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TECHNIQUES AND APPLICATION OF SMART TEXTILES

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Abstract- Smart textiles are fabrics that have been designed and manufactured to include technologies that provide the wearer with increased functionality. Though industrial exploitation of smart textile systems is still in its infancy, the technological implementation is increasing. These textiles have numerous potential applications, such as the ability to communicate with other devices, conduct energy, transform into other materials and protect the wearer from environmental hazards. The smart textiles are wearable and has many potential material are available in the market. It also offers highly conductive fabric with excellent flexibility. The fabrics are made from different metals which produce different stretchable fabric. Among them the Phase change materials (PCM) take advantage of latent heat that can be stored or released from a material over a narrow temperature range. PCM possesses the ability to change their state with a certain temperature range. This is the result of substantial research and development investments directed towards this emerging field. In order to stimulate the progress in smart textiles, emerging developments need to be identified and selectively strengthened.

Keywords: PCM, smart textiles, technology, potential, research development

Introduction

The original function of textiles was to shield man from cold and rain. Later on in history aesthetic aspects also came to play a role in clothing. Much more recently a new generation of textiles has arisen; smart and interactive textiles. Smart textiles are defined as textiles that can sense and react to environmental conditions or stimuli, from mechanical, thermal, magnetic, chemical, electrical, or other sources. They are able to sense

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and respond to external conditions (stimuli) in a predetermined way. Textile products which can act in a different manner than an average fabric and are mostly able to perform a special function certainly count as smart textiles.

Classification of Smart Textiles

Passive smart textiles

The first generations of smart textiles, which provide additional feature in a passive mode i.e. irrespective of the change in the environment. For example, a highly insulating coat would remain insulating to the same degree irrespective of the outside temperature. Wide range of capabilities, including anti-microbial, anti odour, anti-static, bullet proof are the other examples.

Active smart textiles

The second generation has both actuators and sensors. Textiles which adapt their functionality to changing environment automatically are active smart textiles. Active smart textiles are shape memory, chameleonic, water-resistant and vapor permeable (hydrophilic/nonporous), heat storage, thermo regulated, vapor absorbing, and heat evolving fabric and electrically heated suits.

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 fiber and textile materials, and miniaturized 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.

Smart Materials and Fibers 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.

Materials used in smart textiles

The materials of our surroundings are being “intellectualized”. These materials can interact, communicate and sense. Polymericor carbon coated threads Conductive yarn, conductive rubber,

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and conductive ink have been developed into sensors or used as an interconnection substrate. Conductive yarns and fibers are made by mixing pure metallic or natural fibers with conductive materials. Pure metallic yarns can be made of composite stainless steel or fine continuous conductive metal-alloy combination of fibers with conductive materials can be completed by the methods namely: Fibers filled with conductive material (e.g., carbon -or metallic particles); Fibers coated with conductive polymers or metal and Fibers spun with thin metallic or plastic conductive threads. Metallic silk, organza, stainless steel filament, metal clad aramid fiber, conductive polymer fiber, conductive polymer coating and special carbon fiber have been applied to the manufacture of fabric sensors.

Metal fibers

Metal threads are made up of metal fibers which are very thinmetal. The fibers are produced either through a bundle-drawingprocess or else shaved off the edge of thin metal sheeting. Metallicthreads and yarns may be knitted or woven into a textile and used toform interconnects between components. They may also beused as electrodes for monitoring electrical physiological activity suchas electrocardiogram (ECG) signals.Metal threads tend to be heavier than most textile fibers and their brittle characteristics can damage spinning machinery over time and also they may be uncomfortable to wear due to abrasion.

Conductive inks

A layout can be screen-printed using conductive inks to add conductivity to specific areas of a garment. Carbon, copper, silver,nickel and gold may be added to conventional printing inks to make them conductive.Printed areas can be subsequently used as switches or pressure pads for the activation of circuits.

Inherently conductive polymers

Inherently conductive polymers have both sensing and actuation properties. Some commonly had known ICPs include polyacetylene, polypyrrole, polyaniline. Polypyrrole (PP) is most suitable as it has high mechanical strength with high elasticity, is relatively stable in air and electro. The major advantage of this approach is that the sensors retain the natural texture of the material. The problem with these devices is a variation in resistance over time and high response time.

Electrically conductive textiles

Electrically conductive textiles are already used for years in various industrial application fields for the purpose of controlling static and electromagnetic interference shielding. Nowadays, textiles are modified to offer a good electrical conductivity to be applied in smart. Here electrically conductive

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textiles are used as electrodesor as interconnection between the different components.

Optical fibers

Plastic optical fibers may be easily integrated into a textile. They have the advantage of not generating heat and are insensitive to EM radiation. Optical fibers may serve a number of functions in a smart garment-transmit data signals, transmit light for optical sensing, detect deformations in fabrics due to stress and strain and perform chemical sensing. Commercially available Luminex ®fabric is a textile with woven optical fibers capable of emitting its own light. While this has aesthetic appeal for the fashion industry it is also used in safety vests and potential to be used for data transmission.

Coating with nano-particles

Coating a fabric with nano particles is being widely applied within the textile industry to improve the performance and functionality of textiles. Nanotechnology can add permanent effects and provide high durability fabrics. Coating with Nano-particles can enhance the textiles with properties such as anti-bacterial, water-repellence, UV-protection and self-cleaning, while still maintaining breath-ability and tactile properties of the textile. Nano-tex has a range of products using such coatings to resist spills, repel and release stains, and resist static.

Shape memory materials

Shape memory alloys, such as nickel-titanium, have been developed to provide increased protection against sources of heat. Ashape memory alloy possesses different properties below and above the temperature at which it is activated. 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 producing the reversible variation needed for protection from changeable weather conditions. Shape Memory Polymers have the same effect as the Ni-Ti alloys but, being polymers, they will potentially be more compatible with textiles. Electro active polymers EAPs are generally made up of high functionalized polymer.

Chromic materials

Chromic materials can change their color according to external conditions. These materials have mostly used in fashion, to createfunny color changing designs. According to the stimuli type, chromic materials can be categorized as

Photo chromic: External stimulus is light.
Thermo chromic: External stimulus is heat.
Electro chromic: External stimulus is electricity.
Piezoro chromic: External stimulus is pressure.

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Solvate chromic: External stimulus is liquid or gas.

Application of Smart Textiles

Health

The development of wearable monitoring systems is already having an effect on healthcare in the form of "Telemedicine". Wearable devices allow physiological signals to be continuously monitored during normal daily activities. This can overcome the problem of infrequent clinical visits that can only provide a brief window into the physiological status of the patient. Representative examples are e.g.: Wireless-enabled garment with embedded textile sensors for simultaneous acquisition and continuous Monitoring of ECG, respiration, EMG, and physical activity. The "smart cloth" embeds a strain fabric sensor based on piezo resistive yarns and fabric electrodesrealized with metal based yarns. Sensitized vest including fully woventextile sensors for ECG and respiratory frequency detection and aPortable electronic board for motion assessment, signal pre-processing,and bluetooth connection for data transmission. Wearable sensitizedgarment that measures human heart rhythm and respiration using athree lead ECG shirt. The conductive fibre grid and sensors are fullyintegrated (knitted) in the garment (Smart Shirt)

Life belt

Life belt is a trans-abdominal wearable device for long-term healthmonitoring that facilitates the parental monitoring procedures forboth the mother and the fetus. This life belt is very useful in case ofpregnant women. Pregnant women living in remote areas work duringpregnancy and face certain health problems (e.g.high blood pressure,kinetic problems requiring immobilization, kidney or heart diseases,multiple pregnancies). Life belt is a support tool for the obstetrician,who is enabled to monitor patients remotely, evaluate automatedpreliminary diagnosis of their condition based on collected andanalyzed vital signs, access patients' medical data at any time and mostimportantly be alerted.

Life jacket

Life jacket is a medical device worn by the patient that consequentlyreads their blood pressure or monitors the heart rate; the information istransferred to a computer and read by medical staff. A specialized camerain the form of headwear has been developed to be worn by paramedics.Visual information captured by the camera can be transferred directlyto medical staff at the hospital enabling them to advise instantly onappropriate treatment.

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Military/defense

Around the world military forces are exploring how smart clothingcan be used to increase the safety and effectiveness of military forces. Inextreme environmental conditions and hazardous situations there is aneed for real time information technology to increase the protection andsurvivability of the people working in those conditions. Improvementsin performance and additional capabilities would be of immenseassistance within professions such as the defense forces and emergencyresponse services. The requirements for such situations are to monitorvital signs and ease injuries while also monitoring environment hazardssuch as toxic gases. Wireless communication to a centralunit allows medics to conduct remote triage of casualties to help themrespond more rapidly and safely.

Fashion and entertainment

As the technology is becoming more flexible various electronic devices and components clothes becoming truly portable devices.Already there are textile switches integrated into clothing for the controlof such devices. While technology may be hidden through invisiblecoatings and advanced fibers, it can also be used to dramatically changethe appearance of the textile, giving new and dazzling effects. Light emitting textiles are finding their way onto the haute couturecatwalks, suggesting a future trend in technical garments.

Sportswear

Sportswear area of important smart clothing developments. Ingeneral a number of important functions can be implemented usingsmart devices or clothing. These include: Monitoring heartrate, breathing, body temperature and other physiological parameters;Measuring activity, for example determining the number of steps taken,the total distance travelled; Acting to actively stimulate muscles e.g.using electrical muscle stimulation; Work against activity to provide‘smart’ resistance training; Record aspects of performance, such a footpressure or specific joint movements; Protect against injury.

Smart sports shoe

Global Positioning Systems (GPS) incorporated into walking shoeswhich allow the user to be tracked by mountain rescues services. Theycan also used to monitor the where about of young children. Glovesthat contain heaters, or built in LED’s emitting light so that a cyclistcan be seen in the dark.

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The sensory baby vest

The sensory baby vest is equipped with sensors that enable the constant monitoring of vital functions such as heart, lungs, skin and body temperature which can be used in the early detection and monitoring of heart and circulatory illness. It is hoped to use this vest to prevent cot death and other life-threatening situations in babies. The sensors are attached in a way that they do not pinch or disturb the baby when it is sleeping.

The smart bra

The Australian people have developed a bra that will change its properties in response to breast movement. This bra will provide better support to active women when they are in action. The Smart Bra will tighten and loosen its straps, or stiffen and relax its cups to restrict breast motion, preventing breast pain and sag. The conductive polymer coated fabrics will be used in the manufacture of the Smart Bra. The fabrics can alter their elasticity in response to information about how much strain they are under. The Smart Bra will be capable of instantly tightening and loosening its straps or stiffening cups at excessive movement.

Phase change materials

Now days, phase change materials are highly applied in the field of textiles for different kinds of products such as apparel, underwear, socks, shoes, bedding accessories and sleeping bags. For multifunctional products also are applicable in the specialty items like anti - ballistic vests, automotive, medical or for other industrial applications.

Incorporation of PCMs in textiles

The PCMs change phases within a temperature rangejust above and below human skin temperature would besuitable for application in textiles. This interesting propertyof PCMs would be useful for making protective textiles inall-season. Fiber, fabric and foam with PCMs could storethe heat body creates then release it back to body, as itneeds. Since the process of phase change is dynamic; therefore,the materials are constantly changing from a state toanother depending upon level of physical activity of thebody and outside temperature. The thermo-regulatingcharacteristic is possible in manmade fiber by addingPCM microcapsules to a polymer solution prior to fiberextrusion. In the process, PCM microcapsules are integratedinside the fiber itself. Coating, lamination, finishing,melt spinning, bi-component synthetic fiber extrusion,injection molding, foam

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techniques are some of the convenientprocesses for PCMs' incorporation into the textilematrix.

Application of PCMs in textiles

For a Suitable application of PCMs in textiles the temperature must be within a temperature range of human skin. This exciting property of PCMs would be useful for the application of producing protective garments in all- kinds of weathers from the strongest winter to the hottest summer. Textile materials treated with PCMs can store the heat if it is excess and release it back when the heat is needed.Applications of phase changetextiles include apparel, blankets, medical field, insulation,protective clothing and many others. The following is abrief summary of the application of PCM in textile fields.

- Space
- Sportswear
- Bedding accessories
- Medical application
- Shoes and accessories
- others

CONCLUSION

Smart textiles were presented as imaginary products and used in very limited areas. After scientific efforts and development phases, nowadays smart textiles are an implanted customer interestand are presented as the future of the textile industry. Now manycommercial products are available and, as it have been presented in this article. A lot of scientists are developing new solutions, ideas and concrete products with the emerging demand of smart textiles in various phases of life. A focus should also be put on the promotion of smart textiles. Research action should be promoted to get accepted by scientific and medical communities. The developments of electro-conductive polymers/fibres/fabric expertise should be promoted, as they are the building blocks for smart textile systems. The acceptance of smart textile products by the user can be strengthened by R&D.

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