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Wearable Electronics-Prospective and Retrospective Views

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Abstract

E-textiles, also known as electronic textiles, smart textiles or smart fabrics, are fabrics that enable digital component and electronics to be embedded in them. In the mid 1950s, a team of MIT researchers, developed integrated digital electronics with conductive fabrics and developed a method for embroidering electronic circuits. E-textiles can be worn in everyday situations where currently available wearable computers would hinder the user. Wearable computer needs to be less fragile and users who wear this thing should be able to do so without the fear of hurting their wearable. In some cases, power sources such as batteries can also be integrated into clothing or fabrics. Electronic textiles are always coupled with the traditional electronics. The flexibility of fabric provides the opportunity to modify the shape for conforming new requirements of applications. A textile transmission line consists of conductive yarns integrated into a flexible textile base. A vast majority of the studies of textile modifications with NANOMATERIALS have been carried out with NANOPARTICLES. California has devised a method of weaving non-volatile computer memory into garments of clothing or e-textile. Electronics and computer peripherals have started coming in market and a stream of electronic items expected to emerge that are soft, compact, flexible and portable.

Keywords: *Fibrtronics, Electronic textiles, Wearable computers, Micro bicidal, Anti-viral, Anti-poral, Textile substrate*

INTRODUCTION

Electronic textiles (e-textiles) are innovative textile materials (fibers, yarns and fabrics) that incorporate conductive fibers or elements directly into the textile itself. These materials eliminate wires and hard electronics, so that we feel it as the textile itself. E-textiles, are also known as electronic textiles, smart textiles or smart fabrics, are fabrics that enable digital components (including small computers} and electronics to be embedded in them. Many intelligent clothing, smart clothing, wearable technology, and wearable computing projects involve the use of e-textiles. Electronic textiles are distinguishes from wearable computing because emphasis is placed on the seamless integration of textiles with electronic elements, like microcontrollers, sensors and actuators.

The related field of FBERTRONICS explores how electronics and computational functionality can be integrated into textile fibers. Electronic textiles can be created by using minute electrically conductive fibers. The design process of an e-textile should appreciate the complexity, cost and effectiveness of system. An electronic textile refers to a textile substrate that incorporate capabilities for sensing (biometric/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.

The field of electronic textiles combines the worlds of textiles and electronics, and explores techniques that redefine construction methods and streamline production processes. In general, the development of electronic textiles supports the idea of wearable computing, or electronic devices worked in to garment designs.

Electronic textiles are used in many products, including the NUNETRIX Athletic garments that monitor our heart rate, fabric keypads for controlling iPod, and heating products. They are also used to create sensors, thermo chromic displays, data transfer systems, antenna and heating elements. The use of fabric as station to deploy electrical components results wearable electrical computing devices. It makes easer to move with computing devices with less consumption of human energy and efforts. Moreover, the flexibility of fabrics provides the opportunity to modify the shape for conforming new requirements of application. Some electronic textile products may only be built for data storage, while others provide physical interfacing through control element in the garment design.

Although the practical applications of this technology are very new, some projects involving electronic textiles and intelligent garments do exist now. Many of these are aimed at uses within the heath care industry, where wearable computing elements can be used to monitor vital signs and otherwise track a person's health in real time. 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 like strands of sliver or stainless steel to enable electrical conductivity.

E-TEXTILES

E-textiles are distinct from wearable computing because emphasis is placed on the seamless integration of textiles with electronic elements like microcontrollers, sensors and actuators. But e-textiles need not to be wearable, for example, e-textiles are also found in interior design. E-textiles, also known as electronic textiles, smart textiles, or smart fabrics [01], are fabrics that enable digital components and electronics to be embedded in them. Many intelligent clothing, smart clothing, wearable technology, and wearable computing projects involve the use of e-textiles. The basic materials needed to construct e-textiles, like conductive threads and fabrics have been around for over 1000 years. Artisans were using wrapping fine metal foils, mostly gold and silver, around fabric threads for centuries [02]. Queen Elizabeth I's gowns have been found to be embroidered with gold-wrapped threads.

In the 19th century, engineers began to combine electricity with clothing and jewelry by developing series of illuminated and motorized necklaces, broaches and costumes [03, 04]. In the late 1800s, people used to hire young women adorned in the light-studded evening gowns from the Electric Girl Lighting Company to provide cocktail party entertainment [05]. A show focused on the relationship between technology and apparel featured astronaut's space suits along with clothing that could inflate and deflate the light up and heat to cool by itself [06]. In that show, a designer created a line of electronic fashion, including electroluminescent party dresses and belts that could sound alarm sirens [07].

In the mid 1990s, a team of MIT researchers, developed integrated digital electronics with conductive fabrics and developed a method for embroidering electronic circuits [08]. The field of e-textiles can be divided into two main categories, like e-textiles with classical electronic devises and e-textiles with electronics integrated into the textile substrates. Electronic components embedde3d in the textile, such as touch buttons are constructed completely in the textile forms by using conducting textile weaves, and which are then connected to devices such as music players or LEDs are mounted on woven conducting fiber networks to form displays [09, 10].Printed sensors for both physiological and environmental monitoring have been integrated into textiles [11] including cotton Gore Tex and neoprene [12, 13, 14].

One of the most important issues of e-textiles is that the fibers should be made such that it can be washable as the clothes should be washed when it is dirty and the electrical components in it should be an insulator at time of washing. A new class of electronic materials that are more suitable for e-textiles is the class of organic electronics materials because organic fiber transistors [15, 16], the first textile fiber transistor that is completely compatible with textile manufacturing and that contains no metals at all.

APPLICATIONS OF ELECTRONIC TEXTILES

Electronic textiles are the textile fabrics with electronics and interconnections woven in their structure that enable the integration of electronic functions and attachments. They possess the physical flexibility and size not known in conventional electronics. Components and interconnections are intrinsic to the fabric structure with reduced chance to be seen, tangled together or snagged by the surroundings. Electronic textiles can be created by using minute electrically conductive fibers. These metallic fibers have been used for years in various industrial applications for the purpose of controlling static and electromagnetic interference shielding. Today metallic fibers are finding new applications [17] in the development of electronic textiles. Electrically conductive fibers can be classified into two general categories, that are naturally conductive and those that are specially treated to create conductivity.

The design process of e-textiles should appreciate the complexity, cost and effectiveness of system. This process must be based on a set of percept derived from the experience and developing concepts. Software/hardware architecture research, and produce applicable models. An understanding of theories of fabrics embedded conductive threads/fibers and the electronics and fabrics are significant in producing a prototype. E-textiles can be worn everyday situations where currently available wearable computers would hinder the user. E-textiles can also more easily adapt to changes in the computational and sensing requirements of an application, a useful feature for power management and context awareness.

The common types of e-textile with classical electronic devices are, conducting wires, integrated circuits, LEDs, and conventional batteries in garments. E-textiles with modern electronics directly on the textile fiber includes passive electronics such as pure wires, conducting textile fibers or more advanced electronics such as transistors, diodes and solar calls. The field of embedding advanced electronics components on to textiles fibers is sometimes called FIBERTRONICS.

WEARABLE COMPUTERS, REACTIVE FASHION AND SOFT COMPUTAION

The meaning of wearable computers is ironic, although they are powerful, but these wearable computers are not very wearable. They are heavy and angular. Their weight is uncomfortable for extended use and the advantages of wearing such devices are not clear to majority of people. The transition of the computing device from the desktop to the body is physical leap that also requires conceptual leap.

Materials need to change, functionality needs to evolve past, the point where hang along the user's body, and the computer housing needs to be more attractive. Wearable computers need to be less fragile and users who wear this thing should be able to do so without the fear of hurting their wearable. They should be able to jump, dance and push their way into a crowded subway. They require to be wore the computer easily and effortlessly, without the fear of dropping or breaking the component. Wearable computing needs to be integrated and assimilated ideas and methods from another wearable technology, which needs to be knitted onto body and conductive yarn needed to replace wires.

Electronic textiles have close relationship with the field of computer wearable that gives many diverging research directions and possible definitions. On one end of the spectrum, there are pragmatic applications such as military research into interactive camouflage or textiles that can heal wound soldiers. On the other side of the spectrum work is being done by artists and designers, known as "second skin" that can adapt to the environment and to the individual. Fashion health and telecommunication industries are also pursuing the vision of clothing that can express aspects of people's personalities, needs and desires or augment social dynamics through the use of display of aggregate social information.

Research works have developed enabling technology for electronic textiles based on theoretical evaluation of the historical and cultural modalities of textiles as they relate to future computational forms. Using the conductive yarns and fibers for power delivery, communication and net working as well as new materials for display which use electrical ink, NETINOL and thermo chromic pigments are in progress [18]. The textile products are created using traditional textile manufacturing technique like spinning conductive yarns, weaving, knitting, embroidering, sewing and printing with inks.

An electronic textile (e-textile) is a type of fabric that contains electronic elements. In general, the development of electronic textiles supports the idea of wearable computing or electronic devices worked into garment designs. However, there are other applications of electronic textile products may only be built for data storage, while others provide physical interfaces through control element in the garment design. According to TECHNOPEDIA [19], within the relatively new industry around electronic textiles, projects are pursued on various kinds of functionally.

In some cases, power sources such as batteries can also be integrated into clothing or fabrics. Some experts talk about the difference between embedding electronic device in fabric, or actually layering conductive electronics in textiles to make the fabric into the computer. Some new projects like "Musical Jacket" [20], other technologies to provide garments electronic music. Although the practical applications of this technology are very new, some projects involving electronic textiles and intelligent garments do exist now. Many of these are aimed at uses within health care industry, where wearable computing elements can be used to monitor vital signs and other wise track a person’s health in real time.

PRODUCT FAQ FOR E-TEXTILES

Electronic textiles incorporate conductive materials directly into the textile itself. There are many kinds of conductive textile materials available, from yarn to woven and coated fabrics. Most of the electronic textiles are passive circuit, which means that they are resistive or conductive elements. Electronic textiles are used in many products, including the NUMETRIX athlete garments that monitor heart rate, fabric key pad for controlling iPAD heating products. They can be used to create sensors, thermo chromic displays, data transfer systems, antenna and heating elements [21].

E-textiles to-day can be made with a variety of conductive materials including silver, stainless steel, copper and organic conductors. Yarns are available in many structures and can be coated, twisted or spun. Other materials that come in handy are conductive tapes and ink. Electronic textiles are always coupled with traditional electronics. This means that every e-textile project needs a power supply, an electronic component and an e-textile to textile connection. Many people working with e-textiles find the task of buying and combining traditional electronics and e-textile yarns overwhelming. Electronic textile dimmers require just a tap to turn on, off and adjust light levels.

Some of the electronic components of the e-textiles are as durable as any electronic device. They are highly durable and made with materials as that are passed through appropriate durability tests, including ATC performance standards for upholstery. Many listed products comply with all their safety standards. The e-textiles sensors are all antimicrobial. The Electro PUFF lamp Dimmer is made with the highest quality, recycled nylon carpet yarns with antimicrobial features. E-textiles eliminate wires and hard electronics and feels like textile materials. Products made out of these are uniquely soft and tactile.

E-textiles kits are having both e-textile and electronics. Dimmer lamps are more flexible with lighting control. It can be adjusted its lights in a room for a specific activity or create a particular atmosphere, rather than simply having the lights turned on off. Dimmers work by interrupting the current flowing into the filament in incandescent and halogen light bulbs. When less current flows into the filament, the filament does not get as hot, and it produces less light.

ELECTRONIC TEXTILES

An appreciation of the advancement made in the performance and application of textile articles is definitely interesting for those learning and working in the areas of smart textiles, and at the same time it indicates the directions currently pursued in smart textiles research and development. The unique combination of properties like flexibility, softness, permeability, strength, thermal and electrical resistance of textiles provides several reasons to attract the innovation interest for research and development [22]. Such combination of properties is not seen in several other materials including metal, ceramic, plastic, wood, glass, papers, etc. It has resulted in attractive interdisciplinary applications of textiles where electronic textiles are setting interesting examples.

Electronic textiles are the textiles fabrics with electronics and intercommunications woven in their structure. They possess the physical flexibility and size not known in conventional electronic components and interconnections are intrinsic to the fabric structure with reduced chance to be seen, tangled together or snagged by the surroundings. The use of fabrics as station to deploy electrical components results in wearable electrical/ computing. It makes easier to move with computing devices with less consumption of human energy and efforts. The flexibility of fabrics provides the opportunity to modify the shape for conforming new requirements of applications.

The relative positions of components including sensors, actuators, processing elements can be altered. The research activities indicate that future studies and advancements in the area of electronic textiles would introduce numerous applications ranging from simple computing devices to advanced protective and sensing textiles. Embedded system technologies and smart materials can be integrated and interfaced in e-textiles, and such designs will accommodate hard ware and soft ware applications. The design process of an e-textile appreciates the complexity, cost and effectiveness of system. This process must be based on a set of percept derived from the experience and developing concepts. Soft ware /hard ware architecture of an e-textile using defined percept would facilitate the future research and produce applicable models.

An understanding of theories, fabrics, embedded conductive threads/fibers, and the connections in electronics and fabrics are significant in producing a prototype. Computing elements, sensors, and actuators can be seamlessly configured in known textile products such as shirts, hats, parachutes and blankets. Sophisticated fiber technology is introducing new fibers that may function as batteries, durable wires and speakers. The current research and development in e-textiles is addressing the matters in computing to infrastructure and examining the applications. An example is the acoustic beam former that senses the presence of a large vehicle and report its position and direction. This system receives acoustic data through microphones and processes it, communicates the result to outside world or peer system.

WEARABLE ELECTRONIC TEXTILES

Based on the concepts of attachable electronics, the textile transformation system is introduced in which transmission lines and connectors are integrated to the fabrics. The textile transmission system is designed to connect attachable electronics devices by supplying power and transferring data, signals, etc. Relevant fabrication issues, such as design of conductive yarns, integration or interconnection methods and connectors are dealt thoroughly. Electro-textiles refer to fabrics that can electrically function as electronics and physically behave as textiles.

The prominent application of e-textile is smart clothing. Smart clothing system is a new garment that can provide interactive reactions by sensing signals, processing information and actuating the responses. Currently, smart clothing is not practically wearable. The problem of wearable textile is related to a misconception of the word wearable. Much later the concept of wearable became more practical addressing issues of comfort, light weight, breathability and care and maintenance [23].

Having considered the true wearable, the most feasible way to wear complicated electronics or computers at this point is to use attachable electronic components. This clothing itself carries only transmission lines and connectors so that clothing can be flexible and washable enough to be wearable. The attachable electronic system consists of textile transmission lines and connectors [24].

A textile transmission line consists of conductive yarns integrated into a flexible textile base. Conductive yarns are either pure metal yarns or composites of metals and non-conductive textile materials that help improve mechanical properties. In order to produce successful textile transmission line, the best mix of conductive metal and non-conductive textile material is critical. As e-thread becomes more conductive and takes a bigger portion the conductive component, it loses the typical textile properties such as flexibility or drape ability.

Electrical interconnection is required when a conductive path reaches to connectors. The contact area of at a junction point is critical for making a good connection. Improper interconnection causes incomplete contact and varying contact area results in non-uniform electrical resistance at the contacting points. Electrical connections are made possible by soldering or welding or welding, stapling and bonding. Connectors between electronics and e-textiles need to be specially designed. The fastening should be enough to hold electronics and at the same time, it should allow them to be easily detached.

Traditional forms of apparel fasteners can provide a good connection. A two-piece gripper snap can be a good connector. One side of the snap is attached to the e-textile and other side to the electronic device. The size and number of snaps can limit the connection interface and weight of the electronics. For a higher profile connector, the textile USB cable has been developed [25].

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IMPACTS OF ELECTRONIC TEXTILES ON RECYCLING AND DISPOSAL

Electronic textiles are a vanguard of an emerging generation of smart products. They consist of small electronic devices that are seamlessly embedded into clothing and technical textiles. E-textiles provide enhanced functions in a variety of unobtrusive and convenient ways. Like many high-tech products e-textiles may evolve to become a mass market in the future [26]. In this case, large amount of difficult-to-recycle products will be discarded. That can result in new waste problems.

The referred article examines the possible end-of-life implications of textile-integrated electronic waste. Basis of assessment, the innovation trends of e-textiles are reviewed, and an overview of their material composition is provide3d. Then scenarios are developed to estimate the magnitude of future e-textiles waste streams. On that base, established wastes disposal and recycling routes for e-waste and old textiles are assessed in regards to their capabilities to process a blended feed stock of electronic and textile materials. The results suggested that recycling old e-textiles will be difficult because valuable materials are dispersed in large amount of heterogeneous textile waste. Again, electronic component acts as contaminants in the recycling of textile materials.

NANO TECHNOLOGY E-TEXTILES FOR BIOMONITORING AND WEARABLE ELECTRONICS

Electronic textiles (e-textiles) will allow the design and production of a new generation of garments with distributed sensors and electronic functions [27]. Such e-textiles will have the revolutionary ability to sense, act, store, emit and move. We should think biomedical monitoring functions or new man-machine interfaces while ideally leveraging an existing low-cost textile manufacturing infrastructure. Advances in nanotechnology promise to dramatically advance the development of futuristic electronic textiles. To make conductive, carbon NANOTUBE-modified yarn will offer a uniquely simplified but remarkably functional solution for smart textiles which is expected to be close in feel and handling to normal fabric yet with many parameters exceeding existing solutions. Vast majority of the studies on textile modification with NANOMATERIALS have been carried with NANOPARTICLES.

There were many reasons for adding metal and semi-conductor to fabrics such as fashionably glittering colors, anti-microbial functions, UV protection, wrinkle resistance and anti-odor function. A team of researchers developed a method to coat regular cotton yarns with single walled and multi-walled carbon NANOTUBES (CNT) and poly-electrolytes. They pointed out that their scalable process provides a fast, simple, robust, low-cost and readily scalable process for making e-textiles. CNT-cotton yarns have shown high electrical conductivity as well some function ability due to biological modification of inter-NANOTUBE tunneling junctions. When CNT-cotton yarn incorporates ANTI-ALBUMIN, it became an e-textile bio-sensor that quantitatively and selectively detected albumin, the essential protein blood.

The same sensing approach can easily be extended to many problems and bio-molecules. Kotov and others [27}, in their simple process, repeatedly dipped a regular cotton thread in CNT dispersion and dried it. After several repetitive dips, the cotton thread became conductive with sensitivity as well as20 Ω. Interestingly, once the adsorbed CNT-cotton threads were dried, it was impossible to remove the adsorbed CNTs from the fibers by exposure to solvents, heat or a combination of both. The scientists pointed out that the poly-electrolytes are essential for the stability of the CNT coatings on fibers and they are also essential for comfortable wearing because they are hydrophobic. Energy harvesting materials and fabrics with charge storage capabilities become a possibility for the fabrics discussed above.

MEMORY STORING E-TEXTILE MATERIALS

Using a technique that looks strongly reminiscent of 950s and 60s core memory, two NASA nano technologists from Ames research centre in California have devised a method of weaving non-volatile computer memory into garments of clothing or e-textiles [28]. At its most basic, the e-textile is formed from a lattice of copper wires, the bottom wire is coated in copper oxide and at each intersection is small piece of platinum. The data is stored in the copper oxide coating by a process that is called resistive switching and to understand how the transistor works, where the copper oxide is considered as the dielectric layer. The read/write process is also much the same as normal RAM-a high voltage is issued to write bits and a low voltage read bits.

The total capacity of copper/platinum/copper oxide resistive memory is defined by the number of intersections, so in the image above the piece of memory being held between two fingers would store just 28 bits data. For example, the researchers used copper wire that 1 millimeter thick but there is no reason that it's count not be scaled down to just a few nanometers and in that case, the capacity of an e-garment could be measured in gigabytes. In terms of performance and volatility, NASA's copper oxide base memory is surprisingly tenacious. This early proto type should be able to store data for over 15 days and data can be read and written 60 micro second, the weave of the wires make this memory an ideal base for other threads, such as cotton or synthetics and it also makes the memory flexible, a key point for a smart fabric and wearable electronic.

There are technical constraints also. All of those wires have to run to a controller somewhere, and they have to be powered by some kind of battery.

The practical constraints are even more taxing. With punches it may lose data when it is a stepped into direct sunlight and heat, may also lose its integrity. Moreover, a suit made up of copper will rather happy. A review of recent developments in the rapidly changing and advancing field of smart fabric sensor and electronic textile technologies has been provided [29]. Sensing functionality can be created by intrinsic and extrinsic modifications to textile substrates depending on that level of integrating into the fabric platform.

The fabric sensors can be tailored to measure force, pressure, chemical, humidity and temperature variations. Materials, connectors, fabric circuits, interconnections, encapsulation and fabrication method associates with fabric technologies, and proved customizable and versatile but robust than their conventional electronic counterparts. The findings suggest that a complete smart fabric system is possible through the integration of the different types of textile based functional elements.

PROGRESS IN RESEARCH

A new class of electronic materials that are more suitable for e-textiles is the class of organic electronic materials because they can be conducting, semi-conducting and designed as inks and plastics. Some of the advanced functions demonstrated are: organic fiber transistor, the first textile fiber transistor that is completely compatible with textile manufacturing, which contains no metals and organic solar cells on fibers. Electronic textile research in the area for better and stronger soldiers includes the development of integrated sensor arrays and various embedded sensing technologies for deployment in clothing. In military research, active research involves smart, dynamic, responsive or interactive camouflage uniforms that possess CHAINELEON-like qualities and can change color when a soldier moves from a desert environment to an urban area.

Nanotechnology research consists of textiles that facilitate medical diagnosis, provide treatment, and endow the soldier with improved strength like exoskeleton. Electronic, computer and communication devices are also being woven into fabric so that materials can react automatically to stimuli. Projects in military include the study of deformation and failure in high-performance fabrics with superior ballistic projection as well as the development of, micro-bicidal, antiviral and anti-poral fabrics and other materials.

Electronics and computer peripherals are now started coming in the market a stream of electronic items is expected to emerge that are soft, compact, flexible and portable. There are two areas where textiles and electronics are taking directions. First the smart textile interface fabrics are adding values to electronics. In the other areas, electronics are enhancing the functional textiles, for example the sensor and communication technology are used in protective wear outdoor sports, children wear and medical applications.

CONCLUSION

In general, the development of electronic textiles supports the idea of wearable computing, or electronic devices worked into garment designs. One of the most important issues of e-textiles is that the fibers should be made such that it can be washable as the clothes should be washed when it is dirty and the electrical components in it should be insulator at the time of washing. The field of embedded advanced electronics components onto textile fibers is sometimes called FIBERTRONICS. Many of these are aimed at the uses within the health care industry, where wearable computing elements can be used of monitor vital signs and otherwise track a person's health in real time. Electronic textiles are used in many products, including the NUMETRIX athlete garments that monitor heart rate, fabric keypads for controlling iPOD and heating products. Sophisticated fiber technology is introducing new fibers that may function as batteries, durable wires and speakers.

The prominent application of e-textile is smart clothing. Electronic textiles are a vanguard of an emerging generation of smart products. CNT-cotton yarns have shown high electrical conductivity as well as some functionality due to NANOTUBES tunneling junctions. Sensing functionality can be created by intrinsic and extrinsic modifications to textile substrates depending on that level of integrating into the fabric platform. Electronic, computer and communication devices are also being woven into fabric so that materials can react automatically to stimuli.

REFERENCES

[1] E-textiles, en.wikipedia.org>wiki (from Wikipedia, the free encyclopedia).

[2] Harris, J., ed. texiles, 5000 years: an international history and illustrated survey, H. N. Abrams, New York, NY, USA, 1953.

[3] Marvin, C. When Old Technologies Were New: thinking About Electronic Communication in the Late Nineteenth Century. Oxford University Press, USA, 1990.

[4] Gere, C and Rudoe, J. Jewellery in the Age of Queen Victoria: A Mirror to the World, British Museum Press, 2010.

[5] http// query. Nytimes.com/ gst /abstract, html? Res = FA0912FB3A5738DDDAF0A94DC 405B846F0D3.

[6] Smith, P., Body Covering Museum of Contemporary Crafts, the American Craft Council, new York, NY, 1968.

[7] Post, R., Orth, M., Russo, P., and Gershamfeld, N., Embroidery : design and fabrication of textile-based computing, IBM Systems Journal 39, 3-4 (2000), 840-860.

[8] MP3 Blue.Com, (http://mp3blue.de).

[9] http//www.thecreatorproject.com/blog/theoriginal-creators-dianna-dew.

[10] "Lumalive.Com",(http//www.lumalive.com).

[11] "Wearable Electro-chemical Sensors and Bio-sensors: A Review", (http://onlinelibrary.wiley.com/doi/10.1002/elan.201200349/abstract).

[12] ."Thick-film textile-based Ampero-metric Sensors and Bio-sensors" (http://pubs.rsc.org/en/content/Article Landing/2010/An/b926399j).

[13] "Textile based electro-chemical Sensing: Effect of fabric substrate and Defection of Nitro-aromatic Explosive"(http://onlinelibrary.wiley.com/doi/10.1002/elan.201000434/abstract).

[14] Electronic Textiles: Fiber-Embedded Electrolyte-Gated field effect-transistors for e-textiles" (http://www3.intersciencs.wiley.com/journal/121655064/abstract?CRETRY=1& SRETRY=0).WileyOnline Library, John Willy & Sons, Inc, 22 January, 2009.

[15] "Towards Woven Logic from Organic Electronic Fibers" (http://www.nature.com/nmat/Journal/V6/n5/nmat1884.html), Nature Materials, Nature Publishing Group, 4th April, 2007.

[16] . "Solar Power Wires Based on Organic Photovoltaic Materials" (http://www.sciencemag.org/egi Content/abstract/324/5924/232), Science American Association for the advancement of Science, 12th March, 2000.

[17] ."E-textiles/Electronic Textiles/Applications of the Electronic

Textiles”,textilelearner.blogspol.co> 2011/08.

[18] “Electronic Textiles: Wearable Computers, Reactive Fashion, and Soft Computation”, www.xslabs.Technopedia.com.

[19] Electronic Textiles (E-Textile), www.technopedia.com.

[20] E-Textiles for Wearability : Review of Integration Technologies”, www.textileworld.com.

[21] :Product FAQs”, www.ifmachines.com>products-faqs.

[22] “Electronic Textiles”, www.fibre2fashion.com.

[23] Hardesty, Larry., 2001, “Clothed in Health”, MIT technology Review July/August, 2001, 34.

[24] Post,E.R., P.R.Russo and N.Gershenfield 2000, “E-embroidery: design and Fabrication of Textile Based Computing “, IBM Systems Journal, 39 (3,4), 840-60.

[25] Co, Elisa Dee, 2000, “Computation and Technology as Expressive Elements in Fashion”, Master’s Thesis in Media Arts and Sciences, MIT, Cambridge, MA.

[26] “Prospective Impacts of Electronic Textiles on Recycling and Disposal”, Journal of Industrial Ecology, Vol 15, issue 4, P496-511, August, 2011.

[27] “Nanotechnology e-textiles for bio-monitoring and wearable electronics”, Carbon Nanotubes, helixmaterial.com, Nov’2008.

[28] “Wearable Electronics: NASA Develops Memory-storing e-textile Material”, Sebastian Anthiny, September 27th, 2011.

[29] “Smart Fabric Sensors and e-textile Technologies”: A Review, Smart Materials and Structures, Vol 23, No 5, (IOP sciences).