Introduction to Smart textiles
Learning unit 3
Lesson 3

JOINING AND OTHER INTEGRATION TECHNOLOGIES FOR PRODUCTION OF 2D AND 3D SMART TEXTILES

Innovative smart textiles & entrepreneurship

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Challenges and Opportunities for Smart textiles

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Content

Introduction

Smart textiles refer to any fiber, yarn, flat or 3D textile product that is capable of changing its properties in response to a change in some physical quantity or stimulus (Simegnaw et al. 2021). This allows for the achievement of active textile functions such as protection or integrated lighting for interior decoration. By integrating programmable wearable electronics onto or into textile substrates, the resulting intelligent textiles can fulfil increasingly complex functions, such as actively monitoring human health and providing protection (Krajewski et al. 2013). However, it is important to minimize any discomfort or limitations to user comfort that may arise from the increasing number of portable electronic systems. Ideally, these systems should be quasi-invisible and non-noticeable to the user (Dias 2015).

The term "smart textiles" refers to a type of textile material that can detect and react to changes in its surroundings. It encompasses a wide range of textiles and can be classified into two categories: passive and active. Passive smart textiles simply observe their environment, while active smart textiles could sense and respond to environmental changes(Dias 2015; Simegnaw et al. 2021).

Various techniques are utilized to incorporate inflexible microelectronic components onto or into textiles to create smart textiles. These techniques can include physical, mechanical, and chemical methods. It is essential for the integration systems to be flexible, lightweight, and stretchable, as well as washable, to provide superior usability, comfort, and non-intrusiveness. Additionally, the final wearable product should be breathable (Suh, Carroll, and Cassill 2010).

Bosowski 's research focuses on three different levels of integration for electronic components and circuits onto or into textiles. These three levels are categorized as textile-adapted, textile-integrated, and textile-based, as illustrated in Figure 1.(HUGHES-RILEY 2018; Dias 2015)

(a) (b) (c)

Figure: Level of electronics integration in textile: (a) textile-adapted; (b) textile-integrated; (c) textile-based (Dias 2015).

The textile-adapted category involves creating specialized clothing accessories or extensions that can accommodate electronic devices. This allows the electronic function to be integrated by attaching the actual inflexible electronic device onto or into the garment. Examples of such devices include ICD+ (implantable cardioverter-defibrillator), communication devices designed for firefighters, and MP3 players. The textile-integrated category involves integrating electronic components by creating interconnections between the electronic elements and the textile substrate. In this category, the textile material often performs specific functionalities, such as using metal push buttons as an on/off switch (Rantanen et al. 2002). The textile-based category of electronic integration utilizes the textile structure itself to provide more advanced electrical components. This is accomplished by embedding an electrical circuit within the yarn or fibre of the textile, allowing for more complex functionalities to be achieved (Müller et al. 2011).

1. Common smart textiles fabrications methods

Initially, smart textile technologies concentrated on embedding electronics directly onto or into textile materials. This was accomplished by utilizing several methods of interconnecting hard electronic components and soft textiles. Conductive tracks required to be inserted directly onto or into the textile in order to connect diverse electronic components such as conductive yarns, sensors, batteries, and processing circuits. The primary purpose of chip-level interconnections is to provide power and signal distribution electrical lines to and from the substrate.

Two simple connecting steps are needed to integrate electronics into/onto the textiles. The mechanical connection to a textile material comes first, and the electrical connection built into the conductive structures comes afterwards. Both connections need to be trustworthy and operational.

Figure : Smart Textile fabrication . Source : University of Colorado Boulder

Smart textiles are fabrics that have been enhanced with technology to offer additional functionality beyond their traditional role of providing warmth, protection, and comfort. One of the most common integration techniques of smart textiles is the use of sensors and actuators to monitor and control various aspects of the textile's performance. Here are some examples of integration techniques that are commonly used in smart textiles:

Conductive fibers: These are special fibers that conduct electricity and can be integrated into the fabric to create a circuit. Conductive fibers can be used to create sensors that can measure temperature, pressure, or other physical parameters.

Printed electronics: This involves printing circuits, sensors, and other electronic components onto the fabric using conductive inks. Printed electronics offer a flexible and cost-effective way of integrating electronics into textiles.

Embroidery: Embroidery is a traditional technique that involves stitching designs onto fabric. Embroidery can be used to create conductive pathways on the fabric, which can be used to create sensors and circuits.

Weaving: Weaving involves interlacing threads to create a fabric. Smart textiles can be created by integrating conductive fibers into the fabric during the weaving process.

Coatings: Coatings can be applied to the fabric to create a barrier or to enhance its properties. For example, a coating of conductive material can be applied to create a sensor or circuit.

Fiber optic technology: Fiber optic technology involves the use of light to transmit data. Fiber optic sensors can be integrated into textiles to monitor various parameters, such as temperature or strain.

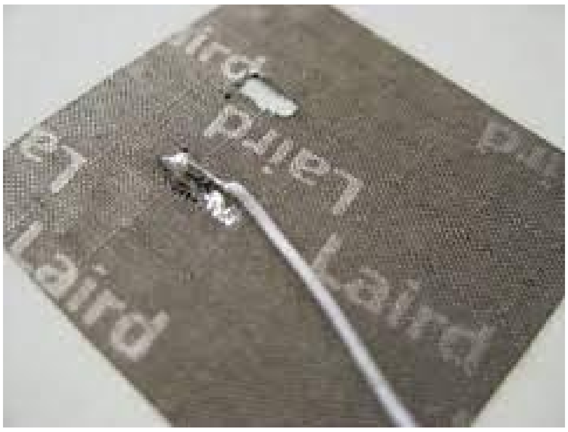

Figure : Soldering

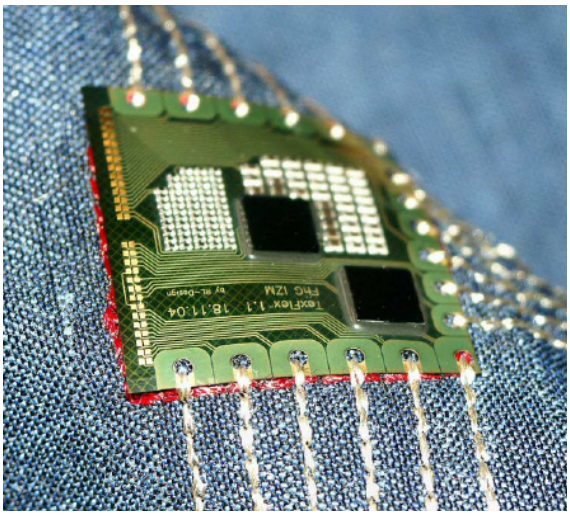

Figure : Sewing and Embroidering (Dias 2015)

In addition to the integration techniques I mentioned earlier, there are some other advanced techniques used in the development of smart textiles, including: **Microfluidics:** Microfluidic systems can be integrated into textiles to allow for the controlled flow of fluids, which can be used for a range of applications such as drug delivery or sweat monitoring. **Energy harvesting:** Smart textiles can be designed to harvest energy from their environment, such as from body heat or motion, and use that energy to power the electronic components of the textile. **Machine learning algorithms:** Machine learning algorithms can be used to analyze data collected from the sensors in smart textiles, enabling the textile to learn and adapt to the user's behavior and preferences. **Wearable computing**: Smart textiles can be designed to function as wearable computers, providing users with access to a range of features such as communication, navigation, and entertainment.

Want to learn more about this topic?

Castano, Lina M., and Alison B. Flatau. "Smart fabric sensors and e-textile technologies: a review." Smart Materials and structures 23, no. 5 (2014): 053001.

Summary

To further the development of functional textiles, advanced materials and integration of electronic devices onto textile substrates are required. Many companies are currently working on e-textile products, and according to Grandview research, the compound annual growth rate for E-textiles is projected to increase significantly in the coming years. As technology advances, there is a growing demand for more sophisticated e-textile products. However, the design and production of wearable textiles have presented issues for the industry, such as creating simple and reliable connectors for integrating electronic components or developing washable, flexible, highly stretchable, durable, and reliable electronic components. These issues have been resolved with proprietary solutions developed by several researchers who hold patents in these areas. This has created a considerable barrier to entry for newcomers and has hindered cost-reduction and product-improvement efforts by existing researchers.

It is predicted that in the future, the incorporation of electronics into textile substrates will be accomplished by automated insertion at the fiber and yarn level to produce e-textiles. The electronic connectors will be lightweight, fully conductive, highly flexible, and have good stretchability behavior to ensure they are comfortable to wear, breathable, washable, easily wearable, and low cost. Despite these advancements, achieving washability remains a significant challenge. Ultimately, the integration of electronics into wearable e-textiles in the future should not alter or impact the textile substrate's final design or characteristics.

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Partnership

Project coordinator
TUIASI - Universitatea Tehnica Gheorghe Asachi din Iasi
www.tuiasi.ro

AEI Tèxtils - Agrupació d'Empreses Innovadores Tèxtils
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