ELECTRONICS IN TEXTILES

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Abstract:

E-textiles have greater flexibility in adapting to changes in the computational and sensing requirements of an application. The number and location of sensor and processing elements can be dynamically tailored to the current needs of the user and application, rather than being fixed at design time. Electronic textiles, also described as smart fabrics in popular media, have become quite a fashionable research area. This paper gives the application area of electronics in textile.

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Introduction

While wearable computers are empowering fashion accessories, clothes are still the heart of fashion, and as humans, we prefer to wear woven cloth against our bodies. The tactile and material properties of what people wear are important to them, and people are reluctant to have wires and hard plastic cases against their bodies. Electronic textiles, or e-textiles, have attracted considerable attentions worldwide due to their potential to bring revolutionary impacts on human life. Electronic textiles (e-textiles) are fabrics that have electronics and interconnections woven into them. Components and interconnections are a part of the fabric and thus are much less visible and, more importantly, not susceptible to becoming tangled together or snagged by the surroundings. Consequently, e-textiles can be worn in everyday situations where currently available wearable computers would hinder the user. An electronic textile refers to a textile substrate that incorporates capabilities for sensing (biometric or external), communication (usually wireless), power transmission, and interconnection technology to allow sensors or things such as information processing devices to be networked together within a fabric. This is different from the smart textiles that feature scientific advances in materials research and include things such as better insulators or fabrics that resist stains. Electronic textiles allow little bits of computation to occur on the body. They usually contain conductive yarns that are either spun or twisted and incorporate some amount of conductive material (such as strands of silver or stainless steel) to enable electrical conductivity. [1] [2]

Materials Used in Electronic Textiles

1) Phase Change Materials

Every material absorbs heat during a heating process, while its temperature is rising constantly. The heat stored in the material is released into the environment through a reverse cooling process. During the cooling process, the material temperature decreases continuously. A normal textile material absorbs about one kilojoule per kilogram of heat, while its temperature rises by one degree Celsius. Comparing the heat absorption during the melting process of a phase change material (PCM), with those in a normal heating process, a much higher amount of heat is absorbed, if a PCM melts. A paraffin-PCM absorbs approximately 200 kilojoules per kilogram of heat, if it undergoes a melting process. In order for a textile to absorb the same amount of heat, its temperature would need to be raised by 2000 K. The high amount of heat absorbed by the paraffin in the melting process is released into the surrounding area in a cooling process starting at the PCM's crystallization temperature. After comparing the heat storage capacities of textiles and PCM, it is obvious that by applying paraffin-PCM to textiles, their heat storagecapacities can be substantially enhanced. During the complete melting process, the temperature of the PCM as well as its surrounding area remains constant. During the entire crystallization process, the temperature of the PCM does not change either. The high heat transfer during the melting process as well as the crystallization process without temperature change makes PCM an area of interest for the heat storage. In their application in textiles, the paraffins are either in solid or liquid state. In order to prevent the paraffin's dissolution, while in the liquid state, it is enclosed into small plastic spheres with diameters of only a few micrometers. These microscopic spheres containing PCM are called PCM-microcapsules. The microencapsulated paraffin is either permanently locked in acrylic fibres and in polyurethane foams or coated onto the surface of a textile structure. [1] [3]

2) Shape Memory Materials

Shape memory alloys, such as nickel-titanium, have been developed to provide increased protection against sources of heat. A shape memory alloy possesses different properties below and above the temperature at which it is activated. Below this temperature, the alloy is easily deformed. At the activation temperature, the alloy exerts a force to return to a previously adopted shape and becomes much stiffer. The temperature of activation can be chosen by altering the ratio of nickel to titanium in the alloy. Cuprous-zinc alloys are capable of a two-way activation and therefore can produce the reversible variation needed for protection from changeable weather conditions. They will also react to temperature changes brought about by variations in physical activity levels. Shape memory polymers have the same effect as the Ni- Ti alloys, but being polymers, they will potentially be morecompatible with textiles. The first SMPs were polynorborene-based with a Tg range of 35°C to 40°C developed by a French Company. Later, several classes of SMPs based on mix of Styrene, Butadiene, Polyethylene Terephtalate, PolyetyleneOxyde, Polyurethane, Polycaprolactone were developed with Tg from -46°C to 125°C, for widening of application. Electro active polymers EAPs are generally made up of high functionalised polymer. [3]

3) Chromic Materials

Photochromic materials are generally reversible unstable organic molecules, that changes molecular configuration with the influence of a special radiation. The molecular arrangement also perturbs the absorption spectra of the molecule and in consequences, its colour. The applications in textile are intended to the fashion area and only a few for the solar protection. Thermochromic materials are those, whose colour changes as a result of reaction to heat, especially through the application of thermo-chromic dyes, whose colours change at particular temperatures. Two types of thermochromic systems that have been used successfully in textiles are: the liquid crystal type and the molecular rearrangement type. In both cases, the dyes are entrapped in microcapsules and applied to fabric like a pigment in a resin binder. The most important types of liquid crystal for thermochromic systems are the so called cholesteric types, where adjacent molecules are arranged so that they form helices. Thermochromism results from the selective reflection of light by the liquid crystal. [3]

4) Luminescent Materials

There are two types of photoluminescent materials, organic and mineral. The organic photoluminescent are rigid compounds (molecular or polymeric), which possess a good molecular conjugation and relaxation mode to allow for the emission of a photon. There are also mineral photoluminescent materials, such as some rare earth (europium, iridium). Photoluminecent materials are generally used in textiles for application in dress for a night club and more interestingly in the marking of labels with UV revelation materials for the detection of imitation goods and the security label. Phosphorescent materials have been applied in inks, which can store light and are used in working clothes for road works/repairs in bad-light situations, or for marking arrows on carpets to guide people during a power failure. The obtained effect is generally known as glow in the dark. Opticoluminescence is the typical effect encountered in optical fibres. The use of these kinds of technical fibres is now implanted for manufacturing textiles that emit light. There are also applications with optical fibres at the development stage for the creation of screens. As for photoluminescent materials, electroluminescent materials could be also organic (molecular or polymeric) compounds or mineral materials. Electroluminescent compounds are, for this time, little used in textiles. [3]

5) Conductive Materials

There are two strategies to create electrical or thermal conductive fabrics and two types of materials are being used; metals and polymers. The same materials could be used for the both conductivity (thermal and electrical), because the two processes are similar and results of an electronic agitation/conduction. The first strategy uses high wicking finishes (ink) with a high metallic content that still retains the comfort required for clothing. With the addition of nickel, copper, silver or carbon coatings of varying thickness, these finishes provide a versatile combination of physical and electrical properties for a variety of demanding applications. The second strategy consists in the direct use of conductive yarns. The yarn could constitute metal such as silver, copper or conductive polymer such as poly thiophene, polyaniline and their derivatives. Although there are many different trademarks commercializing these materials, they all have the same main properties. They are lightweight, durable, and flexible and cost competitive and they are able to be crimped and soldered and subjected to textile processing without any problems. [3, 4, 5]

6) Membranes

Multi-disciplinary research led to the successful development of the cutting-edge technology of laminating a variety of microporous or hydrophilic membranes. The membranes are constituted of polymers and their structure could be made of one or more layers (until 6 layers), according to the wanted properties. Membranes are deposited on textiles in order to add new properties onto their surfaces. The polymers used in the membranes may be of several natures such as biopolymer (generally cellulosic), or synthetic as the ployfluorocarbon or the polyurethanes & theirs derivatives. [3, 4, 5]

Electronics in textiles

1. Photonic textiles

One of the most interesting new developments to go on display is the demonstration of the developments with photonic textiles-fabrics that contain lighting systems and can therefore serve as displays**.** At first glance, objects such as clothing, towels, upholstery, and drapes would seem unlikely places on which to place intelligent and interactive systems. Yet these low-tech objects figure prominently in our lives. By integrating flexible arrays of multicolored light-emitting diodes into fabrics and doing so without compromising the softness of the cloth.

To meet the challenge of creating light-emitting cloth objects that retain their softness, researchers have developed an interconnecting substrate made entirely of cloth. On these substrates, the researchers have placed passive matrices of compact RGB LED packages. The pixilated luminaries with relatively large distance between the RGB pixels have been embedded in such everyday objects as cushions, backpacks, and floor mats.

Since the fabric material covering the miniature light sources naturally diffuses light, each pixel seems bigger than it actually is. The LEDs, therefore, remain small and unobtrusive, while the fabric retains its soft look and feel.

Photonic textiles can also be made interactive, by incorporating sensors (such as orientation and pressure sensors) and communication devices into the fabric. It can also be used to ensure the safety of road workers and bike riders. [1, 6, 7]

2. LED Ballet Shoes

The ballet shoes and accompanying leg-warmers contain LEDs, a soft switch, a power accumulator and a power generator, connected through conductive threads. Dancing illuminates the LEDs creating a sense of satisfaction and wonder. The more the dancer dances, the more light and well-being is created. The Ballerina is now given the chance to illuminate herself, if only for a moment, creating a moment of contemplation and surprise. The underlying principles of human-powered illumination represented also helps to bring to the surface issues of power-conservation and alternative energy sources. [1, 8, 9]

Fig1. LED Shoes

3. Speedo Fabric (Shark Skin)

Speedo Intentional, Japan has developed mimic of shark skin which ensures easy swimming. In case of the swimwear, drag is the major criteria for performance. The sharkskin is made from specially developed polyamide and Lycra fibre coated with Teflon to prevent water penetration. Also this fabric is knitted with 3-dimenssional V- shaped groove with 3-D knitting principal. With help of this V-shaped groove the friction between water and swimmer is negligible and drag up

Fig.2 Speedo Fabric

to zero. So this increases the efficiency of the swimmer by 8-10%. [8, 10]

4. Smart Interiors

SOFT switch allows switching and pressure sensing to be incorporated invisibly into interior textiles in the home or office to control lighting, security, temperature or other electronic appliances. For example, light switches/dimmers can be integrated into seating upholstery or carpets. Audio- visual remote controls can be incorporated into soft furnishings. Interior environmental conditions can be changed using wearable switches or by touching wall coverings. Using SOFT switch fabrics as sensors it is possible to monitor the occupancy of interior spaces as a means of saving energy. [1, 10]

Fig 3.Smart Switch

5. MP3 player woven into the fabric

The electronics of the MP3 player are directly integrated in the fabric of clothing and is packaged to withstand even a washing of the clothing without being damaged. These integrated components are encapsulated in robust plastic enclosures and can be washed in washing machines. Outfitters and clothes manufacturers can sew the washable MP3 package directly in their clothing. The entire MP3 player including the microprocessor for voice control is integrated in a tiny chip. A replaceable multimedia card is used to store the music titles. [8, 9, 10]

6. Musical Fabrics

A whole new generation of truly soft toys is possible using SOFT switch fabric sensors. Electronic music interfaces such as fabric pianos or wearable percussions pads provide new ways of interacting and creating sound. [8, 9, 10]

Fig. 4 Musical Fabrics

7. **Sign Language Console**

SLC acts as a bridge between people with hearing & speech impairment and rest of the world. When a person with this kind of handicap tries to communicate through sign made by hand gestures, SLC senses the movement of the hand and fingers; interprets these movements and displays the corresponding word on the display unit. The entire SLC consists of two modules (Fig.5).

1. The glove unit (hand unit)

2. The console unit (ground unit).

Both the modules interact through wireless connections (Fig.6). The glove unit carries the sensors mounted on each finger to detect position of the fingers, and an accelerometer to sense motion of the hand. The output of the sensors is converted into digital form and is transmitted to the console unit by using an RF trans-receiver module, which is also mounted on the glove. By combining the sensor output of each finger and the output signal of the accelerometer, we derive the information signal, which is used by the microcontroller to detect the sign. The microcontroller in the console-unit compares the received data with the data, which is already stored in the memory while calibrating the console. When a perfect match is found, the meaning of the corresponding gesture i.e. a word is displayed on the display device. [2, 8]

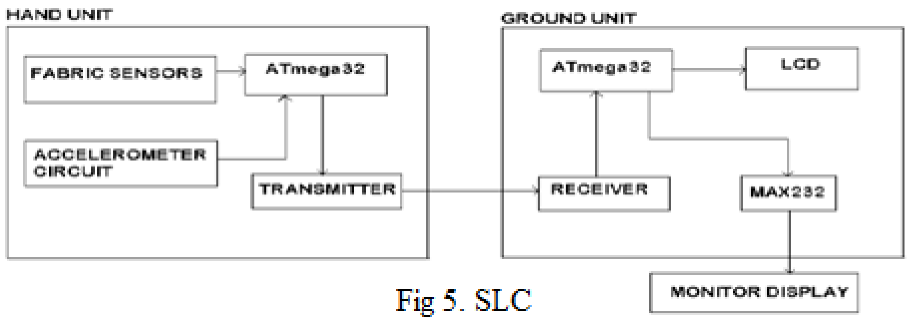

Fig 5. SLC

Hand Glove with fabric

Device to convert into sign langauge

Fig 6. Example of SLC

8. Textile Antennas

The idea was to manufacture the antenna by weaving thin conductors into the parachute fabric. In principle, the technological challenges of integrating an antenna element into parachute fabric are not especially great. The problem is that shape is all important for the radiation properties and since the parachute antenna will be used to pick up very weak signals from a space probe even small distortions will affect transmission. Today, electrically conductive clothing is already used to protect from EMC for example –

Fig 7. Textile Antennas

from unwanted electronic signals or static electricity. But the dream is to be able to make clothing that can be used to measure, process and send information about the body's functions. Being close to the body, clothes enable an excellent and intimate man-machine interaction. In fact, the vision for 'electronic textiles' goes one step further; 'Electronic' means that textiles are capable of exchanging information. And as soon as textiles can autonomously record, analyze, store, send and display data, a new dimension of intelligent high-tech clothing will be reached. [11]

Conclusion

A few years ago, e-textiles were presented as imaginary products and as a non-competitive market. After scientific efforts and development phases, nowadays E-textiles are an implanted customer interest and are presented as the future of the textile industry. A lot of commercial products are available and a lot of scientists are developing new solutions, ideas and concrete products. Their usefulness is unquestionable and cost is worth paying compared to the quality of the service received. Manufacturing them commercially may have good scope, if we take initiative ahead of others.

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