Applications of Smart Textiles

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Abstract

Textiles have historically been a crucial part of our lives, and the ambition to mix textiles and technology only grows stronger day by day. That is when smart textiles come into play. Smart textiles are a sector that has been developed with new technologies, fibers, and textile materials. The production of smart textiles cooperates with many branches of science such us: nanotechnology, materials science, design, electronics, software engineering, data science, etc. Smart textiles are classified into three groups: passive smart textiles, active smart textiles and ultra smart textiles according to their performance characteristics. There is a lot of talk about smart textiles in recent years and their potential for the future. This paper will explain exactly what smart textiles are, their current applications, and their importance for the future.

Keywords — *smart textiles, technology, textiles, applications, science.*

I. Introduction

To begin with, what are smart textiles exactly? Smart textiles are known as fabrics that contain electronic components and can execute one or many functions. Smart textiles can observe or communicate the environmental circumstances and detect and process the user's state. The term "smart textile" was first used in Japan in 1989. The first material to be called "smart" textile was a string of yarn with memory capability. In fact, the discovery of materials with shape memory in the 60s is considered to be the birth of smart textiles. Smart textiles were not launched to the market into the late 90s. In the present day, smart textiles are much more complex to the point that some are even classified as "wearable computers".

Technology has taken control of the textile industry. Smart textiles have superior performance and functionalities for their applications in areas such as military, healthcare, sportswear, etc. There are two commonly known categories for smart textiles, esthetic smart textiles and performance smart textiles. Esthetic smart textiles are used for fashion design, due to their ability to light up and change color. Light-emitting clothes and luminous dresses are the typical examples for esthetic smart textiles. On the other hand, performance smart textiles are

classified into three categories: passive smart textiles, active smart textiles, and ultra smart textiles.

Passive smart textiles can only sense the environment since they just have sensors. UV protecting clothing, conductive fibers, and waterproof fabrics are the common examples of passive smart textiles. Active smart textiles can not only sense the environment but also react to it. They have both a sensor function and an actuator function. Some examples of active smart textiles would include shape memory materials, phase change materials, and heat sensitive dyes. Ultra smart textiles are similar to active but they go even further. Ultra smart textiles can sense, react, adapt, and monitor themselves according to their environment. They receive information from chemical, mechanical, sound, thermal, magnetic, and other sources. Spacesuits, musical jackets, and wearable computers are considered examples of ultra smart textiles.

II. Functions of Smart Textiles

Smart textiles are smart systems that can perceive the environmental conditions while also detecting and processing the wearer's condition. They can use electrical, heat, mechanical, chemical, magnetic, and other detection systems to detect them. Smart garments are separated from wearable computing systems by revealing the importance of the garment on which they are integrated. Wearable computing systems are formed by the traditional systems being attached to the garment in some way. The equipment used is placed in non-textile ways without being integrated. Although some electronic materials have been reduced to be used in garments, the actual smart garments should use materials made entirely by textile production. The electronic materials to be placed must not impair the comfort of the standard textile material garment. Therefore, providing this combination is vital for wearability in smart garment and textile manufacturing. It is clear that smart textiles are simple computer systems and have five functions basically as sensors, data processing, actuators, storage, and communication. But it must be compatible with the function of clothing such as comfort, durability, resistance to regular textile maintenance processes, etc.

Sensors are the components that transform one type of signal into another type of signal. There are already systems in textiles that measure heart, breath rate, temperature, movement, and moisture, but these systems work with the installation of traditional sensors in textiles. At the present stage of intelligent textiles, the sensors are produced from real textile material, and the heart, breath, and movement sensitive sensors are already produced with satisfactory results. There are also different materials and structures that have the capacity of transforming signals such as thermal, light, sound, humidity, pressure, strain, chemical, and biological sensors.

Data processing is one of the components that is required only when active processing is necessary. According to information theory, it is necessary to process every collected information and data and obtain the desired output. Therefore, in order to obtain the desired output by processing the parameters collected by the sensors, a processor suitable for the relevant purpose is required in smart textiles. Actuators are the devices designed to perform the necessary action according to signals from the sensor or processor. These devices are also called actuators. Actuators act by an effect sent from the sensor and possibly by first passing this effect through an information processor to perform objects such as moving objects, releasing materials, and making noise.

Storage is another component of smart textiles. Although not a fundamental goal, smart suits are expected to need a storage capacity to operate on their own. While the information to be stored in smart textiles is usually information or energy, examples such as textiles that inject or emit drugs or odors indicate that this storage unit will also serve different areas. Detection, computing, actuators, and communication units generally require energy, especially electrical energy. Efficient energy management is achieved by combining the energy source and storage in an appropriate manner. Another one of the components of smart textiles is the communication component, which is shaped according to the type and need of communication. There are many types of communication within smart textiles. Some of the basic situations in which smart textiles are contacted are as follows: in one element of the garment itself; can be mounted between two different elements of the garment; and in order to command the garment by the wearer, contact is made to inform the wearer or his surroundings. In today's prototypes, communication within the garment is provided by optical fibers or by conductive fine wires. They are naturally woven and can be placed in textiles without the use of stitches. A specific communication protocol is followed to communicate with the wearer.

III. Applications of Smart Textiles

Materials capable of remembering the original shape are called shape memory materials. Materials are shaped out of its original shape as the temperature change returns to its original shape with a chemical, mechanical, magnetic, or electrical external effect. There are many classes of shape memory materials such as alloys, polymers, gels, and ceramics. Shape memory alloys and shape memory polymers are the types of shape memory materials with applications in textiles. The important point in these applications is that the material used exhibits the shape memory effect at temperatures close to body temperature.

Color-changing textiles are intelligent textile materials that have the ability to change color with an external stimulus effect. They are obtained by incorporating color-changing materials into the structure of textile materials. Color-changing materials are chromic materials or chameleon materials. There are many different color-changing mechanisms, but mostly the

electron density or molecular structure of the material changes due to the external stimulus effect and the color change occurs; when the stimulus effect disappears, they return to their initial state where they are more stable and get their first color. Color changing materials are specified according to the effect mechanism. Light, heat, pH change, solution, friction and pressure are basic effect parameters. They are also called by the effect type as photochromic, thermochromic, electrochromic, solvatochromic, halochromic, tribochromic, and mechanochromic.

Phase change materials are basically thermo regulating materials. When the melting temperature of the material is reached during the heating process, the transition from solid state to liquid, that is, a phase change occurs, during which the phase change material absorbs and stores a large amount of heat. The temperature of the phase-changing material remains virtually constant during the entire phase change. During cooling of the same material, the stored heat is transferred to the medium and the transition from liquid to solid state takes place. Again, the temperature of the material remains constant throughout the phase change process. If the temperature change continues except for phase change, the temperature of the material also changes.

IV. Smart Textile Products on the Market

Smart Yoga Wear NadiX by Wearable X

Wearable X debuted its first direct-to-consumer product, Nadi X, a line of smart yoga wear, in May 2017. Yoga can be done your way with the Nadi X experience. Its patented technology, including built-in sensors and haptic (vibration) feedback, helps you improve your yoga practice.

Sound Shirt by CuteCircuit

CuteCircuit launched the innovative SoundShirt in 2016. This garment uses built-in haptics so that a deaf person can feel music. The SoundShirt PRO has haptic actuators and can be used to listen to music, give hugs, play games and access live performances in venues with a QPRO system. Thanks to added haptic actuation modules, the SoundShirt offers more immersive virtual and augmented reality experiences.

Smart Socks by Sensoria

Sensoria offers a complete line of smart clothing for various activities. Smart socks mainly can detect cadence, foot landing, and impact forces. Sensoria socks include patented 100% textile sensors. They are coupled to a detachable Bluetooth core that improves accuracy in step count, speed, calories, altitude and distance monitoring. Sensoria can help runners identify

the most injury-prone running techniques (heel strike, etc.) and uses a mobile app to coach the runner in real time using auditory cues.

Mercury Smart Jacket by Ministry of Supply

Mercury keeps you at the perfect temperature in real time, thanks to its sophisticated, lightweight heating components and revolutionary stretch insulation. A smart thermostat responds to your body and the environment by managing three lightweight and flexible carbon fiber heating components. The Mercury Jacket is designed to protect you from wind, snow, water and odors, wherever you travel.

V. Conclusion

Current developments in textile technologies, new materials, nanotechnology, miniature electronics, and wearable makes systems more convenient, but the most important parameter for users to accept wearable devices is if comfort is sufficient. This is recognized as a challenging environment for the human body and the environment. In addition, the circuit design of the development of intelligent textiles, the knowledge of intelligent materials, microelectronics, and chemistry is basically integrated with a deep understanding of textile production. It requires a multidisciplinary approach. Wearable smart electronic textiles make lives more reliable, healthy and comfortable in many areas. In this sense, they are perceived as intelligent technologies that will have the qualities to support the vital activities of human beings such as sensation, movement, communication, taking action, and adapting to environmental conditions.

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