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An Overview of Smart and Intelligent Textiles

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ABSTRACT

Humans are close to textiles more than anything, and certainly we carry it most, other than anything. The last few decades have shown enormous growth in the development of wireless communication technologies, nanoengineering, information technologies, and miniaturization of electronic devices. These developments draw the attention of researchers to envisage the significant characteristics of these advancements to the belongings with whom we are most close to. Since the last 20 years, the developments of new kinds of textiles called smart and interactive textiles emerged to the globe. Recently published Literatures, books and journals on the fields of textiles, electronics, information technology, advanced materials and polymers indicate that Smart textile materials and their application will boom in the near future. They are not dreams any longer. Two decades have elapsed since they become one part of the modern technology of clothing, being on the shelves of the apparel and fashion markets. They are everywhere; from geo textiles in the soil to the outer space in the expedition of the universe; from the hospitals beddings and clothing's to the entertainments; and from the personal healthcare to sportswear applications. Smart and interactive textiles are fibrous structures that are capable of sensing, actuating, generating/storing power and/or communicating. Research and development towards wearable textile-based personal systems allowing e.g. health monitoring, protection & safety, and healthy lifestyle gained strong interest during the last 10 years. This work aims to make a look on the literature overview of these incredible, dynamic and very important objects.

Key Words : Smart textiles, Interactive textiles, Wearable antennas, Smart materials

INTRODUCTION

Since the nineteenth century, revolutionary changes have been occurring at an unprecedented rate in many fields of science and technology, which have profound impacts on every human being. Inventions of electronic chips, the Internet, the discovery and complete mapping of the human genome, and many more, have transformed the entire world. The last century also brought tremendous advances in the textile and clothing industry, which has a history of many thousands of years. Solid foundations of scientific understanding have been laid to guide the improved usage and processing technology of natural fibres and the manufacturing of synthetic fibres. We have learnt a lot from nature. Viscose rayon, nylon, polyester and other synthetic fibres were invented initially for the sake of mimicking their natural counterparts. The technology has progressed so that synthetic fibres and their products surpass them in many aspects. Biological routes for synthesizing polymers or textile processing represent an environmentally friendly, sustainable way of utilizing natural resources. Design and processing with the aid of computers, automation with remote centralized or distributed control, and Internet-based integrated supply-chain management systems bring customers closer to the very beginning of the chain than ever before.

In the last few years the marvelous advancement of smart materials and electronics brought intrinsic potentiality in the field of textile technology for innovative high-tech applications, covering market segments that are far away from conventional textile world. One of the best examples is the recent development of new sensing

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and intelligent cloths (Gould, 2008).

Smart and interactive textiles are a budding interdisciplinary field that brings together specialists in information technology, micro systems, materials, and textiles. The focus of this new area is on developing the enabling technologies and fabrication techniques for the economical production of flexible, conformable and, optionally, large-area textile- based information systems that are expected to have unique applications for different end uses. The smart and interactive textiles will be highly applied in the next generation of fibers, fabrics and articles produced from them (Park and Jayaram, 2010)

Many intelligent textiles are already in the global market in all kinds of available opportunities and applications including casual clothing, medical textiles, in the military, in protective and safety garments, as well as in the expedition of the space (Finlay *et.al.,* 2008). The exiting integration and combination of advanced tools with advanced smart materials create a bright tomorrow for dynamic textile market on the entire world.

Smart materials and structures can be defined as the materials and structures that sense and react to environmental conditions or stimuli, such as those from mechanical, thermal, chemical, electrical, magnetic or other sources. According to the manner of reaction, they can be divided into passive smart, active smart and very smart materials. Passive smart materials can only sense the environmental conditions or stimuli; active smart materials will sense and react to the conditions or stimuli; very smart materials can sense, react and adapt themselves accordingly. An even higher level of intelligence can be achieved from those intelligent materials and structures capable of responding or activated to perform a function in a manual or pre-programmed manner. Three components may be present in such materials: sensors, actuators and controlling units. The sensors provide a nerve system to detect signals, thus in a passive smart material, the existence of sensors is essential. The actuators act upon the detected signal either directly or from a central control unit; together with the sensors, they are the essential element for active smart materials. At even higher levels, like very smart or intelligent materials, another kind of unities essential, which works like the brain, with cognition, reasoning and activating capacities. Such textile materials and structures are becoming possible as the result of a successful marriage of traditional textiles/clothing technology with material science, structural mechanics, sensor and actuator technology, advanced processing technology, communication, artificial in-telligence, biology, etc.

Distinct types of smart fibres:

There are actually four distinct types of smart fibres

Passive Smart fibres:

Where the clothing "reads" or senses the environment or something about the person wearing the clothing. Wearable sensors fall into this category, with examples including built-in GPS, clothing-integrated baby breathing monitors, and clothing that gives feedback about potential changes in weather.

Active Smart fibres:

Where clothing not only senses the environment, but also reacts to it. Examples include: Clothing that changes density depending on the temperature outside, jackets that store solar energy that can be used to charge cell phones and cameras, and even built-in sensors that can guide pinpoint massage to a wearer that is regulated depending on his or her level of stress.

Active very smart fibres:

Where clothing has built in computing and or intelligent sensing capacity. Examples include sleeves that function as keyboards for a small handheld device, clothing that can function like a powerful calculator or PDA, and shirts that can store information through a built-in fabric keyboard and send it via Bluetooth to a computer.

Ultra Smart Textiles:

Very smart textiles are the third generation of smart textiles, which can sense, react and adopt themselves to environmental conditions or stimuli. A very smart or intelligent textile essentially consists of a unit, which works like the brain, with cognition, reasoning and activating capacities. The production of very smart textiles is now a reality after a successful marriage of traditional textiles and clothing technology with other branches of science like material science, structural mechanics, sensor and actuator technology, advance processing technology, communication, artificial intelligence, biology, etc.

New fibre and textile materials, and miniaturised electronic components make the preparation of smart textiles possible, in order to create truly usable smart clothes. These intelligent clothes are worn like ordinary clothing, providing help in various situations according to the designed applications (Fraile and Bajo, 2010).

New/Smart Materials and Fibres used in Smart textiles :

'Smart' or 'Functional' materials usually form part of a 'Smart System' that has the capability to sense its environment and the effects thereof and, if truly smart, to respond to that external stimulus via an active control mechanism. Smart materials and systems occupy a 'Technology space', which also includes the areas of sensors and actuators.

Shape memory materials:

Are polymeric smart materials that have the ability to return from a deformed state (temporary) to their original (permanent) shape induced by an external stimulus (trigger) such as temperature change.

There are two types of Shape Memory Materials. The first classes are materials stable at two or more temperature states. In these different temperature states, they have the potential to assume different shapes, when their transformation temperatures have been reached. This technology has been pioneered by the UK Defence Clothing and Textiles Agency.

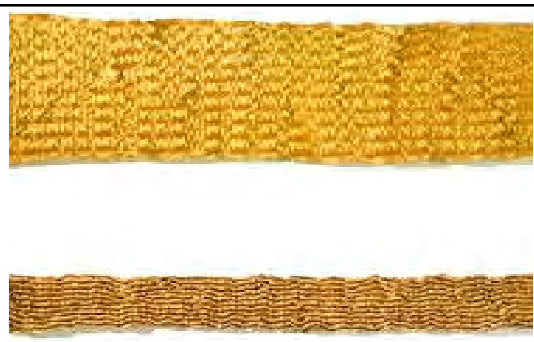

Fig. 1 : Shape Memory Materials

The other types of shape memory materials are the electro active polymers, which can change shape in response to electrical stimuli. In the last decade there have been significant developments in electro active polymers (EAPs) to produce substantial change in size or shape and force generation for actuation mechanisms in a wide range of applications. In contrast to many conventional actuation systems, many types of EAPs are also capable of providing sensing functions. EAPs can provide a range of basic actuator mechanisms, force and displacement levels.

Chromic materials:

Other types of intelligent textiles are those, which change their colour reversibly according to external environmental conditions, for this reason they are also called chameleon fibres. Chromic materials are the general term referring to materials which radiate the colour, erase the colour or just change it because its induction caused by the external stimulus, as "Chromic" is a suffix that means colour. Therefore we can classify chromic materials depending on the stimulus affecting them in bold are indicated those used in textile).

Photochromic: external stimulus is light

Thermochromic: external stimulus is heat

Electrochromic: external stimulus is electricity

Piezorochromic: external stimulus is pressure.

Solvatechromic: external stimulus is liquid or gas.

Fig. 2 : Thermachromic Shirt

Fig. 3 : Thermochromic Crocs

Membranes materials:

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 theirs surfaces. The polymers used in the membranes may be of several natures such as biopolymer (generally cellulosic), or synthetic as the ployfluorocarbone or the polyurethanes and theirs derivatives.

One of the main applications of membranes is in the field of sportswear for the manufacture of breathable and impermeable clothes. Indeed, with a simple system of membrane, fabrics possessing an excellent water exchange are obtained with a good elimination of the sweat at the garment interface (breathability) and the creation of an external barrier with extreme water repellence.

Fig. 4 : Water repellent textile surface

Photovoltaic materials:

The photovoltaic effect has been discovered in 1839 by Becquerel. Photovoltaic materials possess the property to generate electric current by means of a light excitation. The mechanisms of electricity generation could be effectuated by two processes. The first way is the separation of charges at a p-n junction in a device. The materials used are semiconductor and are generally based on doped silicon. At the p-n junction, electrons and holes are separated and form an electric current in the bulk of semiconductor. The extraction from the devices of both species by means of appropriated electrodes allows the generation of the electricity. The second way is the inverse process of electroluminescence.

The main application of solar cells in textile is the electric alimentation of integrated electronic devices, e-textile. The alimentation could be made directly from the solar cell to the devices, but the majority of encountered solutions are using of solar for charging batteries that could deliver energy to the appropriate device; recharging mobile phone, Mp3 player. Nowadays, a new field of investigation consists in the deposition of photovoltaic devices on textile substrates.

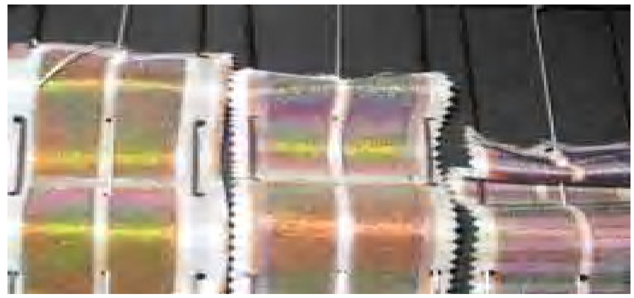

Fig. 5: PhotoVoltaic cells

Fig. 6: PhotoVoltaic cells on textile

Luminescent materials:

The difference between chromic and luminescent materials is that, the first one changes colour, when the second one emits, on subjected to stimulus.

There are several types of luminescent effects;

- **Optic luminescence:** conduction of light.
- **Electroluminescence:** external stimulus is electricity.
- **Chemioluminescence:** external stimulus is chemical reaction.
- **Triboluminescence:** external stimulus is friction.

There are two types of photo luminescent materials, organic and mineral. Photo luminescent 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 Optic luminescence 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 photo luminescent materials, electroluminescent materials could be also organic (molecular or polymeric) compounds or mineral materials. Electroluminescent compounds are, for this time, little used in textiles. The most common application electroluminescent yarn (constituted by mineral compounds) in the area of fashion garments and also for high visibility protection equipments. However, the electroluminescent phenomena is now one of the most studied in the area of smart textiles, after the emergence of the organic light emitting diodes, which possess a flexible character and that are envisaged for the manufacture of flexible screens adequate for the wearable computer.

Fig. 7: Luminescent material

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

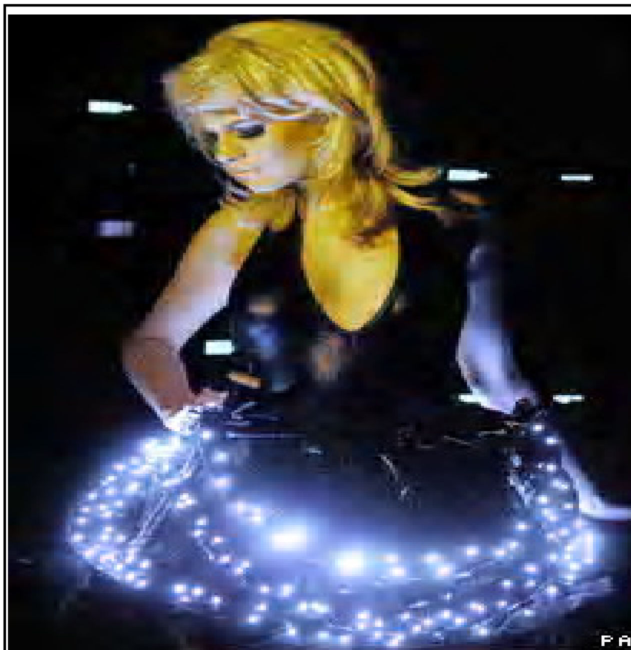

Fig. 8: Glow in the dark textiles

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 trade marks commercialising these materials, they all *have* the same main properties. They are lightweight, durable, flexible and cost competitive and they are able to be crimped and soldered and subjected to textile processing without any problems.

Conductive fibres braided into a shield or sock offer superior performance against electromagnetic interference, antistatic and also they present various advantages. These materials increases thermal conductivity, using metal over conventional polymers and are used in clothing offers sports apparel with the minimum of thermal insulation. Another type of fibres included in this group is carbon fibre. The structure of these materials offers the capability of reading the location, within a fabric sheet, of a pressure point (such as a finger press). It is possible to incorporate this function into an elastic sheet structure, allowing the sheet to conform to many 3-D shapes, including compound curves, while still accurately measuring an X-V position. Readings can be obtained from smart fabric according to force and area. This allows the user to differentiate between separately identified inputs ranging from high-speed impact to gentle stroking.

Fig. 9 : Conductive material

Example For Smartfabrics:

Wearable antennas:

In a program for the US Army, Foster-Miller integrated data and communications antennas into a soldier uniform, maintaining full antenna performance, together with the same ergonomic functionality and weight of an existing uniform. They determined that a loop-type antenna would be the best choice for clothing integration without interfering in or losing function during operations, and then chose suitable body placement for antennas.

Fig. 10 : Army cloth with integrated communication antenna

With Foster-Miller's extensive experience in electro-textile fabrication, they built embedded antenna prototypes and evaluated loop antenna designs. The program established feasibility of the concept and revealed specific loop antenna design tradeoffs necessary for field implementation. The program aimed at developing soldier ensemble of the future, which will monitor individual health, transmit and receive mission-critical information, protect against numerous weapons, all while being robust and comfortable.

Georgitech wearable motherboard (GTWM):

Georgi Tech developed a "Wearable Motherboard" (GTWM) which was initially-itended for use in combat conditions. The Sensate Liner for Combat Casualty Care uses optical fibres to detect bullet wounds and special sensors that interconnects in order to monitor vital signs during combat conditions.

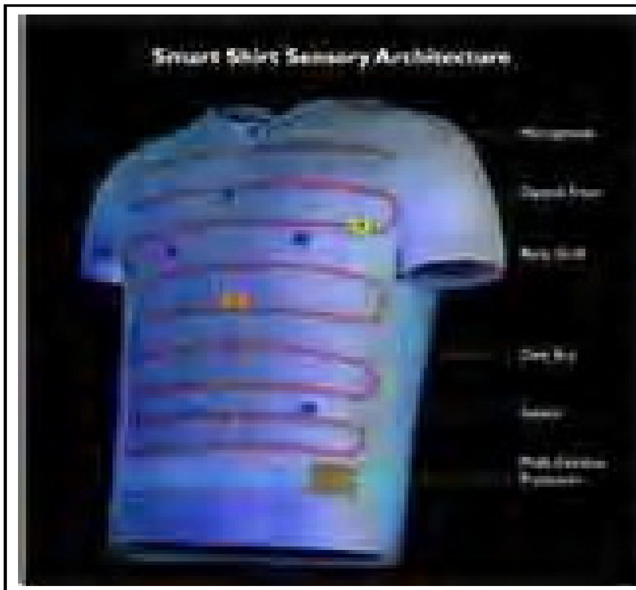

Fig. 11 : Smart shirt

Medical sensing devices that are attached to the body plug into the computerised shirt creating a flexible motherboard. The GTWM is woven so that plastic optical fibers. And other special threads are integrated into structure of the fabric. There are no discontinuities in the GTWM. The GTWM is one piece of fabric, without seams. Because the sensors are detachable from the GTWM, they can be placed at any location, and is therefore adjustable for different bodies. Furthermore, the types of sensors used can be varied depending on the wearer's needs. Therefore, it can be customized for each user. For example, a fire-fighter could have a sensor that monitors oxygen or hazardous gas levels. Other sensors monitor respiration rate and body temperature or can collect voice data through a microphone. GTWM identifies the exact location of the physical problem or injury and transmits the information in seconds. This helps to determine who needs immediate attention within the first hour of combat, which is often the most critical during battle

The Value Added by GTWM:

The GTWM is a breakthrough technology because it is the first unobtrusive and non-invasive way of monitoring vital statistics. Furthermore, the GTWM is worn comfortably underneath clothing, like an undershirt, and can be sized to fit avariety of people. Therefore, it is flexible and customizable to the wearer. Another interesting feature of the GTWM is that it is washable.

The GTWM could be classified as a wearable computing device. Once the wearer has plugged the sensors into the GTWM, he or she proceeds as if wearing any other item of clothing. It is intended to be as unobtrusive as possible, and no direct manipulation of the device is required once the initial setup is completed It is unlike other wearable computers in that it is nearly invisible since it is worn underneath normal clothing with fire-fighter groups, doctors and others in order to create "wearable motherboards," that meet their different needs The commercial applications for the "Smart Shirt" are: in figure

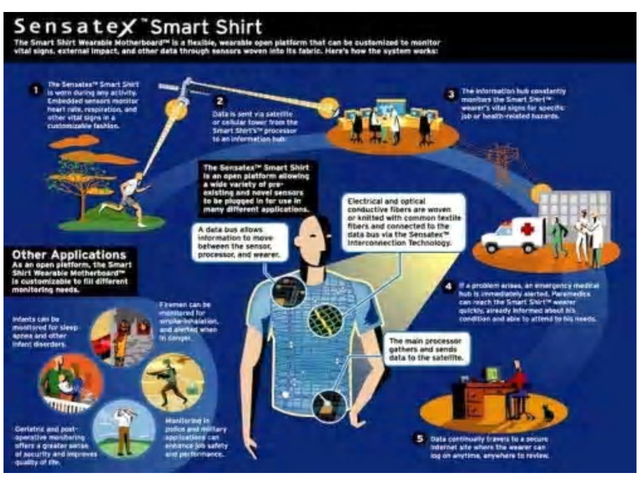

Fig. 12 : Commercial applications for the "Smart Shirt

Scenarios of Use for the Smart shirt:

– Medical Monitoring
– Disease Monitoring
– Infant Monitoring
– Obstetrics Monitoring
– Clinical Trials Monitoring
– Athletics
– Biofeedback

Limitations and Issues of the Smart Shirt :

Some of the wireless technology needed to support the monitoring capabilities of the "Smart Shirt" is not completely reliable. The "Smart Shirt" system uses Bluetooth and WLAN. Both of these technologies are in their formative stages and it will take some time before they become dependable and widespread.

Conclusion:

What smart fabrics cannot is not as important as what it can. This intelligent textiles have managed to pervade into those places where you least expect to find them. It will get hold of your rhythm like a lover. It will enlighten your ways like a mentor. It will care for you like a mother. It will be cautious like a friend. The smart-wears will definitely make you feel in good company, how alone you maybe. One day we may correct Seneca(of his saying As often I have been with men, I have come back less a man´, and suggest that As often I have been in a smart-wear, I have come back wiser a man´.

One day will our senses become superfluous?

REFERENCES

Borges, L.M., Rente, A., Velez, F.J., Salvado, L.R., Lebres, A.S., Oliveira, J.M. and Ferro, J. (2008). Overview of progress in smart-clothing project for health monitoring and sport applications. ISAVEL '08, October 25-28.

Cha, J., Eid, M., Rahal, L. and Saddik, A.E. (2008). HugMeL : An Interpersonal Haptic Communication System, HAVE 2008, Ottawa, 18-19 Oct., pp. 99-102.

Finlay, D.D., Nugent, C.D., Donnelly, M.P., McCullagh, P.J. and Black, N.D. (2008). Optimal Electrocardiographic lead systems: practical scenarios in smart clothing and wearable health systems. *IEEE Transactions on Information Technology in Biomedicine*, **12** (4) : 433-441.

Fraile, J.A., Bajo, H. *et al.* (2010). Applying Wearable Solutions in Dependent Environment. *IEEE Transactions on*

Information Technology in Biomedicine, **14** (2) : 45-49.

Gould, P. (2008). Textiles gain intelligence, Materials Today, October 2003-tion System", HAVE 2008, Ottawa, 18-19 Oct, pp. 99-102.

Park, S. and Jayaraman, S. (2010). Smart Textile-Based Wearable Biomedical Systems: A Transition Plan for Research to Reality, *IEEE Transactions on Information Technology in Biomedicine*, **14** (1) : 86-92.

http://www.sensatex.com

http://www.abcnews.go.com/sections/living/DailyNews/bodysensor000919.html

http://www.tdctrade.com/imn/imn177/gallery.htm

http://www.wearcam.org/personaltechnologies/index.html

http://www.philipsdesign.com

http://www.softswitch.com

http://www.sensatex.com

http://www.avantex.com

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