ELECTRONIC SKIN-THE SENSE OF TOUCH

K. Ranganath, P.Krupali ,M.Sravanthy
Computer Science and Engineering
HITAM
Hyderabad, A.P, India.

Abstract- **This paper focuses on the Electronic skin(E-Skin) to build a skin work similar to that of the human skin and also it is embedded with several sensations or the sense of touch acting on the skin. This skin is already being stitched together. It consists of millions of embedded electronic measuring devices: thermostats, pressure gauges, pollution detectors, cameras, microphones, glucose sensors, EKGs, electronic holographs. This device would enhance the new technology which is emerging and would greatly increase the usefulness of robotic probes in areas where the human cannot venture. The sensor could pave the way for a overabundance of new applications that can wirelessly monitor the vitals and body movements of a patient sending information directly to a computer that can log and store data to better assist in future decisions. This paper offers an insight view of the designing, developing, implementing and usage of E-Skin.**

Keywords- E-Skin, organic field-effect transistor (OFET), Quantum Tunneling Composite (QTC), micrographs.

I. INTRODUCTION

E-Skin has become the new emerging technology and also has great developing aspects as it is going to be one of the most futuristic projects to be enhanced and it also represents the next generation technology[1]. This latest advance is an example of the progress made in the field of microfluidic stretchable radio frequency electronics (μFSRFE), which have demonstrated the possibility of combining established stiff electronic components with channels of elastomers filled with fluid metal. This design means it is possible to build systems that can return to their original form after major mechanical deformation. Ongoing research projects that promoting the virtues of 'E-skin' could, in the future, be deployed in the field of healthcare. This E-skin could be used for a vast array of applications such as medical instruments that need to make controlled incision. Likewise, bandages could be equipped with sensors to ensure they are applied with the proper tightness [2]. Electronic pressure sensitive material that could become a sort of "skin" Imitation for different applications. It was developed by engineers at Berkeley University of California. Artificial skin called "e-skin" and described in an article published in the journal Nature Materials, is the first material of this kind, made of crystal inorganic semiconductors. The idea is of a material able to function like human skin, and this involves the integration capabilities of perception and touch objects. Researchers have developed a flexible wireless sensor that can withstand the stretching and folding that occurs on any fluid surface such as human skin. The team believes the sensors can act as a second layer of smart 'e-skin' to monitor an individual's health. E-skin that is composed of a slender, highly agile layer of rubber sandwiched between two electrically conducting layers. A sensitive artificial skin contact could be a crucial step in robotics to hanlde the necessary grip force modulation and handling a wide variety of objects. Human beings generally know how to grab a fresh egg without breaking it. If we want to have a robot able to empty a dishwasher for instance, you should be sure that will not break the glasses and I will not fall on the floor pans. A long-term goal could be so called "e-ski" for tangible sense rehabilitation in patients with prosthetic limbs, when you have reached an appropriate level of integration of electronic sensors in the human nervous system. Many patents are still researching on the developing process of the E-Skin and would become a breakthrough in the coming upcoming technologies. Sensing a range of pressure is hardly a good substitute for the extremely sophisticated sensors, we have built on our skin. The electronic skin is made out of germanium and silicon wrapped around a sticky polyimide film. The prototype measures about 7.6 square inches and can distinguish different pressures between 0 and 15 kilopascals, which is the range of pressures one might encounter while typing on a keyboard or holding a small object. The E-skin changes its thickness in response to changes in pressure, which is then measured and controlled by built-in capacitors. E-Skin is a very distant future, because the main aim of the E-Skin is to make a skin which performs really like a human skin and it is able to connect it to the nerve cells on the arm and thus restores the sensation. Connecting the artificial skin with the human nerve system is a very difficult task. The prototypes that we imagine would be more like a handled device, or may be the device that connects to other parts of the body that have the skin sensation. A device would generate a pulse that would stimulate other parts of the skin, and it gives a feel or sensation of touch when a human is touching something. The E-Skin senses the pressure like heat, pain, touch of any delicate object. Artificial sensor could be one of the sensors which offer robots the ability to detect anything from radioactivity to biological agents by touch.

II. SYSTEM STRUCTURE AND IMPLEMENTATION

The implementation of E-skin is illustrated in the following section.

A. *Organic field effect transisitors:*

An organic field-effect transistor (OFET) is a field effect transistor using an organic semiconductor in its channel. OFETs can be prepared either by vacuum evaporation of small molecules, by solution casting of polymers or small molecules, or by mechanical transfer of a peeled single-crystalline organic layer onto a substrate[3]. These devices have been developed to realize low-cost, large-area electronic products and biodegradable electronics. OFETs have been fabricated with various device geometries. One of their main technological attractions is that all the layers of an OFET can be deposited and patterned at room temperature by a combination of low-cost solution-processing and direct-write printing, which makes them ideally suited for realization of low-cost, large-area electronic functions on flexible substrates.

B. Flexible array sensors:

Using organic transistors with a floating gate embedded in hybrid dielectrics that comprise a 2-nanometer-thick molecular self-assembled monolayer and a 4-nanometer-thick plasma-grown metal oxide, a nonvolatile memory arrays on flexible plastic substrates is prepared which is used in electronic skin. The small thickness of the dielectrics allows nonvolatile, reversible threshold-voltage shift. By integrating a flexible array of organic floating gate transistors with a pressure sensitive rubber sheet, a sensor matrix that identifies the distribution of applied mechanical pressure and stores the analog sensor input as a two-dimensional image over long periods of time is obtained[4].

C. Nano wire arrays:

The nanowire arrays are made of germanium and silicon (semi conductors). The semiconductor nanowires enable fabrication of high performance, bendable transistors and sensors.

D. Quantum tunneling composite:

Quantum Tunneling Composite (QTC) is a new class of electrically conductive material that has been developed to advance the capability of switching and sensing systems as shown in figure 1. QTC is a pressure switching and sensing material technology. The QTC material can transits from an electrical insulator to a conductor due the deformation in material caused due to applied mechanical pressure.

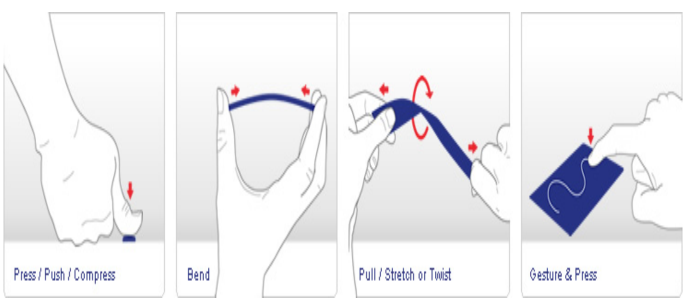


Figure 1. Quantum Tunneling Composite

E. Using Highly Sensitive Flexible Pressure Sensors with Micro-structured Rubber Dielectric Layers:

- The development of an electronic skin is critical to the realization of artificial intelligence that comes into direct contact with humans, and to biomedical applications such as prosthetic skin depicted in figure 2.
- A technology for the production of electronic skin needs to be reasonably priced and able to produce the skin with high throughput[3].
- In order to successfully imitate the properties of natural skin, large arrays of pixel pressure sensors on an elastic and stretchable substrate are required.
- Need for a low-cost, large-area compatible technology for the production of pressure-sensitive pixels that are sensitive in both the medium pressure regime (10-100 kPa) to low-pressure regime (<10 kPa, gentle touch around 1kPa).
- Flexible pressure sensors that utilizes the thin film capacitor and the organic field effect transistor device structures. The key component that enables the sensing of pressure in these devices is a thin dielectric layer of the biocompatible elastomer polydimethylsiloxane into which tiny structures has been molded.

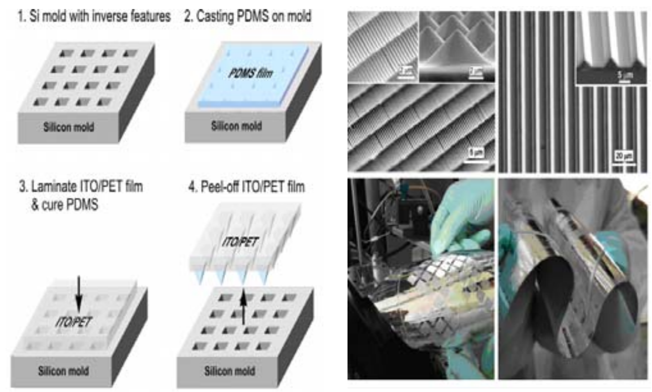


Figure 2. Fabrication Rubber Dielectric Layers

F. Fabrication

- Schematic process for the fabrication of micro-structured PDMS films. A dilute solution of the PDMS mixture is drop cast onto a Si wafer mold; An ITO-coated PET substrate is laminated to the mold, and the PDMS film is cured under pressure. After curing, the flexible substrate is peeled off the mould as shown in Figure 3.
- Scanning electron micrographs of micro-structured PDMS films with pyramid or line features [5]. The pressure sensitive structured PDMS films can be molded at full wafer scale with high uniformity and fidelity on a variety of flexible, plastic substrates.
- Pressure-response curves for different types of micro structured PDMS films. The structured PDMS films exhibit a much higher pressure sensitivity s than the unstructured PDMS films of the same thickness.
- Relaxation and steady state curves for different types of featured after loading and unloading. While both, structured and unstructured PDMS films, show immediate response to the application of pressure, only the structured PDMS films exhibit relaxation times in the millisecond range.
- The micro structured PDMS films are able to sense the application of very small pressures[2]. Shown is the capacitance change on placing and removing a bluebottle fly (20 mg) on an area of 64mm2, corresponding to a pressure of only 3 Pa.

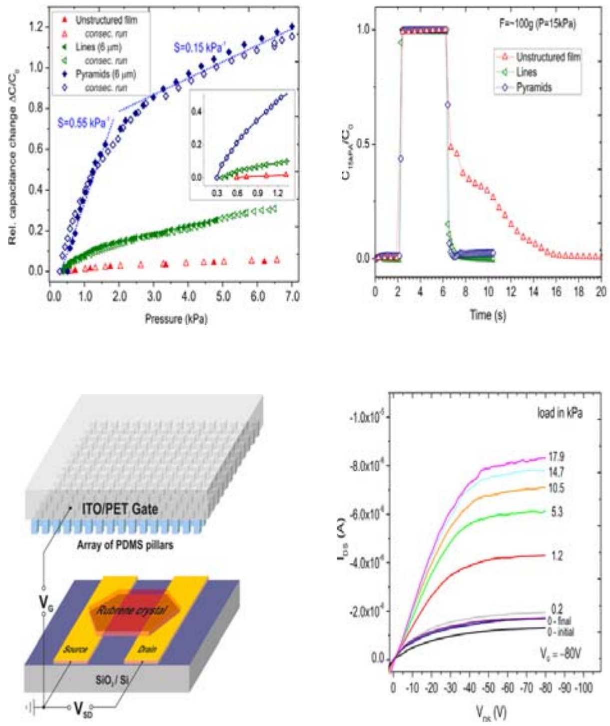


Figure 3. Fabrication array of PDMS Substarte

- Layout of pressure sensing organic single-crystal transistors, consisting of thin rubrene single crystals and micro structured PDMS dielectric films as shown above.
- Output curves of a transistor based sensor with different external pressures applied is also shown in the above graph. The legend lists the applied loads in the order of the original loading cycle

G. Using nano wires, sensor arrays rolled onto a polyimide base:

E-Skin is operated through a complex working principal and construction[7]. The basic technology of the sensor material is a vast network of semiconductor nanowires as shown figure 4. These nanowires are made of germanium and they are rolled onto a polyimide base. This forms a substrate for a rubber film that, when pressure is applied, changes thickness. This change in material thickness is electrically measured through transistors and capacitors. Germanium and silicon are used in the nano wires. This material has good electrical properties and can thus operate at low voltages less than 5 volts.

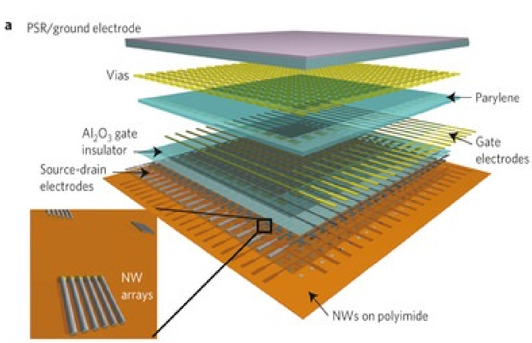


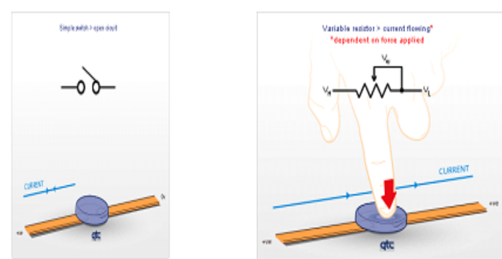
Figure 4. Semiconductor Nanowires

H. A diagram of the construction layers required for E-Skin:

Over the past several years, tremendous progress in the printing and transfer of single-crystalline, inorganic micro- and nanostructures on plastic substrates has been achieved through various process schemes [6]. The 7×7 cm2 integration of parallel Nanowire arrays as the active-matrix back plane of a flexible pressure-sensor array (18×19 pixels) is achieved. The integrated sensor array effectively functions as an artificial electronic skin, capable of monitoring applied pressure profiles with high spatial resolution. The active-matrix circuitry operates at a low operating voltage of less than 5V and exhibits superb mechanical robustness and reliability, without performance degradation on bending to small radii of curvature (2.5mm) for over 2,000 bending cycles. Organic transistors are used to realize a flexible active matrix, which is used to read out pressure images from the sensors. The device is bendable because all of the layers with the exception of the electrodes are made of soft materials.

I. Using quantum tunneling composite material:

Quantum tunneling composite material has a feature of transiting from an electrical insulators into an conductor based on the influence of deformation in the material due to the result of applied mechanical pressure.QTC can be used to produce low profile, low cost, pressure activated switches or sensors that display variable resistance with applied force and return to a quiescent state when the force is removed. And the resistance range. The following figure 5, illustrate the QTC transition from an insulator into a conductor.



Open circuit: Rest state > QTC insulating In unstressed state, QTC behaves as an insulator (R>10[12] Ω).

Closed circuit: Compressed state > QTC conducting Under compression, tension or torsion the resistance drops gradually and controllably. QTC can be capable of passing High currents.

Figure 5. Quantum tunneling composite material

Figure 6. Switching Performance

The Force (N) and Resistance (Ω) the transition from insulator to conductor follows a smooth and repeatable curve as shown in figure 6, with the resistance dropping exponentially. In theory, the resistance of QTC decreases exponentially with compression subsequently, allowing increasing current flow through the material. In practice uniform compression is rarely achieved and therefore the resistance alter with compression will diverge from a true exponential.

J. Robotic sensors implementing the E-skin techno

Robots could soon sense heat and pressure through a flexible e-skin, incorporating a matrix of semiconducting sensors or tactile sensors as shown in the figure 7. A flexible electronic skin that can sense when something is too hot to handle or is being squeezed too hard could give robots an almost-human sense of touch. Robots have mastered picking and placing, welding, and similar tasks that can be precalibrated, but they cannot perform tasks that require a sense of touch, such as biotech wizards have engineered electronic skin that can sense touch, in a major step towards next-generation robotics. New electronic skin could give robots human-like touch. Robotics has made tremendous strides in replicating the senses of sight and sound, but smell and taste are still lagging behind, and touch was thought to be the Impossible [4]. Until new pressure-sensitive electronic skin. New Pressure-Sensitive Electronic Skin Will Give Robots human-like touch. The plates also have six temperature sensors and an accelerometer that allow the machine to accurately register. A new type of electronic skin whose sense of touch rivals that of humans could allow robots to identify an object by the way it feels.

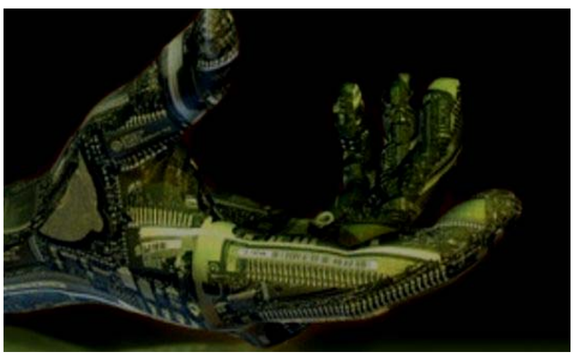


Figure 7.Example of E-Skin post Implementation

Scientists for the Department of Electrical Engineering and Computer Sciences of the University of California at Berkeley have created an electronic skin that can give robots an almost human sense of touch for them. Scientists have figured out how to give robots a sense of touch nearly as sensitive as that of humans. The electronic skin can distinguish extremely subtle texture differences far beyond the capabilities of current robotic. The E-skin is made of QTC material is durable, low cost, flexible integration using very small sensor material profile [6]. The flexible E skin is more sophisticated. The above E.skin fabricated with the PDMS film substrate, flexible sensor arrays, nanowire arrays and the tactile sensors would sense the quantities like pressure and provide the sense of touch to the robot.

III. CONCLUSION

The artificial skin represents a new kind of material that uses an inorganic single crystalline semiconductor to mimic the touch-sensitivity of human skin. The researchers believe further development of this technology could restore the sense of touch in patients with prosthetic limbs. Further advances regarding the integration of electronic sensors with the human central nervous system are needed before this is made possible.

Previous studies conducted to obtain artificial skin were based on organic materials, flexible and easy to treat, unfortunately, weak semiconductor materials are organic, which means that electronic devices built with them would require high voltage circuits to make it work. On the other hand, inorganic materials such as crystalline silicon and can operate at low voltages, in addition to being more stable and chemically[1]. This time, the group of researchers at Berkeley has shown, however, that bands of inorganic materials miniature cables can be very flexible, ideal for making electronic circuits and sensors with high performance. In the near future, the scientists hope to create what they call e-skin, a second layer of skin that would move as a smart health monitoring gadget feature for humans. Thus E-skin would be the new and useful technology in the days to come.

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AUTHORS

Mr.K.Ranganath, Graduated in Computer Science and Engineering from Osmania University Hyderabad, India, in 2006 and M.Tech in Software Engineering from Jawaharlal Nehru Technological University, Hyderabad, A.P., India. He is presently working as Assistant Professor in Department of Computer Science and Engineering, Hyderabad institute of Technology and Management [HITAM], Gowdavally, R.R District, A.P, India. A keen research scholar and has many papers published to his credit. His research interests include Mobile Computing and Data Mining.

P.Krupali, Student of B.Tech III Year**,** Department of Computer Science and Engineering **,** Hyderabad Institute of Technology and Management [HITAM],Gowdavally, R.R District, A.P, INDIA

M.Sravanthy, Student of B.Tech III year CSE , Department of Computer Science and Engineering , Hyderabad Institute of Technology and Management [HITAM], Gowdavally,R.RDistrict,A.P,INDIA.