electronics of the next generation, and they will soon become part of our daily lives. Flexible electronics development strategy depends on the advances in global technology and on market forecasts. It is currently estimated that around 1500 research units worldwide are working on various aspects of flexible electronics. Market analysis estimates that flexible electronics revenues could reach USD 30 billion in 2017, and USD 300 billion in 2028.

Many of the developments in the field of flexible electronics have been fueled by ever evolving advances in thin-film materials and devices [2]. These advances were complemented by the development of new integration processes, allowing for the combination of wafer-scale processes with flexible substrates. In recent years, that has resulted in a wealth of demonstrators. After many decades of substantial development and optimization, thin film materials can now offer a host of advantages such as low cost and compatibility with large areas, and high scalability in addition to seamless heterogeneous integration.

Diodes and transistors are two of the most frequently used active thin film devices in a wide range of digital and analog circuits, as well as for detection and generation of energy. While they have been successfully used in flexible platforms, there are a number of factors limiting their performance and applicability in systems, inevitability requiring the use of exotic device architectures, consisting of highly optimized geometries combined with the integration of new material. This has often facilitated tailoring of electronic properties to specific applications showing vast improvements in form factor, although typically at significant financial cost, which is unacceptable on a mass scale. Although such bone-off devices are of considerable interest to the academic community, little has been achieved in the way of full-scale integration of the system. Simple devices, such as resistive and inductive networks, have indeed been demonstrated in large-scale areas. A paradigm shift in design and manufacturing is needed to achieve the goal of full system integration in flexible systems of next generation. The ethos of the manufacturer of the conventional integrated circuit (IC)has to be adjusted [3]. Despite this, an improved understanding of material growth / deposition, integration, and processing must certainly be advanced and this knowledge is often derived through the academic speculative. Reduced cost, large area, roll-to-roll and flexible systems, such as low-cost flexible displays, require conformal, distributed, and integrated functionality, which is previously unavailable from more traditional brittle materials and device platforms.

This paper reviews the materials, design issues, and technologies for flexible electronics of the next generation, and focuses primarily on future applications thee summarize the potential of flexible thin-film devices, the manufacturability limitations of particular materials, deposition problems, and monitoring techniques which need to be resolved and improved before their wide adoption, with particular reference to a new class of materials available to nanomaterial system designers. This paper is primarily organized from the application point of view, with some of the more relevant questions being introduced to stimulate discussion by the materials engineer they present examples of potential applications of flexible electronics in different sectors of society, including: healthcare; automotive industry; human – machine interfaces; mobile communications and computing platforms; embedded systems in both living and hostile environments; As well as market-specific applications such as: human – machine interactivity, energy storage and generation, mobile communications and networking, while addressing the use of flexible electronics on all-round computing platforms.

MANUFACTURING TECHNIQUES

Polydimethylsilioxane (PDMS)is the ideal substrate material for flexible electronics and composite matrix material [4]. It is optically transparent, viscoelastic, chemically and thermally stable, highly flexible and hydrophobic and can be easily molded with high resolution and aspect ratio. Electrically conductive adhesive (ECA) is used to prevent metallization. ECAs are conductive composites which consist of metallic fillers in a polymer matrix. This technology is coined as Electronics PDMS-in-PDMS. Flexible electronics basically deals with circuits which are developed using Thin Film Transistors (TFT)[5]. Circuits are being developed today using different TFT technologies.

Amorphous Silicon Technology:

Hydrogenated amorphous silicon (a Si: H) TFTs is the workforce of today's LCD displays with active matrix [6]. Its emissive characteristics, good color saturation and clarity are the main driving force for OLED display. It is also readable by sunlight. This technology is suitable for displays with bi-stability such as electrophoretic and cholesteric displays integrated drivers based on Si: H TFT can be used in applications requiring only occasionally updated images such as advertising, map applications, point-of-sale labels, etc.

Poly-silicon Technology:

Poly-silicon TFTs are processed at higher temperatures using a Si: H material's laser recrystallization and may have mobility greater than $100cm^2v^{-1}s^{-1}$. These of TFTs are threshold voltages that are very stable. The Poly-Si TFTs can be used to develop backplanes for display and digital circuits for CMOS[7]. The process and substratum costs, however, are comparatively higher and thus limit the use of these TFTs in high-resolution displays on smart phones and high-end radio frequency tags.

Organic Thin Film Transistors:

Organic TFTs can be produced using a variety of organic semiconductors such as Pentacene, Pentacene TIPS etc. These semiconductors can be processed using solution processes or vacuum evaporated processes, such as spin coating and ink-jet printing, at low temperatures. Roll-to-roll processing can cut production costs. The OTFTis air-sensitive and therefore degrades its performance over time when exposed to the environment. It requires barrier coating to protect it against exposure [8].

Single Crystal Silicon on Flexible Substrates;

Single crystal silicone circuits can be developed on flexible substrates with mobilities exceeding $500cm^2v^{-1}s^{-1}$ and response frequencies exceeding 500MHz.In this techniques To produce high performance TFTs, the semi-conducting micro / nanomaterial known as microstructural silicon is printed on plastic substrates using dry transfer or solution-based techniques.

Mixed Oxide Thin Film Transistors:

Mixed oxide thin film transistors like IZO, IGZO provide improved mobility, higher current densities and better stability compared to a Si: H TFTs. Another trait of TFT mixed oxide is that it is transparent [9]. Therefore, the development of transparent electronics on large area flexible substrate is of great interest.

Hybrid (CMOS) Technology:

CMOS technology has several advantages over technologies which are n-MOS or p-MOS only. CMOS technology speeds significantly faster than any other technology with much lower power loss. By including n-type and p-type TFTs on the same substratum, CMOS circuits can be implemented that reduce power consumption, leakage currents and improve the digital logic circuit gain Research conducted at the Flexible Display Center in cooperation with Dallas University of Texas shows that these CMOS logic circuits are more stable than a Si: H TFT circuit. This is because the Si: H TFT's V(t) shifts with electrical stress in a positive direction while that of organic TFTs shifts negative as shown in Figure 1. A Si-H TFTs and Pentacene TETs on PEN substratum demonstrated a CMOS column driver for electrophoretic[10] displays successfully in this technology.

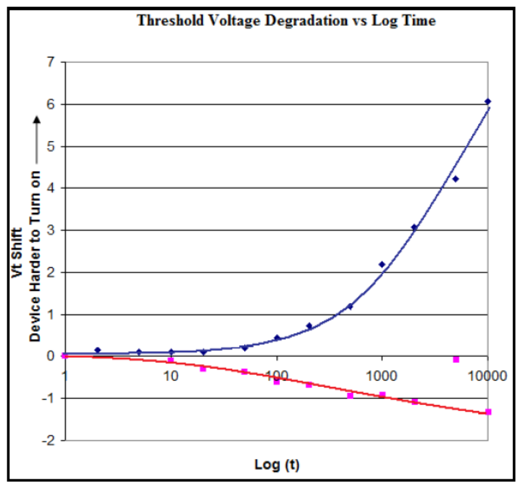

Fig.1: V(t) Shift- a –Si:H n-MOS and Pentacene p-MOS

APPLICATIONS

A wide range of applications were developed including displays, computational systems, energy storage and generation, healthcare and e-textiles etc.

Healthcare:

Flexibility in electronic materials is extremely attractive for medical and bioengineering applications. Some of the electronics were incorporated into human bodies. For example, bionic eyes, bionic ears, optic nerves etc. arrays of heat, humidity, salt or pressure sensors can be used as bed sheets and monitor a patient in real time. Flexible thin films could also play a key role in deciphering the brain thought processes.

Automotive industry:

Smart roads will be designed with the aim of improving road safety, reducing road congestion and energy consumption. As well, the road and vehicle will be able to interact dynamically, adjusting either party to optimize their systems energetically.

Displays and Human-Machine Interactivity:

As a consumer slip fingertips on the wall, the changing capacity of the time added involves occasional enticing and repulsive electrostatic pressures between the conductive material buried and the skin. This electrostatic attraction varies the normal contact forces between the skin and surface of the user and modulates the dynamic friction and the perception of touch.

Smart Textiles:

Recently, interest in smart textiles has increased for health monitoring, entertainment, and display applications. These clever textiles can be embedded with multiple sensors and display devices for monitoring stress, environmentally toxic gasses basically; each smart thread is a shift register with a small display pixel and possibly a sensor that can be used to transfer data from one end to another.

Electronic Paper:

Currently, electronic paper is the most successful technology and industry; the main applications are e-readers, electronic shelf labels, smart cards, electronic posters etc. The E-Reader is not really flexible at the moment, because it uses a backplane of glass E-Ink Holdings and ITRI comprise organic conductive and printing processes, substrates are PET films that can only be processed at low temperatures. ITRI also develops a passive cholesterol liquid crystal technology which can be produced using a full roll-to-roll technology.

CHALLENGES

Electrical Instability:

For flexible circuit design, reliability is critical to ensuring the circuit would operate reliably throughout its lifetime. Thin film transistor (TFTs) often suffers from electrical instability, but a single TFT's threshold voltage shift can be modelled by analyzing its operating conditions and the lifetime of the circuit can be predicted using SPICE simulation accordingly.

Flexible Substrate Handling and Alignment:

Due to variations in temperature, humidity and tension, special roll-to-roll operation, the dimensional control of the plastic substratum is very difficult.

Flexible Conductor Conductivity and Work Function:

Thanks to liquid offset or jetting operations, special multilayer or large area film printing, the printing qualities are not easy to control.

Printing Quality:

Thanks to liquid offset or jetting operations, special multilayer or large area film printing, the printing qualities are not easy to control.

CONCLUSION

In this paper, we discussed some of the manufacturing techniques, applications, challenges and future thin-film technology socioeconomic trends are likely to enhance device performance though this field is growing and maturing, it has been rapidly and dynamically expanding. The key to success includes grasping the tempo, building a full value chain, and attracting the entities needed to join the efforts and cooperate This paper provides a brief overview of how the flexible electronics field has evolved over the years and what the future holds for the large, rough, low-power electronics sector. Some of the applications were introduced which can be developed on flexible substrates.

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