The exciting E-textile technology

E-textile technology for personal safety and health applications will someday provide smart garments for everyday wear.

SHIKHA NAGPAL

E-textiles known as, electronic textiles, are fabrics that enable computing, digital components and electronics to be embedded in them. Part of the development of wearable technology, they are referred to as intelligent clothing or smart clothing that allow for the incorporation of built-in technological elements in everyday textiles and clothes. While not part of the mainstream form of fashion, its popularity is increasing and more research is being devoted to it

Smart fabrics are ones which can change/react automatically to their surroundings. Smart fabrics (-or intelligent textiles) are being developed to be able to sense what is happening to the wearer or its immediate surroundings.

An example of this would be smart shirt with capacity to know when the wearers heart rate spikes or drops unexpectedly, then being able to send such information to appropriate people.

There is a substantive difference between the terms, Smart and Intelligent, Smart materials or textiles can be defined as the materials and structures which can sense the environmental conditions or stimuli. Whereas intelligent textiles can be defined as textile structures which not only can sense but can also react and respond to environmental conditions or stimuli. These stimuli as well as response, could be thermal, chemical, mechanical, electric or magnetic.

The potential of E-textile

The most exciting development is the potential for textiles to sense and respond to their environments and situations. In particular, integrating sensors and computational devices into fabrics will enable the fabrics to provide a much richer set of capabilities than is currently possible. These electronic textiles (e-textiles) will allow us to build smart garments, as well as home and office furnishings that look and feel like their everyday counterparts while being able to sense our presence, monitor our health, and dynamically adapt to our individual needs.

For the most part, researchers are creating the new capabilities for textiles. While the market is beginning to see the possibilities for intelligent textiles, the technology will only take off when the market drives the deployment of these capabilities in the form of compelling new products.

Types of E-textiles

The field of e-textiles can be divided into two main categories:

• The first category involves mounting classical electronic devices such as conducting wires, ICs, LEDs and conventional batteries into garments.
• The second category involves creating electronic function directly on the textile fibers. These functions can either be passive such as pure wires, conducting textile fibers, or more advanced functions such as transistors, diodes and solar cells. The field of embedding advanced electronic components onto textile fibers is sometimes referred to as fibertronics.
The most common approach to e-textiles today comprise the first category, which is technically the most simple approach, and where even a number of commercial products exists such as textiles with incorporated LED components.
Conductive textile is a fabric which can conduct electricity. Conductive textiles can be made with metal strands woven into the construction of the textile. There is also a interest in semiconducting textiles, made by impregnating normal textiles with carbon- or metal-based powders.
Conductive fibers consist of a non-conductive or less conductive substrate, which is then either coated or embedded with electrically conductive elements, often carbon, nickel, copper, gold, silver, or titanium. Substrates typically include cotton, polyester, nylon, stainless steel to high performance fibers such as aramids and PBO. Straddling the worlds of textiles and wires, conductive fibers are sold either by weight or length, and measured in denier.

Applications

Uses of conductive fibers and textiles include static dissipation, EMI shielding, signal and power transfer in low resistance versions, and as a heating element in higher resistance versions. Their benefits over solid or stranded metal wires come from conductive fibers' flexibility and ability to use in existing textile machinery (weaving, sewing, braiding, etc.)
A very common type of smart fabric is Gore-Tex, called a smart fabric because of its material properties to let water or moisture flow in one direction and not the other.
There is a wide range of applications for E-textiles:
• Technical outdoor apparel (Trekking, mountaineering, special task force etc.)
• Fire Brigade, metal casting industry
• Mining Industry
• Military, law enforcement
• Commercial food-processing protection
• Industrial safety and protection
• Motorcycle apparel and accessories
• Heavy-duty diving suit protection (Coast Guards, adventure sports etc
• Cleaning products (scrub pads, etc)
There are two more modern types of smart fabrics, one using nanotechnology such as carbon nanotubes or fireproof treatments, the other a combination of electronics and conductive fabrics for sensing a persons vital signs.

Material technology

Given the ubiquity of textiles in our immediate environment, textile structures represent an attractive platform for integration and encapsulation of sensing, computing and communication capabilities, in furtherance of the envisioned goal of pervasive computing. The focus on building an intelligent environment into everyday items is leading to the rapid evolution of wearable computers and electronics, which in turn is poised to amply benefit the market for smart fabrics and interactive textiles. The market also stands to benefit from technology developments and innovations in the field of integration of electronic devices into textiles at the yarn level and performance and functionality improvements in integrated textile sensors, switches, interconnects etc. For instance, miniaturization of capacitive fabric sensors enables easy integration into substrate fabrics. In the healthcare sector, efforts are also being directed towards developing nanotechnology-based 3D textile structures called Net Shape Nonwovens (NSNs), the porous nature of which enhances cell growth and thereby acting as bone substitutes.
Noteworthy innovations in the marketplace till date includes photovoltaic fabrics for use in photovoltaic structures such as, solar-powered tents, canopy covers for parking lots, charging stations, awnings for solar shadings, sailboat sails, truck tarp, boat

E-textile - the most robust growth in the near future is likely to occur in sports, home health monitoring, emergency response and personal protective equipment. These application areas require sensing and giving feedback to the user, which can be provided by an intelligent textile, and all of them can bear higher costs if there is a clear benefit.

covers etc, and illuminated fashion for the consumer market comprising of illuminated textiles containing hundreds of LEDs embroidered onto the fabric. Other innovations include smart bandages, based on stretchable circuit technology, to detect the presence of specific proteins in the wound, thereby monitoring the healing process. Smart shoe insoles detect pressure marks in diabetic patients for preventing ulcers and wounds. Respiratory sensors incorporated in baby clothes to help prevent crib death. Newer avenues for growth will stem from emerging applications such as in the military, construction, transportation, and healthcare among others.

Power Sources

E-textile applications with integrated electronic functions typically use batteries as a power source. These applications can already be designed to have very limited power consumption, but existing battery technologies are often bulky, relatively weighty and lack flexibility in relation to the soft drape of materials used in wearable applications. Since the rationale for integration of these functions into a garment is often that they are always at hand and never forgotten, then ideally the power supply should also be seamlessly integrated as part of the product, without the need for human intervention to recharge or change batteries (energy autonomous systems). The desire for autonomous self-powered systems has led to considerable research into systems that harvest or scavenge energy from the garments wearer. Human energy is primarily stored as fat (other energy forms are very limited) and is first available for harvesting during metabolism when it is converted into heat and movement. On average, muscles convert just 25% of chemical energy to mechanical movement, while the remaining 75% is dissipated as heat. As a result, potential energy which can be harvested using piezoelectronic or mechanical technologies is extremely limited.

Solar Power Source

Solar cells are the preferred devices as the energy harvesting technology. While the efficiency of such cells has increased so that they can generate useful power from indoor lighting, glass or crystalline silicon-based devices can be heavy. However, a new generation of amorphous flexible cells is becoming increasingly popular to integrate into clothing to supply power.
One such example comes from researchers at the Australian National University, who have developed a thin, flexible solar panel called Sliver Cell. The technology has been developed for military use as wearable solar panels to power equipment and creates a step to more rugged yet flexible cells.

Piezoelectronics

In principle, mechanical energy may be harvested from any human movement, whether generated by muscles or gravity. Focus for many wearable technologies is on size, and although developments in MEMS (Micro-Electro-Mechanical Systems) technology have made it possible to reduce mechanical generator units to a size that makes their integration in smart garments feasible, their very small size also means that mechanical moving elements are limited in weight and movement and as a result operate at relatively high resonance frequencies (10 kHz) while human movements have a typical frequency of maximum 10Hz.

Thermal harvesting

Since muscles are relatively inefficient converters of chemical to mechanical energy, a substantial amount of energy used during physical activity is released as heat. The process involved in scavenging energy from heat is based upon the Seebeck effect which defines output voltage as proportional to the temperature difference between two materials. Since differences in body temperature are limited, out-put voltages of 25 - 50mV are typical using a 10cm2 thermal harvester. Body-worn applications thus far have shown ultra-low output voltages in the region of 10's of milli-volts and the horizon for commercially mature and viable technologies is distant.