Impact of Smart Technology on Fashion

Abstract

Modern technology has paved for incorporating a variety of intelligent materials in clothing substrates. Current day innovations create significant demand and scope on creative capability in the clothing industry, leading to functional clothing. These functional garments exhibit a marked difference in its performance & aesthetic appeal which has a massive impact on today's fashion trends.

Functional clothing, also termed Smart textiles, are materials that respond to the environmental changes and manifest their functions according to the change. Smart developments in textiles includes deodorizing fabrics, breathable fabrics, insect killer clothing, hazard warning clothing, functional sportswear, medical and safety wear, anti-stress wear etc. Micro encapsulation of Stimuli sensitive materials in the fabrics helps the fabric to respond to physical / chemical / biological external stimuli e.g. temperature. Smart textiles technologies that can be incorporated into fashion includes color changing fabrics; shape memory textiles, sweat-free garments etc. Thermo chromic materials (TCM), when encapsulated in the fabrics, sense the changes in environmental temperature which accordingly changes the color of the fabric to suit the external climate. Similarly, by encapsulating Phase change Materials (PCM) in fabrics, which absorb heat energy when it changes from solid state to liquid state and releases heat energy when it reverts back, a temporary cooling or heating effect on the clothing layer, keeps the wearer comfortable. Textiles incorporated with shape memory polymers helps fabric / garment to retain a particular shape under certain environmental conditions. These techniques avail flexibility to the designer to select a wide range of materials irrespective of climate or geographic location. For instance, for cold climates, thin fabrics coated with PCMs can be used in order to impart functional fashion, which makes the wearer sport an attractive look.

These smart techniques create a whole new horizon to develop high fashion products which will take the fashion industry to its pinnacle. This paper reviews the outlook of dashing technologies and its role in futuristic fashion.

Introduction

Fashion, as a cycle, always demands for new varieties in both fabrics and designs. This demand creates a need for exploring the possibilities of incorporating emerging technologies in developing fabrics and garments, that will establish and sustain financial and competitive advantages in future fashion. Such advanced technology incorporated fabrics/garments not only satisfies the basic customer but also creates customers for innovative and functional fashion apparels. Future trends in fashion are expected to be highly performance oriented rather than mere aesthetic appeal. Smart textiles are characterized by intelligence and elegance. Smart materials appear to think and some have a 'memory' as they revert back to their original condition. [1, 2] Some typical smart materials which could be used to develop swanky outfits include Temperature Control Fabrics, Shape Memory Fabrics, Color Changing Fabrics, Conductive, Embedded fabrics and Self Cleaning Fabrics.

Intelligent fabrics are developed by embedding Stimuli Sensitive Materials in textile structures by micro encapsulation or printing techniques. Stimuli Sensitive Materials are special polymers packed in micro capsules which act as tiny containers and exhibit changes in response to the external stimuli. These containers release their core contents, whose inherent properties can be favorably changed to meet performance needs when stimulated. In order to produce temperature sensor fabric, the stimuli sensitive materials shall be incorporated, which will sense the change in temperature in the environment and respond accordingly.[3] These changes may be one or combination of physical, chemical and biological factors such as temperature, pressure, pH, electrolytes, bacteria, fungi etc.

Temperature Control Fabrics

Generally, in extreme climatic conditions, the wearer requires clothing, that keeps him comfortable. For a hot climate the wearer uses a very lightweight material and during cold climatic conditions, uses a heavy, bulky material to keep warm. But a single lightweight fabric, incorporated with Phase Change Material (PCM), a stimuli sensitive material, keeps the person cool or warm, according to the climatic conditions.

Phase change materials absorb heat energy when it changes from solid state to liquid state and releases heat energy when it reverts back. [2,3] PCMs are low melting paraffin waxes (e.g. Octadecane, eicosane), either in the form of wet-filter cake or as a dry powder. They are enclosed in microcapsules, which act as a protective cover and prevent them from leakage,

when it is in liquid state. The melting point ranges from 0 - 50ºC, which can absorb and release large amount of heat. The freezing and melting points of the PCM can be altered by changing the type and proportion of the paraffin used. The capsule wall is an inert, very stable polymer or plastic.

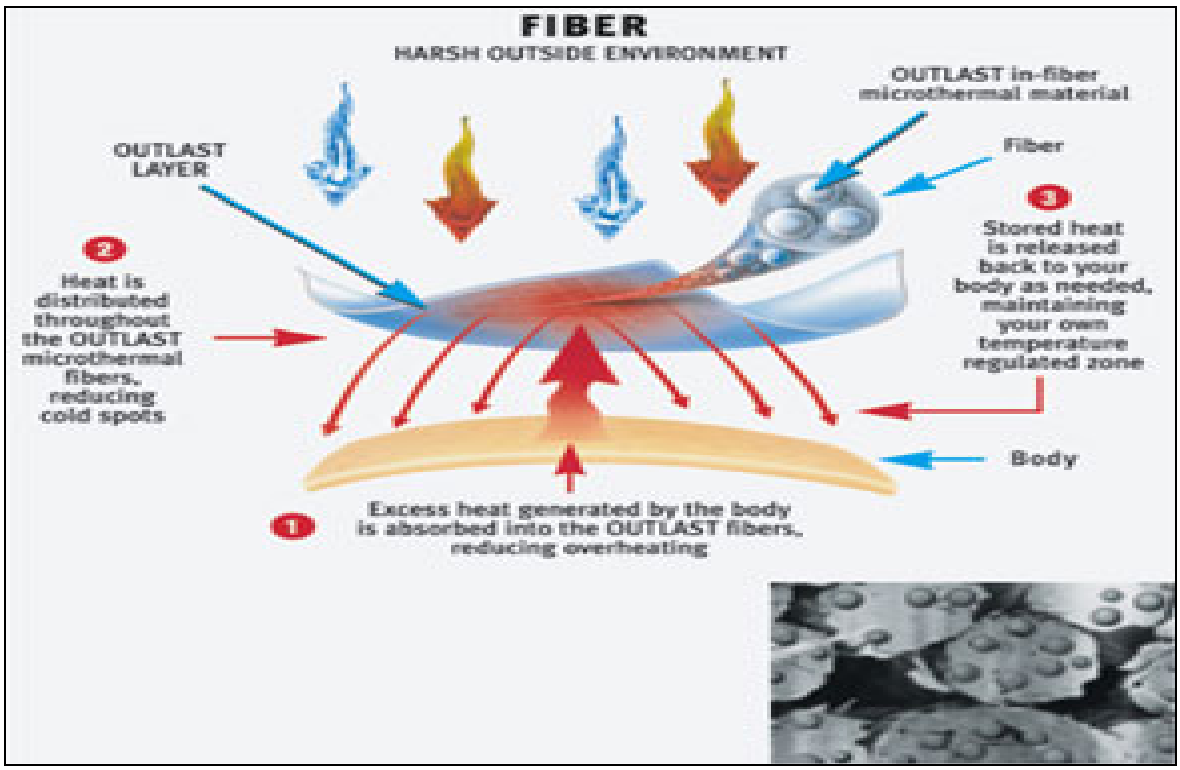


Figure 1. PCM incorporated clothing (http://www.outlast.com)

These microcapsules, having size in few microns, are generally incorporated into the textile materials either in fibre or fabric form as shown in Figures 1 and 2.

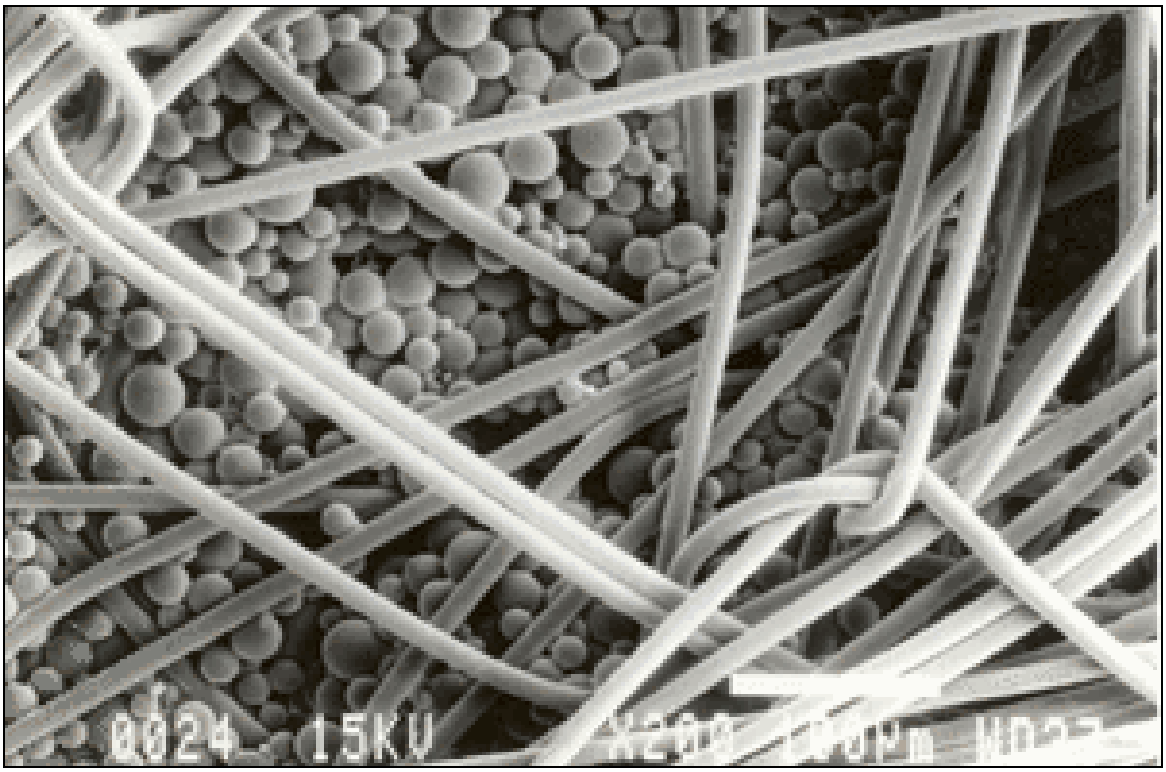


Figure 2. Fabric encapsulated with PCM (http://www.outlast.com)

In fibers, they are embodied in the spinning dope and in case of fabrics they are coated on the surface, which increases the fabric thickness, only by two thousandth of an inch.[3] The PCM garment, when worn in a hot climate, produces a temporary cooling effect on the microenvironment. For example, if the micro PCM were used in a ski jacket, the paraffin wax would initially absorb the skier's body heat and store it until the body temperature drops from the outside environment; at which time, the heat is released giving warmth to the skier and keeping the temperature regulated for his/her comfort. The PCM action and the comfort level achieved in the garment are depicted in Figures 3 and 4 respectively for better understanding.

Similarly, if the PCM garment is worn in an environment where the temperature is below the PCM's freezing point, the PCM will change back to the solid state, releasing heat energy and generating a temporary warming effect. These changes take place within preselected temperature ranges. General applications include apparels such as inner and outer garments, military uniforms, gloves, footwear, bedding materials and foam (for example used in cushions for wheelchairs, car seats, etc.)

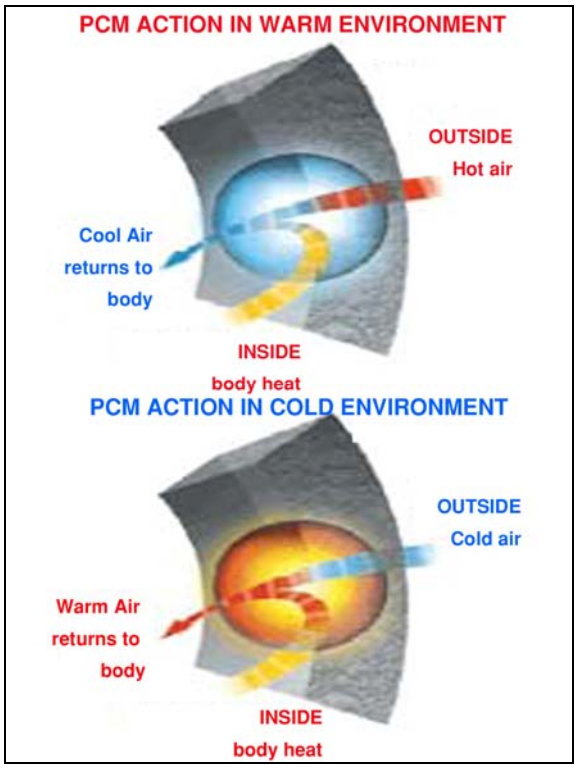


Figure 3. PCM action in different environments
(http://www.ottobockus.com)

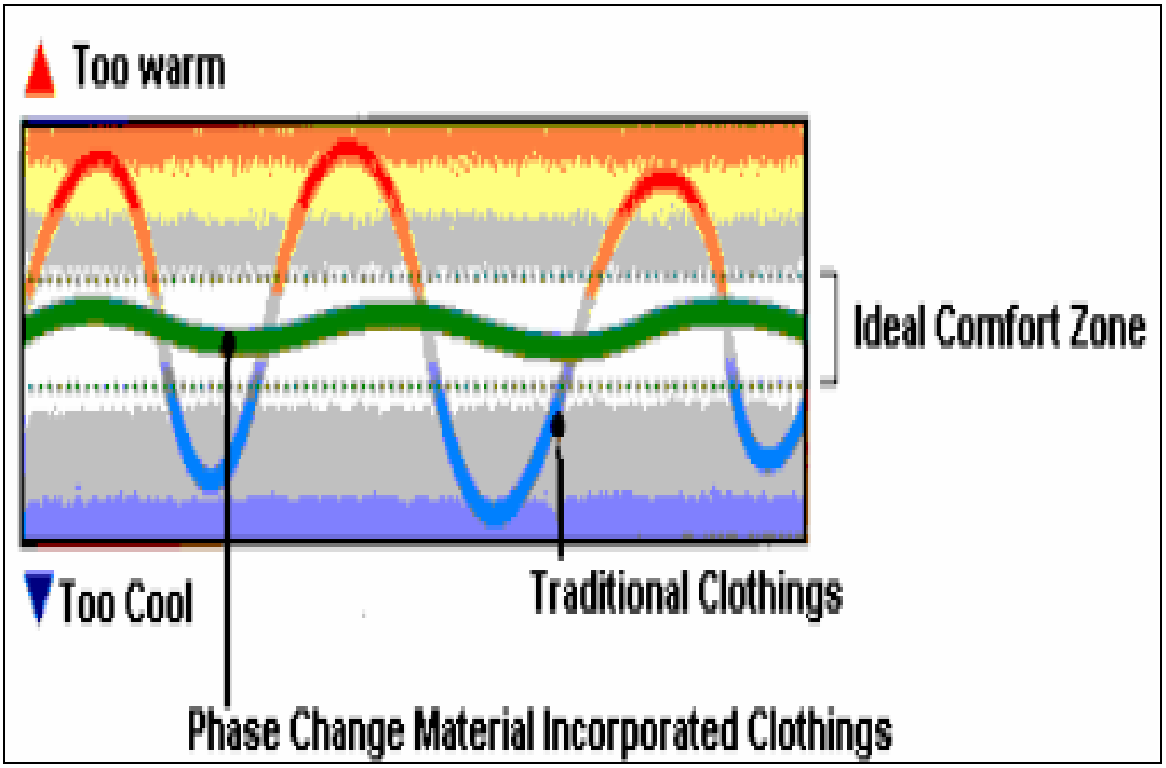


Figure 4. Thermoregulation of PCM incorporated clothing
(http://www.ottobockus.com)

This technology can be easily applied for daily winter wear / fashion apparels which will make winter wear very light and increase the scope for designs. They also diminish the moisture level in the garments and prevent fungal and bacterial infection due to prolonged use of heavy clothing during the entire course of winter[4]. Furthermore, these techno-edge fabrics could replace the use of leather, fur and skins of exotic animals in apparels, eventually leading to wild life conservation. Commercial PCM encapsulated garments like Jackets, vests, ski gloves, socks and boots are nowadays available from various top labels including Bugatti, Burton, Gordini, New balance, Obermeyer, Rukka, and Serat. PCM embedded active fashion and performance apparels are manufactured and marketed by Gucci, Pierre Cardin, Polo Ralph Lauren, Prada, Schoeller, Freudenberg etc.[5]

Shape Memory Fabrics

Shape memory fabrics as well as garments tend to change their physical shape in response to the external stimuli. For instance, “Temperature Adaptive Shirts” rolls off its length at elevated temperature for providing additional airflow to the body. The shirt fabric material, nitinol, a nylon based fibre, shortens its length as the room temperature increases for a few degrees.

Figure 5. Shape Memory Shirts (http://www.textielmuseum.nl)

The fabrics can be popped back to its original shape and size by subjecting the fabrics to suitable temperature conditions (Figure 5).Other merits of the fabric include, metallic look, appearing to be completely different in color under various light sources, non-allergenic and easy maintenance. Garments with such peculiar features very much enamors the fashion mass.

Shape memory materials or shape memory polymers are defined as polymeric materials with the ability to sense and respond to the external stimuli in a predetermined shape. Shape memory polymers are made of copolymers, which have hard as well as soft segments. They exhibit extraordinary functions like sensitivity, actuation, damping, adaptive response to external stimuli such as temperature, light, stress, electrical field etc.[6] Some polymers, which are discovered with shape memory effects, include Polynorbornylene, trans-polyisorprene, styrene-butadiene copolymer, ethylene-vinyl acetate copolymer, polyethylene, polyester copolymerized with other polymers, block polyurethane etc. Shape memory alloys, such as nickel-titanium, have been developed to provide increased protection against extreme temperature conditions. As seen in Figure 6, Shape memory alloy is usually in the shape of a spring. The spring is flat below the activation temperature but becomes extended above it. By incorporating these alloys between the layers of a garment, the gap between the layers can be substantially increased above the activation temperature. As a result, considerably improved protection against external heat could be achieved. The incorporation of shape memory materials into garments thus confers greater versatility in protection provided against extreme heat or cold.

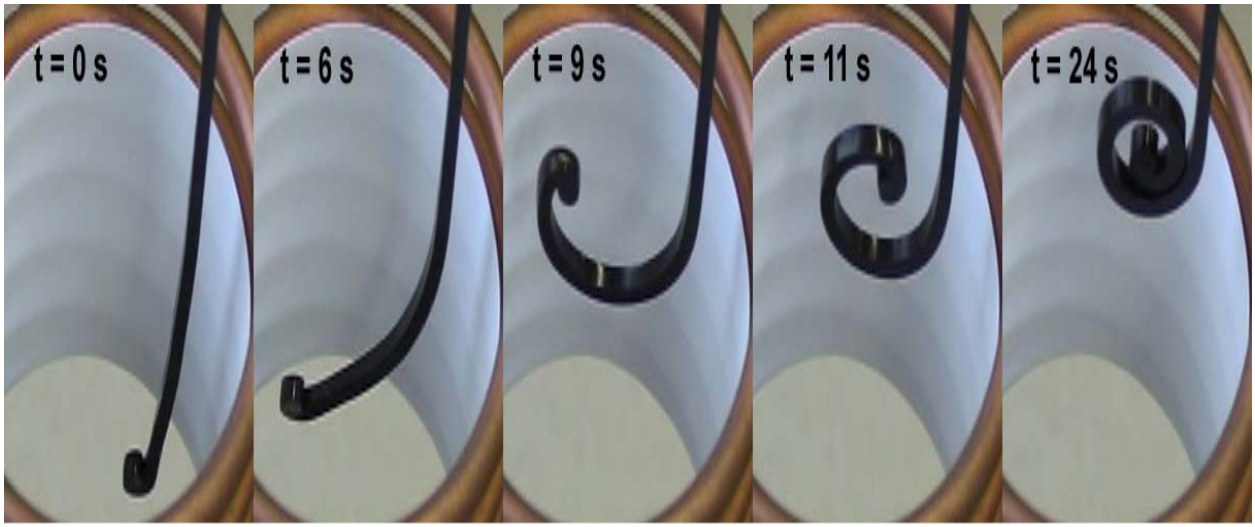


Figure 6. A shape memory polymer in action (http://www.gkss.de)

Scientists at the University of Wollongong, Australia have developed a brassiere that responds to breast movement and gives better support to women during work. One major discomfort faced by full busted women is chest pain due to brassieres which tightly press the breasts towards the chest and restricts movement followed by breathing problems. A cutting edge product called, “Smart Bra” has been developed which will tighten and loosen its straps, or stiffen and relax its cups, to restrict breast motion, preventing breast pain and sag.[7] This will prevent the breast clavicles snapping from the sudden movement of excessively heavy breasts and encourage more large-breasted women to sports. The movement of the breast is perceived by the fabric sensors attached to the straps and midriff of a standard bra and a telemetry system relays the data in real time to a computer (Figure 7). Information gathered from the tests will eventually be stored on a tiny microchip that will serve as the 'brain' of the ultimate ‘Smart Bra’, signaling the polymer fabric to expand and contract in response to breast movement. Such innovative technologies widen the scope for designing lingerie for full busted women, which helps them look fashionable without discomfiture.

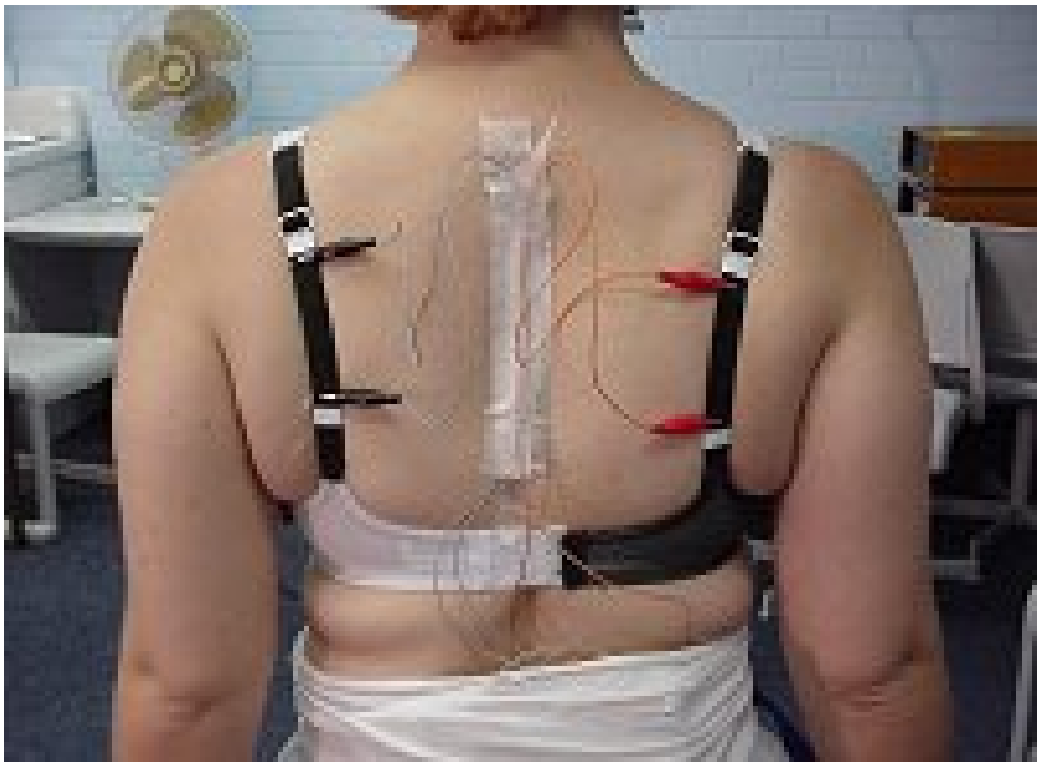


Figure 7. Smart bra coated with sensors to detect breast movement and adjust cup size (http://www.abc.net.au)

Shape memory garment not only helps the wearer to be comfortable but also aids in giving a remarkable fit. These additional features make the wearer stand out from the rest, which creates a wave for new trends to flow as functional fashion rather than mere aesthetic fashion.

Colour Changing Fabrics

Colour changing fabrics are developed by incorporating chromic materials within the fabrics. Chromic materials changes its color based on changes in atmospheric condition, which ultimately changes the fabric colour.[5, 8] Reversible change in colour of such chromatic materials is termed as “Chromism”. Chromic materials radiate or change or irradiate color, when induced by the external stimuli. Chromic materials can be further classified depending on the stimulus which effects the colour change as given below:

- Thermochromic : Heat
- Photochromic : Light
- Ionochromic : pH value
- Electrochromic : Electricity
- Piezorochromic : Pressure
- Solvatechromic : Liquid
- Carsolchromic : Electron beam

Among these, thermo chromic and photo chromic materials are commercially advantageous. Thermochromic materials (TCMs) are incorporated into fabrics by micro encapsulation or printing. As the atmospheric temperature increases, the garment fades and when there is a temperature decrease, it becomes dark.[9] This effect can be applied for the whole garment or in the form of printed designs. This concept will make the garment most suitable in hot climates. Temperature induced changes in color are created with thermo chromic (TC) pigments. The pigment is composed of microcapsules with size ranging between 1 and 10 microns. When temperature of the surrounding media changes, the molecular structure of the TC pigments are altered, either by breaking of covalent bonds or flipping of the molecule into a different conformation and hence colour of the pigment changes.[10] For textile purpose, this pigment can be selected in such a way that it should alter their colour with slight change in temperature at around room and body temperatures. The visual effects of TCM shirt at different temperature level are depicted in Figure 8.

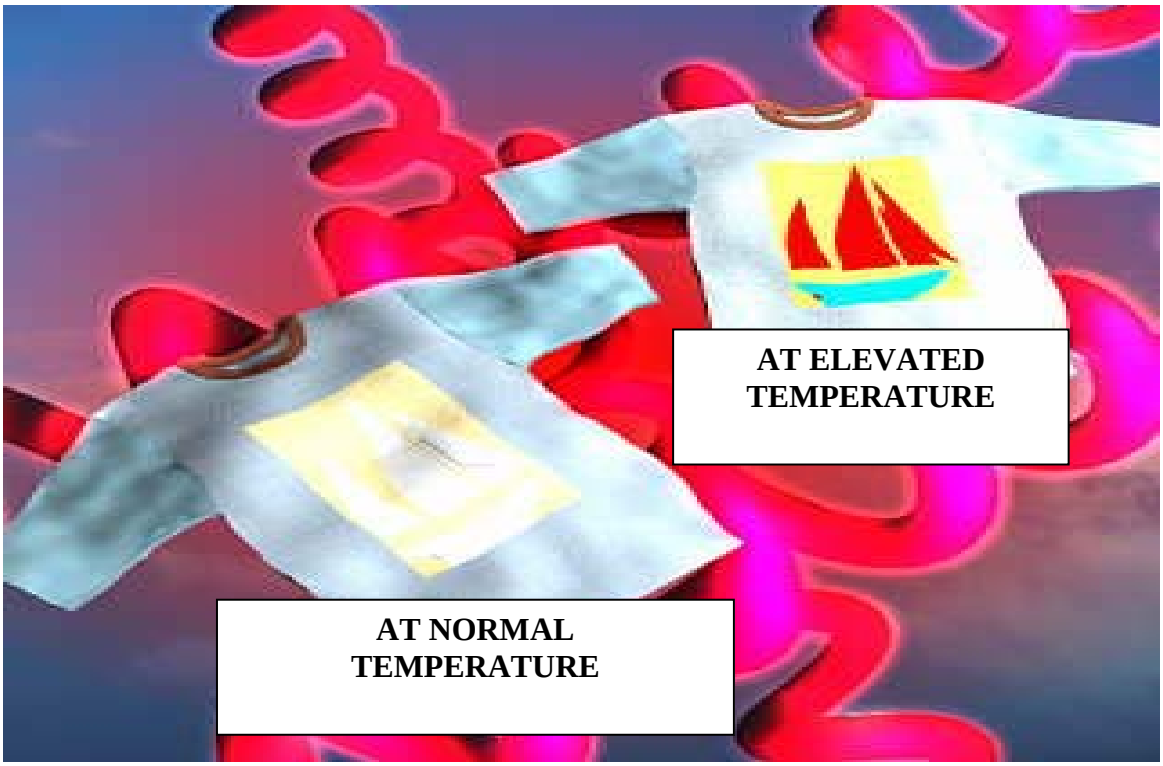
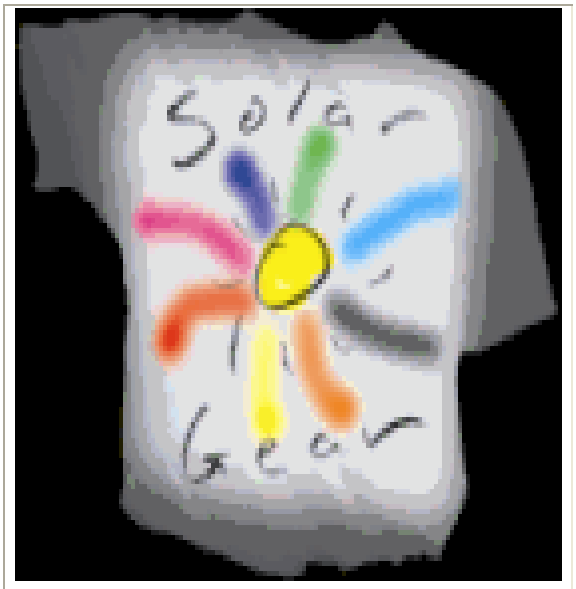


Figure 8. Thermo chromic T-Shirts at different temperature levels. (www.techexchange.com)

There are two types of Thermochromic materials viz. liquid crystals and leuco dyes. Liquid crystals are generally used for higher precision applications like aquarium thermometers, medical forehead thermometers, and "stress" cards, since the temperature response point can be tightly engineered. Leuco dyes are less precise and commonly used for textiles and other novelty applications such as coffee mugs, toys and novelty products as shown in Figure 9, 10 and 11. An increase of inner temperature of the mug when a hot beverage is filled changes the visual effect of the design printed on the mug.

Thermochromic dyes are used extensively in the printing of textiles, micro encapsulation, coating or dope dyeing which creates scope for developing a wide range of collections in the fashion sector with exciting effects of the garments. Photo chromic Materials (PCs) change from clear when indoors to colour when outdoors and are reversible. Specifically, PCs change color in response to ultraviolet (UV) light, usually from the sun or a black light.[8]

Figure 9: Indoors	Figure 10 :Outdoors
	

Figures 9 & 10. Effect of Photo chromic T-shirt in indoor and outdoor (www.colorchange.com)

Figure 11. Mugs printed with Leuco dyes (www.colorchange.com)

Reversible PCs change color in the presence of UV light but return to their original state when the UV source is removed. Some examples of reversible Photochromic applications are lenses, screen printing inks, sunglasses, nail polish and novelty items. Irreversible PCs begin as one color and change to another color in response to UV exposure. These materials do not return to their original state when the UV source is removed. This makes them useful only for applications requiring a single use such as document security devices, UV curing measurement and sunburn prevention.

Photochromic inks changes color with sunlight. Nearly invisible inside, the ink becomes brightly colored outside after just 15 seconds. When back inside, the color disappears again. Photochromic inks in combination with standard inks to make images come alive as shown below. The advantages of PCIs are longer life, wide color range and edgy look for the products. Photo chromic inks change color when exposed to ultraviolet light usually from the sun or a black light. Photo chromic ink can be used for artwork and printing. Shirts with a high quality dense weave or ring-spun T-shirt gives the best print quality, coloration and minimal fibrillation.

The ink is available with the following three key features:

Color formulation (CMYK) (Cyan, Magenta, Yellow, Black)	Allows any combination of colors to be printed using four-color process printing. A full range of spot colors are also available.
Superior stabilization system	T-shirts printed with will Photochromic inks withstand a minimum of 20 typical wearing, even in Miami.
Low background color and high color saturation	Nearly invisible indoor coloration with vibrant and intense colors in sunshine.

T- shirt printed with Photochromic Ink is depicted in Figure. 12:

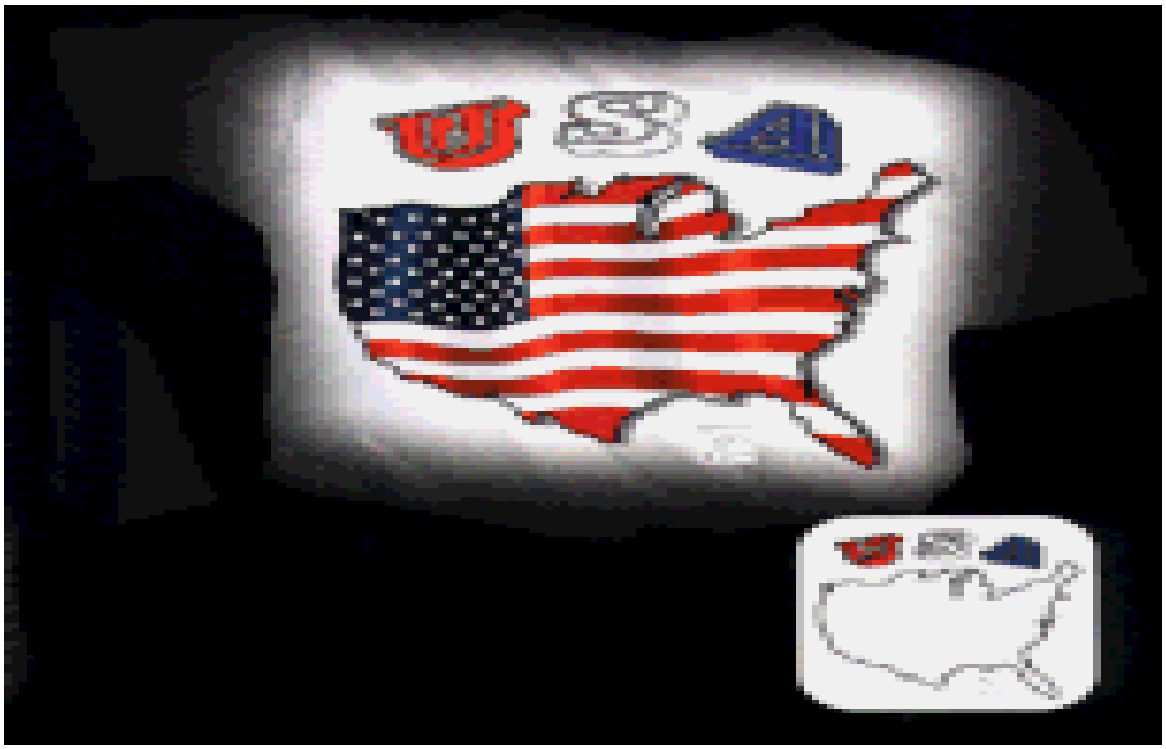


Figure 12. Photochromic Shirt – Indoor and outdoor
(www.colorchange.com)

Conductive Textiles

Conductive and composite textile has been developed to manufacture wearable electronics, considered as e-apparel, where electronics are added to the textile. In forthcoming years, clothing assortments are likely to incorporate more intelligence and interface between a broad range of micro-systems. Micro-system technology is continuously making tinier components permitting intelligence to be blended with more exclusive products, thereby creating a new fashion range. The first successful step towards wearable electronics was the ICD+ line at the end of the 90s, which was the result of co-operation between Levi's and Philips.[11] This line's coat architecture was adapted in such a way that existing apparatuses could be put in the coat: a microphone, an earphone, a remote control, a mobile phone and an MP3 player. Other similar incorporated features, so far include, a bikini with an integrated MP3 audio player, a shirt with its own mobile phone and ski jacket that warm up its wearer and alerts about position of other skiers that are coming too close to back off.

Hug Shirts armed with electronic sensors that gauge body temperature, pressure and heart rate. The Hug Shirt allows wearers to give long-distance embraces to loved ones. "Wearers hug themselves, and then using Bluetooth technology and their cell phone, they can send it to

someone else wearing a Hug Shirt that simulates the feeling of the hug," says Francesca Rosella, creative director of London-based Cute Circuit, which developed the interactive top. It copies the strength, length, temperature and heart rate of the hug. This hug shirt has been named as one of the top inventions of 2006 by Time magazine.[12] Researchers at the Wearable Computer Laboratory at the University of South Australia in Adelaide have been working on a "smart suit," a jacket that functions like a wearable PDA and cell phone, complete with a "smart hangar and wardrobe" that recharges imbedded electronic gear and synchronizes the suit with a desktop computer upon every hanging.

Textiles produced by the new process have potential to incorporate an array of communication devices, and act as sensors for temperature, strain, pressure, humidity, and chemical biosensing. The embedded electronic functionality in textiles is more durable and stable, even surviving the knockabout world of machine washing.

Electronic items embedded garments copiously augment the precincts of techno-fashion with some very exciting features.[13] [14] [15] Some examples include,

1. Musical jacket, which allow the wearer listen to his/her favorite music stored on a chip, or to tune into the favorite radio station. They can also have moving images on the inbuilt screen, which is shown in below. (Figure 13)

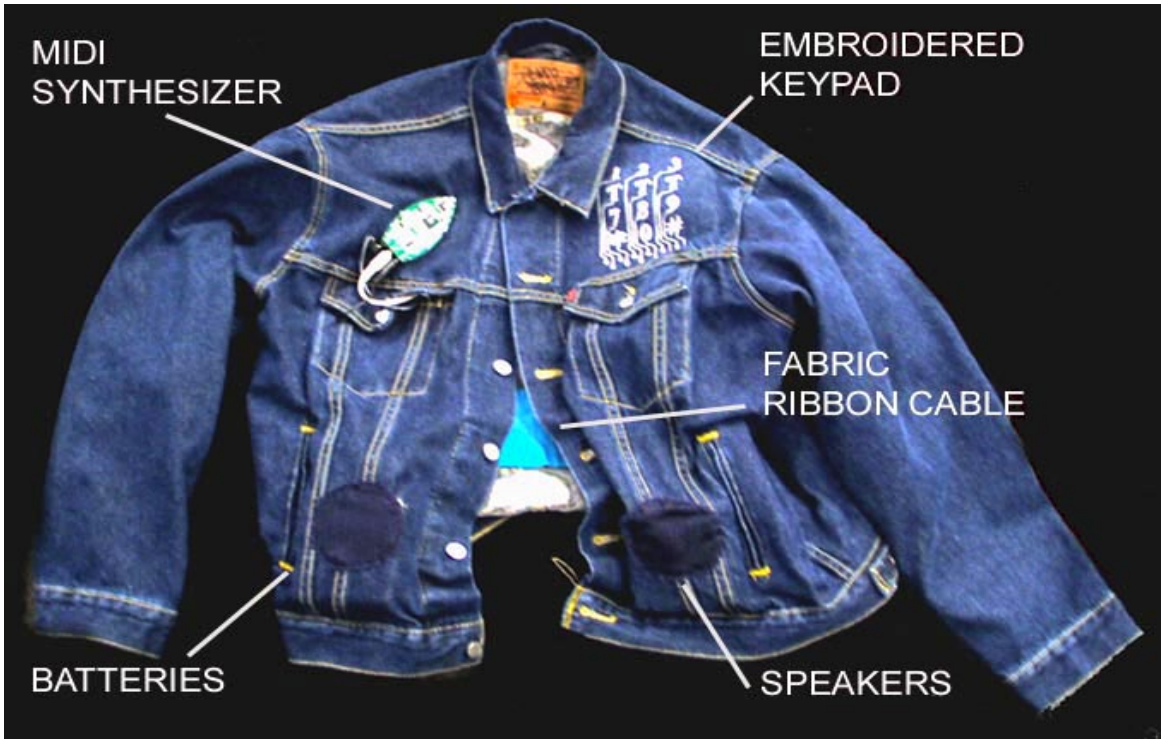


Figure 13. Musical Jacket (www.berzowska.com)

2.Business garments, which has a microphone and MP3, incorporated in the collar, a display, and a personal digital assistant in the sleeve.

3.Solar energy re-charge jacket, which incorporates in itself, some tools for creative playing and communication, such as a camera, display and microphone attachments.

4.Massage kits, giving a soothing massage to the wearer that can be regulated depending on the level of relaxation desired by the user by applying vibration and pressure.

5. A solar bikini that overlays the basic swimsuit with narrow strips of photovoltaic film sewn on with conductive thread by designer Andrew Schneider. The suit produces a five volt output that, via the attached USB connector, can recharge gadgets like the i-pod.

6. Cameraflage exploits the CCD and CMOS sensors in digital cameras to add a hidden layer of meaning or interest to clothing. Designs that are invisible to the naked eye are sewn onto garments. These are then picked up by digital camera sensors when the clothing is photographed.

7. Jackets fitted with sensors, microcontrollers and LED arrays, are designed for couples who want to let the world know how they feel. When two people are wearing the garment, hold hands the sensors pick up the connection and pipe text messages onto one array that then scrolls across to the other.

8. Garments are studded with a variety of motion sensors that feed the information via Bluetooth about how the dancer is moving to a computer that interprets the sensor data. This can be used to create music or cue up video, audio or light displays to enhance performances

These embedded techno viable garments are not only functional but also amplifies the voguish look of the garment as well as the wearer.

Self-Cleaning Fabrics

Fabrics which are cleaned by molecular disintegration are referred as Self cleaning fabrics.[16] The self-cleaning fabrics work using the photocatalytic properties of titanium dioxide, a compound used in many new nanotechnology solar cell applications. The fabric is coated with a thin layer of titanium dioxide particles that measure only 20 nanometers in diameter. When this semi-conductive layer is exposed to light, photons with energy equal to or greater than the band gap of the titanium dioxide excite electrons up to the conduction band. The excited electrons within the crystal structure react with oxygen atoms in the air, creating free-radical oxygen. These oxygen atoms are powerful oxidizing agents, which can break down most carbon-based compounds through oxidation-reduction reactions. In these reactions, the organic compounds (i.e. dirt, pollutants, and micro organisms) are broken down into substances such as carbon

dioxide and water. (Figure 14) Since the titanium dioxide only acts as a catalyst to the reactions, it is never used up. This allows the coating to continue breaking down stains over and over.

Breakthroughs in nanotechnology have made self-cleaning fabrics both practical and economical. With commercial production making the technology readily available to the masses, this may lead to obsolete washing machines and laundry detergents. But one may need to hangout the garment in sunlight for specified period for activating TiO_2 electrons. Apart from cleaning, a fresh and clean look is maintained.

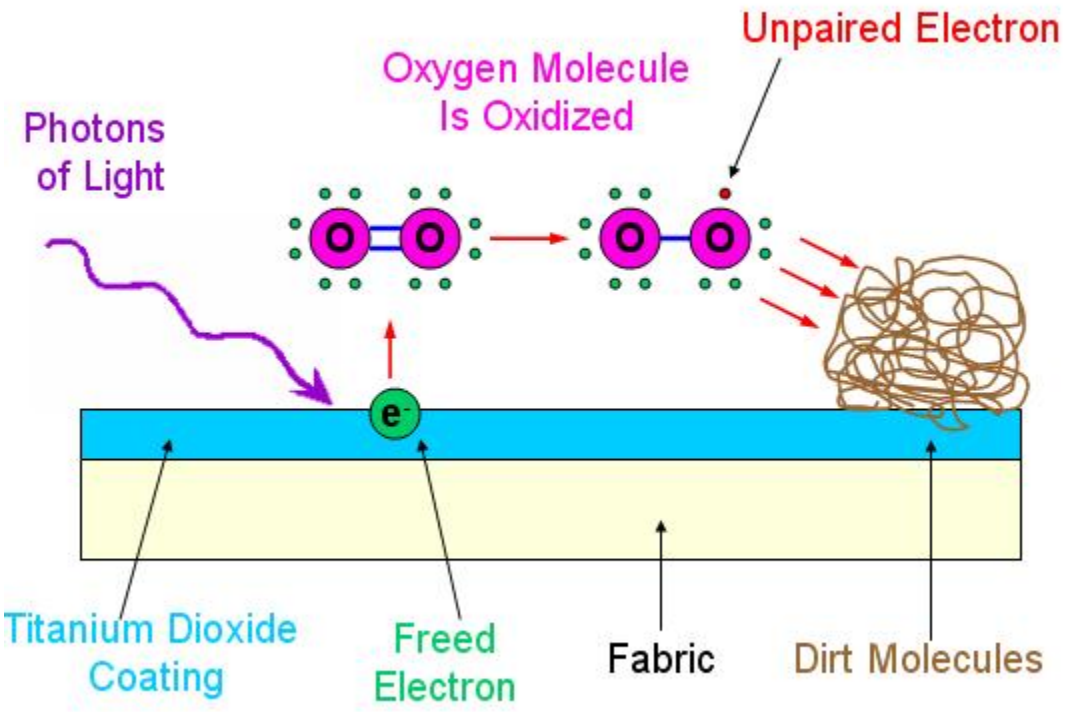


Figure 14. Molecular breakdown technique of self cleaning fabrics
(www.nanopedia.case.edu)

Conclusion

According to the latest survey by Venture Development Corporation estimates that demand for global smart fabrics and interactive textiles (SFIT) products and solutions totaled $369.2 million for 2006 and will reach $1,129 million by 2010, representing a four-year compound annual growth rate of 32% [17]. Even though the main drivers have been identified as their need in

critical applications (e.g. health and survival), practicality of some applications, niche consumer markets tend to use it as a luxury as well as fashion statements.

There is a now a buzz in the fashion and high tech industries about the integration of technical and smart intelligent functionality into fabrics for clothing and interior environments. But there is a big gap between aspiration and reality due to the gulf between designers who generate ideas, and technologists who develop technologies and materials to realize those ideas. This means that, to date, much wearable technology has been developed by electronics and technology sectors and has used clothing as a carrier of entertainment and communications systems.

Fashion and Textile designers need to work with technologists and scientists, at the outset of materials development to ensure seamless integration of technology into products, as well as ensuring that their products are both attractive and demanding. Work within smart fashion and textiles group explores the use of design as a tool to better understand users, and as a tool to facilitate multi-disciplinary collaboration between science and design. The integration of smart functionality will expand the scope of our material environment exponentially, and as a result designers need a better understanding of users. Efforts of techno-designers would help to materialize imaginations and creativity, to deliver better products with dual features, “comfort” and “smart fashion”. Such innovations will hoist fashion to a whole new realm.

Endnotes

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