

VIRTUAL GUIDE
Learning unit 1
Lesson 1

Introduction to the smart textiles market



Innovative smart textiles & entrepreneurship

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Introduction to the smart textiles market

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Abstract

Smart textiles market is one of the most promising and emerging markets lately. Due to the technological revolution they are experiencing since few decades ago, the possibilities that a traditional textile product could offer in past have increased dramatically.

The combination of classical textiles' concept with several elements such as materials with particular properties, sensors, electrification, and internet are leading textiles to a new era.

This book will provide a necessary contextualisation necessary to understand the potential of smart textiles and which kind of relationship they have and they might have with the commercial market.

Then, it will provide some more deep information of specific markets and show examples about how they are evolving.

1. Introduction

1.1. Definition of smart textiles¹

Smart textiles are materials that incorporate electronics and other advanced technologies to provide additional functionality beyond their traditional roles as fabrics. They can sense, react, and adapt to changing environmental conditions, making them useful in a variety of applications.

In that sense, Smart Textiles can react to mechanical, thermal, chemical, biological and magnetic stimuli, among others and can be classified in two groups depending on their reaction degree as passive and active smart textiles.

Smart textiles have the potential to revolutionise a wide range of industries, from healthcare (proven during the COVID-19 pandemics) and sports to fashion and transportation. They can enhance not only safety, but also comfort, and performance in everyday life, as well as enable new forms of communication and self-expression.

A key fact is the link existing between smart textiles and electronics. Electronics endorse textiles with capabilities never expected before, making them a new actor in several traditionally unusual environments. Their performance in all these new environments, indeed, is innovative, provides new solutions and applications, and is expanding all over the world because of its versatility.

Still, one of the main challenges constraining the sector are usually linked to technological capabilities of the industry and its readiness to produce smart textiles products at large scale.

1.2. Relevance of smart textiles

The importance of smart textiles: Smart textiles have the potential to revolutionise a wide range of industries, from healthcare and sports to fashion and transportation. They can enhance safety, comfort, and performance in everyday life, as well as enable new forms of communication and self-expression.

To better explain and understand the potentialities and limitations of smart textiles, it is important to have an overview of its value chain.

This chain explains the whole process in which a smart textile product goes through from its initial stage, when their components are separated and come from different industries and environments, to its manufacturing and end-of-life processes.

¹ Ivanoska-Dacikj, Aleksandra and Stachewicz, Urszula. "Smart textiles and wearable technologies – opportunities offered in the fight against pandemics in relation to current COVID-19 state" *REVIEWS ON ADVANCED MATERIALS SCIENCE*, vol. 59, no. 1, 2020, pp. 487-505. <https://doi.org/10.1515/rams-2020-0048>

The SmartX *smart textiles value chain map* explains in a complete way what it is all about. As said, It is visible that the smart textiles value chain involves several industries. Firstly electronics, which contributes to the development of necessary materials, components and devices to be integrated into the textile yarns, fabrics and garments to endorse them with smart application afterwards.

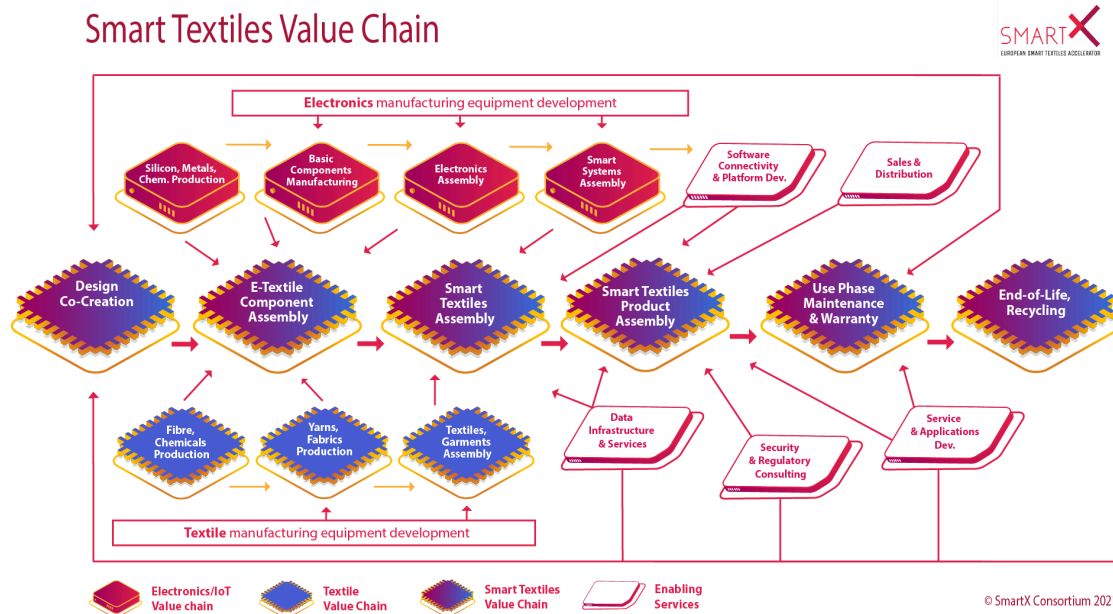


Figure 1: Full Smart Textiles Value Chain Map by SmartX²

The second and already mentioned industry is, indeed, the textiles one. It is necessary to select and develop yarns, fibres and garments for them to possess the proper qualities that will permit the allocation of the electronics.

And, finally, the services sector. This piece of the puzzle is essential. By involving this industry, the qualities acquired by a smart textile become applications that might be useful for the user, that might cover a need not covered before with a conventional product. This means that, for example, the data compilation (body constants, humidity, solar radiation,...) by itself can be just an amount of numbers and graphs, or can be interpreted and read if endorsed with connectivity, an app that give to the user the information simplified and organised, and it provides the user with personal data safety according to regulations, etc.

Also, it is necessary to mention a couple of significant constraint smart textiles are currently finding: on one side, these industries are not yet well prepared to develop such products at large scale and that is why they remain being prototypes for now and on the other side,

² <https://www.smartx-europe.eu/introducing-the-full-smart-textiles-value-chain-map/>

recycling process for those complex materials once their life has come to an end becomes much more complicated.³

2. General trends

Smart textiles rely on advanced electronics and sensors to provide their functionality. As these technologies continue to improve, smart textiles will become even more powerful and versatile.

In this chapter we will see several applications of smart textiles. Most of the examples to be shown below come from several European companies' products.

2.1. Wearable technology

A good example of a wearable product is the one as follows: a smart sock. In this case, a traditional concept of a sock has been endorsed with conductivity, which means it acquired with new properties that a traditional sock wouldn't have, for example it is able to monitor constants of the person who is wearing it and transfer the data via bluetooth technology to an app.

Texisense is a French-based company focused at "Flexible, extendable, and conformable" sensors to be integrated on wearable textiles. Most of their connected textiles are developed in line to provide solutions when the human body is in contact and makes pressure to another surface.

But, beyond the new and multiple applications a smart textile product might have, there is a crucial element to take into account.



Image 2: [Texisense](https://www.texisense.com/) e-socks (left) & siren e-socks (right)⁴

³ Paula Veske & Elina Ilén (2021) Review of the end-of-life solutions in electronics-based smart textiles, The Journal of The Textile Institute, 112:9, 1500-1513, DOI: 10.1080/00405000.2020.1825176

⁴ <https://www.texisense.com/>

When we talk about smart textiles to be worn by humans, the comfort and safety aspects become central, as long as a failure or a misconception of them could lead the product to a fail within the market.

As it is expressed in Digitex project E-Book “Medical, sensorial and protective textiles development in the context of the european economy and digitalization”, Chapter 2 “Sensorial comfort evaluation”, 2023, *“it is about the successful integration of wearable textile-made products with electronics and sensors. The wearability is directly linked to two key factors: comfortability and safety. If we assume the smart application of a textile is perfectly working, what we need to focus in is a) on the smoothness level the smart textile offers to the consumer who is wearing it, the humidity, which is a possible limitation on comfort if it on high levels, among others. Also, we need to focus on b) safety aspects that must guarantee, in first instance, the wearability of the smart textile in question will not provoke, for example, burnings, electrocution, sensitive data filtrations, or inefficient/ irregular functioning that leaves, potentially, the user without the help/support they may expect from the smart product”*. So, several physical factors will intervene in the market possibilities of a product, that need to be taken in to account. In other words, if the smart textile wearable is not comfortable, users will not acquire it.

Furthermore, and even if the smart textile wearable succeeds with the comfort issue, another element already mentioned is a must: security⁵.

And this element can be translated in multiple scenarios: physical but also virtual. The first scenario means zero impact on human health. Knowing that the most problematic piece of a smart textile wearable would be the integrated sensors that collect the data from the body, it is important to keep them isolated from the skin, among other measures. And for the virtual security, it is important to remark that any smart textile that manages personal data needs to be protected from hackers or any other external actor that might threaten the user with their data. Particularly if this data is related with their health. In order to protect users in a uniform way, the European Union legislated in 2016 the *General Data Protection Regulation* (GDPR).

2.2. Internet of Things (IoT)

There's no exist a commonly agreed definition of the IoT⁶. The academia, researchers, investigators and producers are divided between whether the data which circulates through the virtual networks is created by humans or not. Still, there is a common agreement in the following affirmation: The IoT is “an open and comprehensive network of intelligent objects that have the capacity to auto-organize, share

⁵ [Digitex Project](#), 2023, *Book of best practices smart sensors based textiles from production management to end-user*, Chapter 14 “Ethics and requirements for smart sensors and actuators integrated in textile products”

⁶ Somayya Madakam, R. Ramaswamy, Siddharth Tripathi (2015) Internet of Things (IoT): A Literature Review. *Journal of Computer and Communications*, **03**,164-173. doi: [10.4236/jcc.2015.35021](https://doi.org/10.4236/jcc.2015.35021)

information, data and resources, reacting and acting in face of situations and changes in the environment”.

The Internet of Things “*exemplifies that the network of devices capable of acquiring and sharing the information. Often, these network devices use internet protocol (IP) to communicate with one another. The Internet of Everything (IoE) is an extension of IoT which includes people, process, data and things in network connections*”, as it is said in Srinivasan, C. R., Rajesh, B., Saikalyan, P., Premsagar, K., & Yadav, E. S. (2019).

In that sense, materials which these products are made of need to have some particularities and properties such as graphene and/or carbon nanotubes, as well as the way they are manufactured and compose the final product become a basis for the final product performance, and safety. They need to be conductive to guarantee a high performance afterwards⁷.

Furthermore, the physical structure (hardware) the IoT must have to work is also relevant: the applications, where the data is collected; the transportation methods, through where the information will get to the final stage; and the processors, where the information is processed. In the picture below, it is shown an scheme:

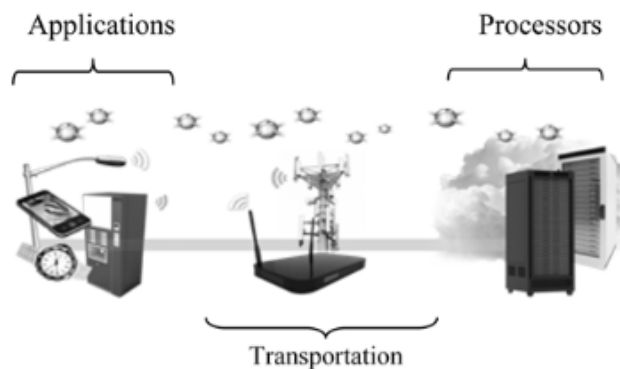


Image 3: Virtual data circuit scheme

2.3. Sustainability

A relevant focus of smart textiles needs to be placed on sustainability. Smart textiles “*combines the massive waste streams of both the digital electronics and textiles industries*”⁸ and this is a

⁷ Srinivasan, C. R., Rajesh, B., Saikalyan, P., Premsagar, K., & Yadav, E. S. (2019). A review on the different types of internet of things (IoT). *Journal of Advanced Research in Dynamical and Control Systems*, 11(1), 154-158.

⁸ Wu, S., Devendorf, L. (2020). Unfabricate: Designing Smart Textiles for Disassembly. CHI '20: Proceedings of the 2020 CHI Conference on Human Factors in Computing SystemsPages 1–14 <https://doi.org/10.1145/3313831.3376227>

potential counterpart for this sector. In that sense, *“techniques and practices for reclaiming and reusing smart textiles materials”* is very important, and some researchers are currently investigating that. And this is because *“combining electronics and textiles, which both are relatively short-lived mass consumer goods, would intensify product obsolescence and lead to even shorter life cycles and abandonment of products. Although there is extensive research on the sustainability of fashion, limited research exists on the sustainability of smart textiles and clothing”*⁹.

Furthermore, and leaving the waste impact another factor that turns around sustainability is the energy consumption and, in extension the durability of a product. Some studies¹⁰ suggest that the difference between ordinary sustainable methods based on saving energy and resources and methods that tackle excessive consumption, such as user involved design to enhance product durability need to be evaluated differently. And this is something that can be applied on smart textiles, particularly the longevity.

In other words, it is determinant that smart textiles are being developed with a sustainability criteria that fits with the coherence of the society's progress, without leaving behind the eco-friendly standards by using proper materials and implementing efficient and sustainable manufacturing processes. This is important for reducing the environmental impact of textile, not only consumption, but also its production.

Focusing on sustainability, we go back to the smart textiles value chain, as it includes a relevant process related with. As long as it is determinant that smart textiles are being developed with a sustainability criteria that fits with the coherence of the society's progress, without leaving behind the eco-friendly coherence by using proper materials and implementing efficient and sustainable manufacturing processes.

⁹ Goncu-Berk, G. (2019). Smart textiles and clothing: An opportunity or a threat for sustainability. *Proceedings of the Textile Intersections*.

¹⁰ S.H.W. Ossevoort (2013). Improving the sustainability of smart textiles. *Multidisciplinary Know-How for Smart-Textiles Developers*. Woodhead Publishing Series in Textiles, Chapter 14, Pages 399-419

Conclusions

In conclusion, smart textiles have a bright future ahead. Ongoing technological revolutions lead to new applications, which at the same time lead to new and emerging niche markets. And the more versatile these innovations are, the more niche markets will appear and consolidate. Smart textiles are poised to transform a wide range of industries and applications.

These smart textiles' new applications and possibilities have been endorsed with, generally thanks to electronic devices and sensors that can revolution the concept of a classical textile product we have had until nowadays, but also specific properties achieved thanks to materials' ones or chemicals.

- The elaboration of smart textiles involve several sectors (electronic+textile+services) and does not forget sustainability aspects.
- Smart textiles need to be wearable comfortably and safety talking. Otherwise, their new applications remain useless.
- Smart textile niche markets can -and do- offer improvements and revolutions in multiple sectors.

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Partnership



Project coordinator

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