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Design, Structure and Fabrication of Exotic Flexible Materials in IoT and Wearable Application

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Abstract: Flexible electronics, also known as flex circuits, is a technology for assembling electronic circuits by mounting electronic devices on flexible plastic substrates. Flexible electronics based upon organic and inorganic nano-structured materials have the identical features required for IoT. In this paper the recent progress in research and the future prospects of flexible electronics is discussed then key technologies, including flexible RFID, sensor, memory and display technologies are also described in detail. The paper will also focus on future scope and applications of these fantastic materials

***Key Word**:* Conductive electrodes, 3-D printing, flexible RFID.

I. Introduction

The key advantages of flexible electronics, compared with current silicon technologies, are low-cost manufacturing (e.g. ink-jet printing and roll-to-roll imprinting) and inexpensive flexible substrates (e.g. plastics).

Flexible electronics technology platform enables new product paradigms across multiple industries, including automotive, digital signage, consumer electronics, biometrics and healthcare.

5G Brings Evolutionary Changes to the IoT. 5G is the fifth generation wireless cellular technology standard that promises ground-breaking new capabilities and to unlock the potential of technologies such as Artificial Intelligence (AI), Extended Reality (XR) and the Internet of Things (IoT).

5G is the foundation for realizing the full potential of IoT. While 5G is set for commercial availability sometime around 2020, the industry is already working to develop new global standards and pre 5G products to benefit industries everywhere.

5G is much more than just fast downloads. Its unique combination of high-speed connectivity, very low latency, and ubiquitous coverage will support smart vehicles and transport infrastructure such as connected cars, trucks, and buses, where a split second delay could mean the difference between a smooth flow of traffic and a 4-way crash at an intersection.5G will enable us to control more devices remotely in applications where real-time network performance is critical, such as remote control of heavy machinery in hazardous environments, thereby improving worker safety, and even remote surgery.

Non-flexibility of devices and weight considerations are the hurdles to technological advancements of next generation IOT related devices. Flexible electronics systems require the involvement of stretchable antennas to provide wireless connectivity. Flexible, textile and stretchable electronics are emerging research areas and may yield mainstream technologies.

1.1 On way to 5G and Internet of Things

With connectivity at the heart of industry transformation, 5G will have a key role to play not just in the evolution of communication but in the evolution of businesses and society as a whole. On the road to 5G, operators will need to do more than just evolve networks; they will need to transform their business to address new opportunities.

2. Materials for Wearable Devices

Choice of material for any wearable application is based on following properties:

2.1 Conductive Materials

In wireless applications, the realization of conductive patterns with superior electrical conductivity is essential for ensuring high gain, efficiency, and bandwidth. Additionally, resistance to degradation due to mechanical deformation is another desired feature for the conductive material. Nano particle (NP) inks (i.e., silver and copper) are often preferred for fabrication due to their high electrical conductivity. Silver-nano particle ink edges over copper nano particles due to their low rate of oxide formation. Conductive polymers like polyaniline (PANI), polypyrrole (PPy), and poly (3,4- seem to be promising materials for wearable transmitting devices. The low conductivity of conductive polymers was improved by adding carbon nanotubes, graphene, and carbon nanoparticles.

Use of graphene are increasing rapidly due to their decent electrical conductivity and excellent mechanical properties [3]. Some of the examples include silver nanowire embedded silicone, silver loaded fluorine rubber, carbon nanotubes (CNT)-based conductive polymers, liquid metals in the stretchable substrate, and use of stretchable fabric itself.

2.2 Substrates

The properties of metamaterials can be affected by changing the properties of substrate material. There are many different types of substrates that can be used in wearable devices like Felt, Cardura, electro textile materials and complex polymers. The only limitation of PDMS substrate is poor metal–polymer adhesion. Due to their congruous response and practical acceptability, flexible materials have gained vast proclivity. These flexible materials need to be chosen carefully to withstand the physical deformation conditions such as bending, stretching, and even twisting while maintaining its functionality.

3. Fabrication Techniques for Flexible Materials

Recent progress in fabricating flexible devices has been significantly developed because of the increased interest in flexible electronics. Flexible electronics can be applied to a wide range of fields, such as flexible displays, flexible power storages, flexible solar cells, wearable electronics, and biomedical devices.

Most of the effort towards flexible electronics has often involved employing atomically thin 2D electronics, materials with a single atom thickness, making them flexible and bendable while maintaining excellent mechanical and electrical properties. However, the formation of these ultra-thin devices typically requires an extremely hot manufacturing process, so hot that the flexible plastic substrates of the electronics would melt and decompose in the production process.

3.1 Popular Fabrication Methods

Conventional photolithography, soft lithography, nanoimprint lithography, growth, assembly and chemical vapor deposition (CVD) are most popular fabrication methods.

3.2 "3D Printing"

Among the many methods of fabricating conductive components, printing emerges as one of the most promising methods due to the relatively easy implementation, various materials and substrates compatibility, the low cost of fabrication and immense upscaling possibilities thanks to the application of roll-to-roll (R2R) printing techniques.

3.3 Chemical Etching

Chemical etching, which is frequently combined with photolithography, is a corrosive method of producing metallic designs using photoresist and etchants. It is the finest choice among all other manufacturing techniques for creating complicated designs with high resolution precisely.

4. Applications of Flexible Materials

4.1 Medical Applications

Flexible materials in conjunction with the internet of things are at the forefront of healthcare advancements. Wound healing, wearable electronics, implanted gadgets, and surgical tools are just a few of the new uses for flexible electronics. Artificial electronic skin [5] is one of the most advanced healthcare applications.

Stretchable e-skins with great sensitivity have attracted a lot of attention in recent years because they can mimic human skin functions by detecting minute changes like pressure, strain, shear, temperature, vibration, and pain and converting them to electronic impulses. They are highly conformable to soft, curvy, and complex surfaces at the same time. A variety of micro/nanomaterials have been used to create artificial flexible and elastic e-skins

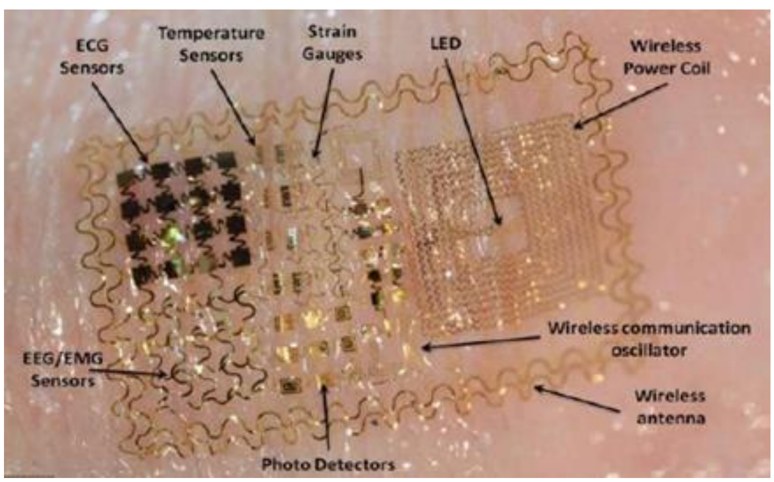

Figure 1: Electronic-Skin

4.2 Applications in the field of Environment

Recent advancements in the creation of stretchable electronic devices for environmental applications have opened up new opportunities in the automobile, oil and gas, maritime, and geothermal power industries, among others.

4.3 Applications in the field of Military

Soldiers with new technology that provide increased situational awareness, command and control, communication, and sensing will be critical to the accomplishment of future military ambitions.

Additionally, improved data processing, computing, and networking capabilities will be required to support these enhanced capabilities. Lightweight, flexible, and energy-efficient technology will improve manoeuvrability by reducing the weight and volume carried by individual soldiers.

2D materials like graphene, hexagonal Boron Nitride, and Molybdenum di Selenide offer a lot of potential in military applications such energy storage, sensors, electronic devices, and weapon systems [7].

Advanced 2D material-based sensors and detectors provide high awareness and significant potential for obtaining precise data for planning, optimization, and decision-making, which are all key components of military command and control procedures.

Nowadays aircraft, naval ships and submarines, missiles and satellites are often covered with radar-absorbent material, such as paint, to hide them from radar, sonar, infrared and other detection methods.

4.4 Application in the field of Antennas

4.4.1 Flexible Antennas for Implantable Applications

The recorded physiological parameters are transmitted and stored using an implantable antenna system, which allows for real-time communication. The essential prerequisites for constructing an implanted antenna are compact size, optimal placement inside the human body, higher bandwidth, flexibility, and a low specific absorption rate. Due to the varying dielectric constants of the two materials, the task is extremely difficult.

4.4.2 Flexible Antennas for Ingestible Application

Special forms of flexible antennas are required for monitoring devices and medicine delivery systems, as well as monitoring the patient's interior state. Wireless IMDs are commonly utilized for diagnostic purposes, particularly for gastrointestinal imaging (GI). Wireless capsule endoscopy is a medical imaging technology that records images of the gastrointestinal tract. This approach provides a number of advantages.

5. Future Prospects of Flexible Electronics

Flexible wireless device research has recently gotten a lot of interest because of its ability to meet the needs of biomedical applications, vehicle navigation systems, wearables, and other applications. An antenna is one of the most important components in this system, and it should be flexible and elastic to ensure device compliance.

Due to the rising need for wire-free applications such as the Internet of Things (IoT), body area network (BAN), and biomedical devices, flexible devices with elastic antennas for future wireless solutions are expected to work in a broad range of frequencies.

Flexible electron-ics will provide a lot of value to the industrial sector of the economy. Flexi-ble electronics' potential to speed up manufacturing with tiny sensors and electrical components will be used by a variety of manufacturers, including automakers.

6. Conclusion

Flexible technologies offer unique ways to interact with the environment that were not conceivable with current conventional electronics due to two essential parameters: performance and processing capacity. The field is still a long way from providing finished products because to issues such as device durability, stability, and dependability, as well as manufacturing limits.

Proponents of flexible electronics often envision future technologies used in devices like foldable smartphones, smart textiles, wearable electronics, and implantable sensors; all are heavily invested in academia and industry.

Still, like any technology in its infancy, there are many obstacles to overcome, especially in that foggy area between university research and getting to market. Fortunately, with the momentum in the field of flexible electronics, developments appear to be happening at blazing fast speeds.

In terms of two important parameters that are performance and computing power, flexible devices offer innovative ways to interact with environment which was not possible with current conventional electronics being used.

The field is still a long way from delivering end products, as limitations including durability, stability, and reliability in terms of device functionalities, as well as manufacturing barriers including the adaptation of equipment to developed materials. However, there is huge potential in bioelectronics and personalized medicine. Research that progresses the functionality and compatibility of materials with the body, sensors with improved accuracy and reliability, and the integration of multiple devices to autonomously gather, analyse, and transfer data without the need of bulky and expensive external components, will set the field at the frontiers of new products and applications.

References

[1]. Wang, D., Chen, D., Song, B., Guizani N.,Yu X., Du X., “The Next Generation IoT-Based Intelligent Algorithms and 5G Technologies”, IEEE Community Magazine, issue 56, 114–120, 2018.
[2]. Zhan, Y., Mei, Y., Zheng, L, “Materials capability and device performance in flexible electronics for the Internet of Things”, J. Mater. Chem. C, 2, 1220–1232, 2014.
[3]. Liu, Y., Wang, H., Zhao, W., Zhang, M., Qin, H., Xie Y, “Flexible, Stretchable Sensors for Wearable Health Monitoring: Sensing Mechanisms, Materials, Fabrication Strategies and Features”, Sensors,18, 645, 2018.
[4]. Kirtania S.G., Riheen M.A., Kim, S.U. Sekhar, K., Wisniewska A., Sekhar, P.K., “Inkjet Printing on a New Flexible Ceramic Substrate for Internet of Things (IoT) Applications”, Micromachines, vol. 11, 841, 2020.
[5]. Rogers, J. A., Someya, T. & Huang, Y. Materials and mechanics for stretchable electronics. Science 327, 1603–1607 (2010).
[6]. Ma, Y., Feng, X., Rogers, J. A., Huang, Y. & Zhang, Y. Design and application of ‘Jshaped’ stress-strain behavior in stretchable electronics: a review. Lab Chip 17, 1689–1704 (2017).
[7]. Baca, A. J. et al. Semiconductor wires and ribbons for high-performance flexible electronics. Angew. Chem. Int. Ed. 47, 5524–5542 (2008).
[8]. Manoj Thakur et al., Flexible Electronic Skin, 4042 |International Journal of Current Engineering and Technology, Vol.4, No.6 (Dec 2014)