Think Biosolution

Fabrics for designing smart apparel

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Introduction

It is hard to determine when wearable technology truly became “wearable” in the eyes of the consumer. Until recently, these devices were constructed from predominately large, bulky and uncomfortable materials—the same materials used to construct most non-wearable technology. This has proven to be problematic for target consumers, as most people prefer garments made from fabric over those that are made from large pieces of non-flexible plastic and excessive wires (Plummer, 2018). Product developers and designers have become increasingly aware of the extreme requirement for wearables to be comfortable and have adapted to this market need by making their devices more compact and inherently wearable.

Several advancements are being made regarding the wearable aspect of wearable technology. Many product developers and their respective designers are beginning to explore the idea of building fully functioning circuits from textile materials such as yarn and other conductive fabrics (Twombly, 2018). There is, however, a serious lack of existing research and general understanding of how to successfully incorporate conductive materials into functional wearable technology. This disparity can make it difficult and expensive for new companies wanting to enter the field of wearable technology. This article aims to introduce the concept and potential benefits of conductive fabrics by analyzing the available technologies, current trends and challenges facing product developers and designers today.

Conductive fabrics

Conductive fabrics are, by definition, “materials that are made from, coated or blended with conductive metals including but not limited to gold, carbon, titanium, nickel, silver, or copper”. This novel technology works with many different types of textiles, but is most commonly paired with cotton, nylon, polyester or wood (Twombly, 2018).

Conductive fabrics are still a new concept within the wearable technology field, but their lightweight and flexible nature has become increasingly intriguing amongst product developers and designers. One of the biggest challenges facing the wearable technology industry today is the large size and impracticality of many of the devices. New research being done on conductive fibers shows that solutions to these problems may not be as out-of-reach as they seem.

A small handful of existing conductive fiber technologies are beginning to enter the wearable marketplace. Technology and apparel companies have started exploring the incorporation of metal threads into the fabrics of the proposed garments, so as to replace large batteries or external wire paths. Another popular application has been the printing of conductive materials, such as metallic inks, directly onto the surface of inherently non-conductive fabrics (Twombly, 2018). Both of these applications provide versatility and may offer a competitive advantage to companies in the future if developed and incorporated properly.

Current trends

During the last few decades of the 20th century, the only reason fashion designers weaved metallic yarn into their garments was to create a certain aesthetic appeal, and it had nothing at all to do with the garment's function (Post and Orth, 1997). Today, metallic yarns and other conductive fibers are being incorporated into clothing in order to harness energy to power the garment itself. While a few conductive fabrics are currently available to product developers and designers, many of the most promising applications are still in early stages of development.

A group of researchers at the University of Oulu in Finland are currently studying a type of **ferroelectric material (KBNNO)** that has the ability to "harness kinetic energy, heat and sunlight – all at the same time" (Plummer, 2018). These scientists are hopeful that this technology will be largely available to product developers across the wearable technology industry in the next ten years and will be able to entirely replace the bulky batteries that often add weight to available wearable technology today (Plummer, 2018).

Another application receiving much attention is **graphene**, which scientists have recently discovered has unusual and unparalleled electrical capabilities. Scientists from the University of Cambridge and the University of Jiangnan are particularly interested in graphene's extremely flexible nature and are enthusiastic about plans to incorporate the substance into cotton garments by printing it directly onto the surface of the fabric. Currently the graphene-cotton garments are able to withstand up to 20 wash cycles (Donaldson, 2017). A group of researchers from Tsinghua University in China is also experimenting with graphene by feeding micro amounts of the substance to silk worms that, in turn, produce silk that is laced with the impressive electricity conductor (Plummer, 2018).

New York based start up Bonbouton recently developed a "smart insole" designed specifically to help those affected by diabetes. The insole contains graphene sensors that are capable of monitoring a patient's foot health in order to avoid the loss of a limb. By utilizing graphene's unique thermal conductivity abilities, the smart insole helps prevent ulcers and may be able to prevent frequent visits to the doctor's office (Kaverina, 2017).

Skin patch based wearables are becoming increasingly popular amongst wearable technology developers, but many of the currently available forms are stiff and uncomfortable. Researchers from Germany have plans to increase the wearability of skin patch technology by using a thin, flexible plastic film made from **polyurethane**. Although the patch is lightweight and breathable, it still provides the necessary insulation and protection for the technological components and sensors necessary to carry out the patch's function. Polyurethane's water-repellant nature makes it particularly relevant to the telehealth sector of wearable technology (Plummer, 2018).

Although wristband wearables are currently the market favorite, companies like Covestro are confident that skin patches will soon be just as popular. The Germany based materials science company unveiled its skin patch containing polyurethane in 2016 and expects them to appeal to a mass audience due to their lightweight and flexible nature and countless medical diagnostic capabilities. Their patches contain sensors that are able to measure “humidity, temperature, e.g. discomfort-index or heat-stroke alarm, furthermore geo-magnetics, acceleration, pressure, e.g. fall-down alarm, environmental stress meter, and UV/ambient light.” Covestro believes their product could offer an important and less expensive option for health monitoring and treatment (Covestro, 2016).

Stretchable batteries are also beginning to make their way into wearable technologies. Scientists at Binghamton University in New York have been working on producing a microbial cell-powered, stretchable battery made completely from fabric. Researchers have identified that bacteria cells could serve as surprisingly reliable sources of energy for devices due to their ability to create and sustain enzymatic reactions. Additionally, in a world where sustainability has grown from a fad into a necessity, these stretchable batteries could provide a very eco-friendly alternative to current power sources (Binghampton University, 2017). Although no wearable electronics containing stretchable batteries are presently available to consumers, it is likely that they will be integrated into wearables in the near future.

Another popular battery alternative is **copper yarn**, which has the ability to harness power from the sun. With a bilateral design featuring a type of miniature solar panel on one end of the wire and energy storage chambers on the other, copper yarn is a suitable battery replacement when coupled with regular yarn and woven directly into garments (Plummer, 2018).

One of the current prototypes of electronic yarn wearables is a pair of socks that are capable of sensing temperature. Similar to the graphene smart insole, temperature sensing socks may be able to detect ulcers and other foot wounds and are intended to cut down doctor visits for the wearer. Another prototype is the vibration sensing glove, which was designed to protect construction workers from hand transmitted vibrations (HTVs), which can cause “musculoskeletal, neurological, and vascular disorders such as hand-arm vibration syndrome and carpal tunnel syndrome.” The technology embedded in the glove records the amount of vibration exposure and warns the wearer when exposure has reached a dangerous level (Dias and Hughes-Riley, 2017).

Arguably the most intriguing application of all is a product of the research being done on **electric eel-style synthetic fibers** at Fudan University in Shanghai. This team of researchers has discovered a way to replicate the electric system of an electric eel by “using tiny conductive nanotubes spun into a stretchy fiber”. Although these scientists are still developing this unique textile, they are hopeful that these fibers will eventually be realistic components of future wearable technology devices (Plummer, 2018).

Current challenges

Many consider wearable technology to be part of a very exciting future in technology and telehealth, but still multiple and large barriers exist that cannot be overlooked. Conductive fabrics will likely provide solutions to many of the current disparities in wearable technology, such as wearableness itself, but these fabrics are often delicate and precarious to work with.

Some of the current challenges regarding conductive fabrics and the incorporation of these new fibers into wearable technology include the difficulty of running a signal in any chosen direction throughout a garment. This can be tedious and sometimes impossible to achieve due to the limitations provided by the necessary weaving or knitting of the fibers themselves (Hunt, Ashayer-Soltani and Wills, 2016). Additionally, these fabrics are fundamentally complicated in their design and may be expensive and dubious to experiment with for a company trying to design and launch a new product line. With the present lack of available information on conductive fibers, companies may want to consider alternative solutions, at least for the time being.

Conclusion

The wearable industry is constantly changing as more and more technologies emerge from University science labs across the globe. As these new technologies become available to the community of product developers and designers, there is an increasingly large emphasis placed on transitioning the technological component of wearables from visible to invisible. Multiple and exciting advancements are being made in the field of conductive fabrics, but much remains in question and many of the mentioned applications are still in the early stages of development. While these unique, energy-harnessing textiles are something to keep an eye on in the near future, new and established companies alike ought to consider the costly and perhaps disadvantageous effects of venturing into the unknown.

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