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Advances in Wearable and Implantable Smart Electronics Skin for Real Time Medical Applications

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Abstract: *Recent advancements in wearable and implantable smart electronics skin have opened up new possibilities for real-time medical applications. These devices are designed to be worn or implanted on the skin and can monitor a wide range of physiological parameter, including body temperature, heart rate, blood pressure and oxygen saturation levels. The ability to monitor patients in real-time can aid in the diagnosis of Medical conditions and alert healthcare professionals if there are any changes in a patient's condition. Implantable sensors can also be used to monitor patients undergoing surgery or other medical procedures. Additionally, these devices can be used to deliver drugs or other therapies directly to the skin, providing targeted treatment for skin conditions. As these technologies continue to evolve, they have the potential to play an increasingly important role in healthcare.*

Keywords: smart electronic skin, implantable sensor, Heart rate and Blood pressure.

I. INTRODUCTION

The development of electronic technology, medical treatment and the environment as greatly improved the quality of life and life span of human beings world wide, which as lead to the aging of the global population. wearable technology in health care refers to devices that patients attack to their bodies to collect health and fitness data, which they may provide to doctors, health providers, insurers and other relevant parties [2].

Wearable electronics consists of sensors, actuators, electronics and power supply or generation. They have unique characteristics such as low modulus, light weight, highly flexible and stretchable. Wearable sensor systems composed of flexible and stretchable materials or likely to make better contact with human skin, while E-skin is very efficient in sensing signals and combining with the human body. Due to the latest developments in e-skin technologies, they can realised long-term and continues tracking of blood oxygen, blood flow, arterial pulse pressure, heart rate, temperature and other important physiological signals in daily activities.

Wearable devices or real time and non-invasive biosensor allowing for the continues monitoring of individuals, and thus provide sufficient information for determining health status, and even preliminary medical diagnosis.[3] In addition, wearable biosensor allow healthcare provides to monitor the physiological traits of patience after the repeitics or treatments.

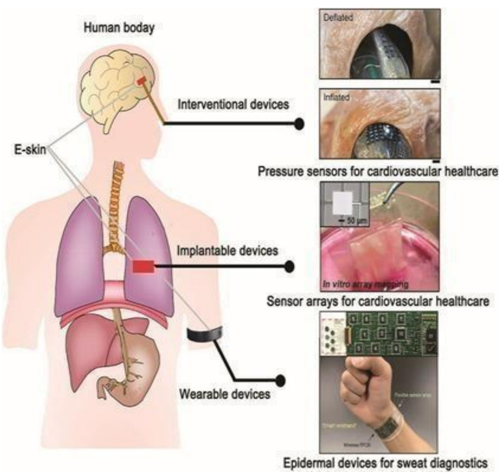

Figure 1 – Focused areas of flexible and wearable medical devices. Human body reproduced with permission.

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Wearable biosensor have received tremendous attention over the past decade, mainly concentrated in the healthcare industry, which attempts to apply physical signals such as heart rate, blood pressure, skin temperature, respiratory rate and body motion to extract clinically relevant information.[4]

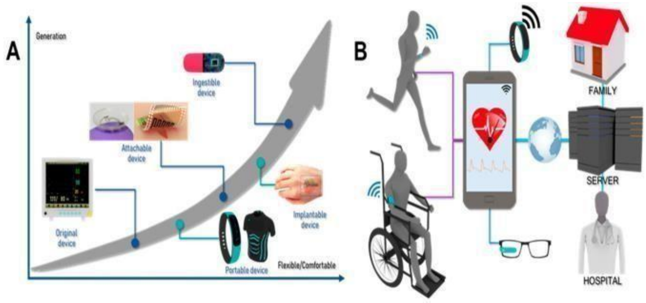

Fig 2- Industrial wearable technologies. (**A**) Evolution of wearable medical devices (**B**) Application of wearable devices in the healthcare and biomedical monitoring systems. Reproduced with permission from Hwang.

The first implantable medical device developed was a pacemaker for arrhythmia patients in 1958. Since then, various types of pacemakers and implantable cerebellar stimulators have been developed and used. In recent years, flexible and stretchable electronic devices have allowed implantable systems to be deployed in the deep brain, the intravascular area, the intracardiac area and even the singlecell interiar. At present, wearable devices are driven by their own receiver, future a signal processor, and are batterypowered, enabling them to opearate as a "microcomputer and allowing for the connection of all processes, from information collection and processing, to communication and power supply [5]. Wearable devices connect to other smart devices via Bluetooth, infrared, radio- frequency identification (RFID) and near-field communication (NFC) technology. Together, this connectivity has led to the development of wearable systems for remote and long-term patient monitoring in homes and communities that were previously impossible[6]. This capability is expected to make a significant contribution to reducing medical and healthcare costs in countries with a large population of elderly people. This article provides a review of the evolutionary clinical applications of commercially available, newly emerging, technically challenging and future wearable devices. we also discuss the technical barrier's and challenges of currently available biosensors and the future prospects for emerging biosensor [7].

II. (a) WEARABLE ELECRONICS TECHNOLOGY

Wearable devices have proven useful in helping the patients and clinician create a plan of care and track outcomes. Wearable devices are also helpful in providing real-time data and promoting self-management for chronic conditions[15].

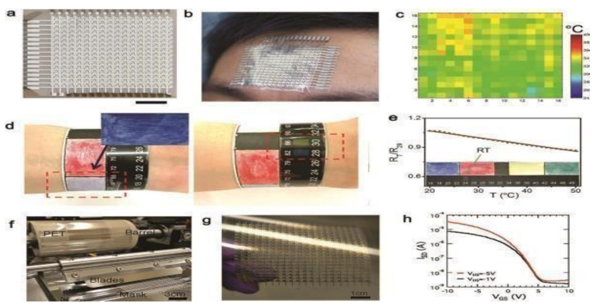

Figure 4 : E-skin as wearable medical devices. b) Optical image of flexible temperature sensor arrays (scale bar: 10 mm). c) Measured temperature distribution of the forehead by flexible temperature sensor. Reproduced with permission.[10], John Wiley and Sons. d) Visual-aided
smart thermos sensors on human body. e) The standard curve of the resistance changes versus the temperature of the paper-based.

Examples include fitness trackers, blood pressure monitor and biosensors. Because of these benefits, wearable medical devices like fitness trackers, smartwatches, electrocardiogram (ECG) monitors, blood pressure monitors and biosensors have witnessed booming demand[9].

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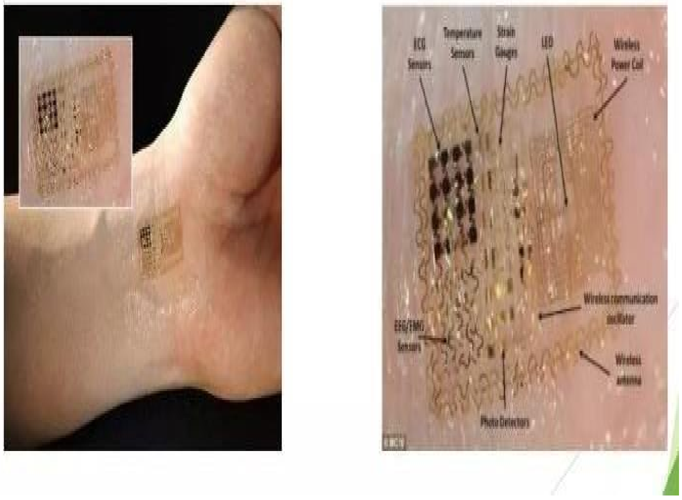

Figure 3-wearable Electronic-Skin for human bodies

(b) IMPLANTABLE ELECTRONIC TECHNOLOGY

Biomedical patches are commonly known as scaffolds, matrices or structures, which are important biomaterial-based medical devices for clinical repair and treatment of organ and tissue diseases. In other words, during the process of tissue regeneration, these biomedical patches provide support by good direct contact with the heart. In addition, many studies have focussed on interfacial adhesion[9].

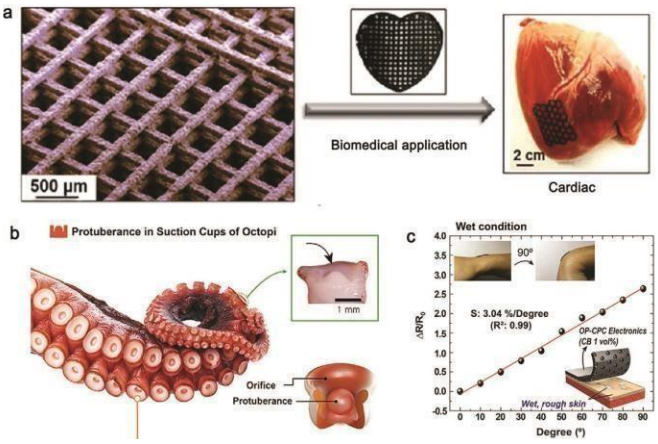

Fig 5-E-Skinas wearable medical devices. b) Optical image of flexible image scale arrays. c)Measured temperature distribution. d)visual aided smart thermos human body. E)Curve of standard resistance changes versus temperature.

These devices are intended to be used in the medical field to treat, alleviate are diagnose diseases, prevent diseases of humans are other animals, and effect the structure and functions of humans are other animals. However this devices do not realise any of the main intended purposes by chemical action and metabolism in humans are other animals. E-skins have been rapidly developed in the fields of consumer electronics, soft robotics, and bionic electronics, especially in the field of health monitoring, which requires direct interaction with soft and curvy linear human bodies. Stretchable sensors can adopt to human mechanics and provide maximum compliance with organs and skin, resulting in enhanced comfort and reduced restriction on the wearers daily activities. Impact, if medical devices are to be used in the human body for a long time, then they must meet specific requirements, such as safety, non-toxicity, and biocompatibility. If these requirements are not guaranteed are met, then users may experience some side effects, even death. Therefore, strict design and risk assessment must be carried out before the equipment is installed on the human body. The additional characteristics of stretchable devices include being light, viscous, mechanically flexible and hydrophobic to ensure that the devices are closely integrated with the human body or organ. The biocompatibility and further and bio absorb ability of the material used allow these devices to be used safely and for a long time while considering any harmful effects of

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them on the human body. This chapter introduces the required characteristics(such as mechanical flexibility, biodegradability, biocompatibility, self-healing and adhesion) of stretchable sensors in health monitoring applications.

III. E-SKIN TECHNOLOGY

CONSTRUCTION OF E-SKIN :

Circuit is made of silicon. It is filamentary serpentine safe. It allows them to bend, twist, srunch and stretch. Approximate dimension of tattoo circuit 2.1cm*3.1*5microns[8].

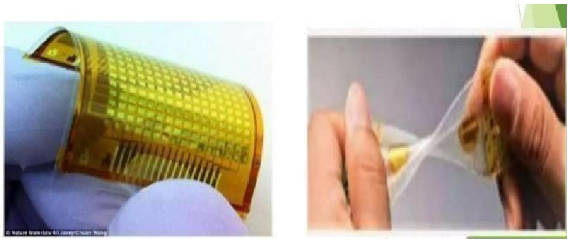

Figure 6-detailed construction of the Electronic Skin

IV. ARCHITECTURE OF E-SKIN :

With the interactive e-skin, demonstration is takes place and elegant system on plastic that can be wrapped around different objects to unable a new form of HML, other companies, including Massachusetts-based engineering from MC10, have created flexible electronic circuits that are attached to a bearers skin using a rubber stamp.

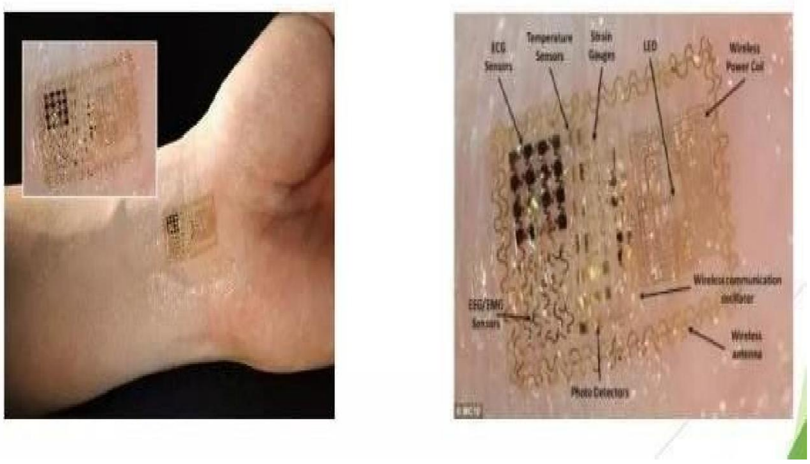

Figure 7-detailed construction of the Electronic Skin

V. WORKING OF E-SKIN

Antennas is used to transmit the recorded electrical signals of skin to the receiver. Strain gauges are used for measuring the signals generated by the heart. Temperature sensors are used for measuring the temperature. Light is a readily available power source, and is used to change the e-skin stretchable solar cells are used.'

VI. E-SKIN FOR MEDICAL APPLICATIONS

According to FDA regulations, medical devices are designed to diagnose, prevent and treat diseases, rather than achieve their purpose through the body or chemical action in the body. Wearable sensor systems composed of flexible and stretchable materials are likely to make better contact with human skin, while e- skin is very efficient in sensing signals and combining with the human body[9]. Due to the latest development in e-skin technologies, they can realised long term and continues tracking of blood oxygen, blood flow, arterial pulse pressure, heart rate, comfortable. In addition glaucoma and diabetes diseases can be diagnosed and treated non-invasive e-skin technology that provides real time detection of indicators of percutaneous treatment, such as the intraocular pressure and blood glucose concentration.

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Flexible sensors have the ability to be bent and stretched during use and can still maintain their electrical and mechanical properties With the development of bioresorbable and biocompatible materials, flexible in vivo e-skin systems have been developed and demonstrated for electrocorticography(ECoG),electrospinography,electrop hysiology(EC G), intracranial temperature /pressure monitoring, and clinical biomedical therapy, providing ideal quality and commercial clinical devices[8]. In this section, we will review various types of e-skins at exhibit the biological functions(mechanical properties, biocompatibility, biodegradability, self-healing, and adhesion). For these sensors, we describe in detail their applications in the medical field (such as wearable, Implantable, and Interventional medical devices.With the rapid development of biomedicine and flexible electronics, the demand for and development of implantable medical electronics are increasing.[141] However, due to the power supply limitation, implantable electronic devices are hindered in practical applications. Even if they are wirelessly powered by an external radiofrequency source, a radio-frequency generator has to be held nearby, which still limits mobility.[142] To address the above limitations, researchers have invested great energy and enthusiasm in studying the power supply. The solutions usually focused on one of two aspects: increasing the power capacity of implantable medical electronics or obtaining energy from organisms or the surrounding environment. The sensors prepared by e- skin include pressure sensor, strain sensor, temperature sensor, and multifunctional sensor. The essential working principle of these sensors is that the electrical resistance (capacitance/current) of the conductive material inside the sensor changed under the stimulation of external mechanical deformation and is converted into a quantitative electrical signal. It is sensitive enough to detect small physiological signals such as temperature, pulse, and heart rate within a narrow stretch. For a sensitive pressure sensor, the intermediate conductor is normally sealed with a support matrix that is susceptible to deformation. According to the sensing mechanism of the pressure sensor, the pressure sensor can be divided into capacitive, piezoresistive, piezoelectric and triboelectric. For a capacitive pressure sensor, the intermediate dielectric layer can be processed to form microstructure to improve the sensitivity. In order to the construction of microstructure, the pre-stretched PDMS surface is treated with plasma and released to form a microarray structure,[86, 88] and CO2 laser ablation technology used to prepare a micro-needle array with PMMA as the main mold when the permission of mechanical equipment. It is sensitive enough to detect small physiological signals such as temperature, pulse, and heart rate within a narrow stretch. For a sensitive pressure sensor, the intermediate conductor is normally sealed with a support matrix that is susceptible to deformation. According to the sensing mechanism of the pressure sensor, the pressure sensor can be divided into capacitive, piezoresistive, piezoelectric and tri bioelectric.

VII. ADVANTAGES

- Wearable technology is easy to use, they're lighter, smarter and more comfortable than ever to wear by tracking patient activity and data, wearable technologies can help doctors better understand how their patients are feeling and managing their diseases.
- Reduced material cost by integrating sensors with other components.
- Flexible sensors have the ability to be bent and stretched during use and can still maintain their electrical and mechanical properties.
- Flexible substrates are not structurally damaged or broken by application of external forces.

VIII. APPLICATIONS

- Wearable devices are used to send a patient's health information to a doctor.
- Medical wearable electronic gadgets use sensors to monitor, analyse, store and transfer data.
- Flexible electronics has focused on medical applications such as counting steps and calories, blood pressure monitors, oxygen monitors, glucose meters.
- Flexible electronics can be used in batteries, Automotive circuit , Printers and Solar cells.

IX. CHALLENGES AND FUTURE SCOPE

- Wearables are growing in popularity and enabling people to monitor their health 24/7. In 2022 alone, over 320 million wearable health devices are forecasted to ship worldwide and grow to 440 million by 2024 – a CAGR of 17%.[10]
- In future even virtual screens may be placed on device for knowing our body functions.
- Used in car dashboard, interactive wallpapers, smart watches. We can predict patient of an oncoming heart attack hours in advance.[8]

X. CONCLUSION

Wearable are growing in popularity and enabling people to monitor their health 24/7. In 2022 alone, over 320 million wearable health devices are forecasted to ship worldwide and grow to 440 million by 2024- a CAGR of 17%..More sensors for collecting other bio-signals such as galvanic skin response (GSR) signal, peripheral capillary oxygen saturation (SpO2), and continuous blood pressure will be added into the systems.

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