International Journal of Sciences & Applied Research

www.ijsar.in

APPLICATIONS OF E-TEXTILES IN DEFENSE SECTOR - A REVIEW

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Abstract

This paper aims to study about the changing role of textiles and its application in various sectors. Now textiles are not only used for clothing but it has various functions. In near future textile products including what one wear will transform from their present to adaptive a responsive system. The functions include communication, computation, health monitoring etc. Here the focus is mainly on the role of e-textiles (electronic textiles), the fabric which contains electronics, circuits, interconnections woven and its application in defense sector. The review aims at recent advances in e-textiles and its use in military uniform. The textiles are basically made by using various manufacturing techniques as weaving, knitting, embroidery, and printing etc.

Keywords: E-Textiles, Defense, circuits, interconnections, communication

Introduction

Our armed forces confront many threats and challenges in all areas as land, sea and air. They are constantly under menace from the invaders and along with this they have to face varying weather condition and geographical challenges. Hence it is inevitable for them to use protective clothing having special features. E-Textiles or electronic textiles is one such technology being used in defense clothing and its usability includes, health monitoring, communication, enhanced mobility, survivability, reduction of heat stress, reduction of logistic burdens, camouflage.

E- Textiles also called electronic textiles, smart textiles, smart fabrics are the fabrics that enable digital components and electronics to be embedded in them. They are the textiles with electronics and interconnections woven in their structure. They usually contain conductive yarns that are either a spun or twisted an incorporated some amount of conductive material to enable electricity conductivity.

According to Pailes – Friedman of the Pratt Institutes states that “What makes smart fabric revolutionary that is that they have the ability to do many things that traditional fabrics cannot ,including communicate, transform, conduct energy and even grow."

1.1 E-textiles comprise the following components

1. Sensors to detect body/environmental parameters. Basically sensing is the

function of transforming a signal into another signal that can be read and understood by a predefined reader which can be a real device or person.

2. A Data Processing unit to collect and process the obtained data.
3. An actuator that can give signal to the wearer. It responds to an impulse resulting from sensor function, possibly data processing.
4. An energy supply. Power supply technologies typically batteries provide the electrical power for activating components in an electronic textile.
5. Interconnections for both power and supply
6. A communication device that establishes a wireless communication link with a nearby base station.

1.2 Responsive materials for E -Textiles

The smart materials used are metallic and optical fibers, conductive threads, yarns, fabrics, coatings and inksare being used to supply conductivity and create wireless textile circuitry.

1.2.1 Metallic and optical Fibers /Conductive Fibers

Electronically conductive fibers can be produced in filament or staple length and can be spun with varying ratios of traditional non- conductive fibers to create yarns. Electrically conductive fibers falls into two basic categories ,the first one as natural conductive such as ferrous alloys, nickel, stainless steel, titanium, aluminium, copper and carbon and second those that are specially treated to create conductivity. Here fibers are produced by coating the fibers with metals, galvanic substances or metallic salts like copper sulfide and copper iodide. Galvanic coatings produces fibers with relatively high conductivity, therefore it is not usually used for textiles.

The electronic textiles is completed when microelectronics are linked to the fabric. Microelectronics provide digital and analog functions in response to mouse input to activate sound and voice synthesis, and to incorporate remote controls for signals, guiding and controlling the electronic textile.

Optical fibers carry computer data signals in the form of pulses of light; can also be used to produce interactive textiles.

1.2.2 Conductive yarns and Threads

Conductive and optical are the two materials that can be used to develop conductive yarns and therefore, interactive electronics textiles.

Metallic yarns are made by wrapping a non – conductive yarn with a metallic copper, silver or gold foil to provide conductivity.

Metallic silk organza is used for this technology. The warp is a plain silk yarn wrapped in a thin copper foil or thread and is highly conductive. The copper thread transforms the silk yarn into a highly conductive yarn and is used for mass producing interactive electronic textiles. Conductive fiber, yarn and threads can be processed on ordinary textile machinery or by using embroidery techniques.

1.2.3 Conductive coatings

Traditional Textiles can be transformed into electrically conductive materials by using conductive coatings. They produce good conductivity without changing the properties such as density, flexibility and handle.

Electro less plating, evaporative deposition, sputtering, coating the textile with a conductive polymer are the methods for coating.

1.2.4 Conductive Inks

Conductive ink technology is another method used to create interactive electronic textiles. Metals such as carbon, copper, silver, nickel and gold is added to traditional printing inks and create electronically active patterns and therefore electronic textiles. These inks are used in for printing on paper, plastic and textiles to create electrically active patterns and therefore electronic textiles.

1.3 Performance of E Textiles in Defense

Defense is one of the most demanding area in terms of application of technical textiles. Military personals are constantly exposed to various threats such as chemical, biological, and nuclear threats. Therefore armed forces require personal to combat these situation and protect them also. The technical textile has proved to be the major contributor to the technical textiles since last couple of decades. Protective textiles are used for manufacturing clothing for armed forces working in hazardous environment.Protech products include bullet-proof jackets, radiation protection textile/NBC suits, high-altitude clothing, fire-retardant fabrics and apparel, ballistic protective clothing, high-visibility and foul weather clothing, chemical protection clothing, industrial gloves, radiation protection textiles, etc.

Textiles which are widely used in defense are called “Combat Essentials” including uniforms, protective clothing, parachutes, blankets and hospital supplies. The application of military textiles can be divided into two categories (i) Personal protective clothing (battle dress, chemical protection suits, belts, ropes, and field packs etc and (ii) Defense systems and weapons(tents, parachutes, shelters, tarpaulins and textile composites.

1.3.1 E-Textiles for Sensing the Environment

In e-textiles, conductive metal or polymeric fibers need to be embedded in the fabrics to carry the signals, which are created by the sensors that react to various input parameters such as sound, light, movement and chemicals, as well as to certain gases and liquid vapors in the environment. The sensors can be classified as light sensors. Environmental sensing can also detect the presence of enemies or potential biochemical threats. Appropriate sensors can identify blast situations and report if there
are any health risks.

1.3.4 E-Textiles for Health Monitoring of Defense Person

A soldier should be in good physical condition to optimally perform his or her mission. Health monitoring can help to improve the promptness in provision of medical facilities in the treatment of casualties. An e-textile-based wearable computer motherboard was developed by Georgia Tech to serve as a flexible information infrastructure platform and to monitor vital body signs such as heart rate, temperature, respiration rate and information about wounds (Park and Jayaraman, 2003).

Due to high level of activity, soldiers can face dehydration and loss of sodium (Na) in sweat, which can lead to hyper- or hypo-natremia. Sensors can be used to detect dehydration, fatigue and exhaustion of soldiers under combat conditions.

1.3.4 E-Textiles for Early Warning Systems

One of the most important tasks to be accomplished by the integration of e-textiles into military is early warning. Various systems could be designed to provide early warning of ballistic missile attack, aerial attack or other potential threats. The primary purpose of an early warning system would be to detect potential threats before they reach the targets. This can save the lives of soldiers and civilians or prevent other similar mass-scale devastation, provided that enough warning is given for evasive action to be taken. Sensors and actuators can be used for the detection and signaling (light, sound, haptic feedback) of threats such as bombs, improvised explosive devices (IEDs),mortars, toxic gases or even unexpected attacks from enemies (Chapman, 2012).The sensors and actuators can be integrated into military uniforms, accessories or vehicles and linked to the warning systems.

Featured image above: BAE Systems new e-textile could benefit a wide variety of professions, including the military. Credit: BAE Systems

1.3.5 E-Textiles for Communication

The integration of communication devices into textiles is rapidly increasing in civilian as well as military applications. Developments in communication devices have occurred in three main areas: personal communication networks (PCNs), WANs and information systems (IS). PCNs are involved with the collection and storage of information provided by sensors and converting the data into signals that can be transferred for analysis. WAN systems deal with the information collected from PCNs and transfers it to remote locations. It helps in the analysis, storage and interpretation of results.

A soldier wearing the BAE Broadsword power and data distribution harness, which uses e-textiles embedded within the uniform. Photo by BAE Systems

1.3.5 E-Textiles for Camouflaging

E-textiles can be included in the development of camouflage uniforms with chameleon like properties. The clothing could change its colour, for example, when a soldier moves from a desert to an urban area. The material now being used as a camouflage structure is a non-woven fabric on which PVC is coated and the PVC is impregnated with specific pigments to obtain desired camouflage. Mission Research Commission, in Santa Barbara, California, is designing an automatic camouflage system using hollow fibers, filled with a mixture of liquid dye and a solid pigment. The solid pigments respond to the changing electric fields generated by a computerized camera, effecting an overall change in color of the mixture, resulting in a camouflage system that adapts to the soldiers current environment.

1.3.6 E-textiles for Thermal Regulation

E-textiles are also used for protection from extremities of hot and cold.

Thermocouple-based temperature sensors are available in wire form, which could be integrated into the textiles for thermal regulation. Military operations in extreme climates could benefit from the integration of active or passive heating or cooling systems into clothing. The integration of traditional electric resistive heating wires or conductive fibers can achieve active heating of uniforms, socks and gloves. The mechanism involves applying a controlled voltage to a series of conductive wires/yarns. Actively heated commercial vests, jackets, boots, socks andgloves are now available. Passive heating can be achieved for a short duration by the use of multiple layers, phase change materials and insulation materials.

Army soldiers guarding the icy frontiers in Siachen.

1.3.7 E-textiles for Position Detection

The sensors used for monitoring the movement and position of soldiers are based on GPS, MEMS (microelectromechanical systems) accelerometers and in some cases gyroscopes. These elements could be placed as small pockets on textiles for wearable applications (Zephyr, 2010). The position of soldiers may be detected and displayed by a graphic interface, such as that based on Google Earth software. The boots worn by soldiers can also be fitted with sensors to detect their position and measure their movement.

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