Electronic Skin (E-Skin)

E-skin Enables Development of Stretchable Electronics and Next Gen Wearables

What is Electronic Skin?

Electronic skin (E-skin) is an ultrathin, flexible electronics technology which can be worn on human/animal skin. It can be used to measure and monitor body's internal vital and physiological signs. Advancements in E-skin support technological developments in the field of flexible and stretchable displays which can be imprinted on the skin.

E-Skin Will Highly Impact Healthcare Sector

Currently, E-skin market is niche and technology development is at a relatively nascent stage. The technology eliminates the need for the use of bulky devices, especially for health monitoring applications such as vital signs monitoring, drug delivery systems, and external controller devices such as smart televisions, smartphones, and other smart computing devices.

Trends Driving Developments in E-skin

- E-skin capability of embedding semiconductor components and offering **flexibility and stretchability** are driving advancements in this space.
- The major driver for proliferation of E-skin is **advancement in materials and efficient manufacturing technology** capable of producing miniaturized electronics.
- **Non-invasive, real-time, and highly accurate remote monitoring** solutions are in high demand for healthcare applications. E-skin technology has a high potential to address the demand.
- **Collaboration and Partnership Initiatives** to speed up technology developments and commercialization. Various universities and companies from pharmaceutical and cosmetic industries are collaborating to develop and leverage advanced E-skin technology in different applications. For instance, MC10 has partnered with L'Oréal to develop skin sensor device called "My UV Patch."

Nature of Disruption

~ Incremental Innovation

The market entry and penetration of E-skin technology will be in a slow and incremental manner.

- **Enabling Flexible and Stretchable Electronics:** Technology advancements in E-skin enable flexible and stretchable displays to be imprinted on the skin.
- **Next-generation Wearables:** E-skin is expected to transform the consumer electronics sector to the next level, particularly in the field of wearable devices.
- **External Device Accessing and Controlling:** E-skin with multiple functionalities for controlling the external device will become a key success factor for consumer applications.

APAC Poses Increased Market Opportunity with Japan Becoming a Key Market for E-skin

Regulations Play A Key Role in Maintaining Market Leadership

The North American region is the largest market for E-skin technology. It is driven by increased research and development (R&D) activities. Technology development and large-scale adoption are very high in this region. This region has a good combination of mature participants such as MC10 Inc. and Gentag Inc. and research universities.

EU Regions Advancing in E-skin Technology at a Medium Pace

- The European Union is funding various projects on E-skin research.
- The adoption pattern of Europe is expected to grow rapidly in the near term.
- Universities and large pharmaceutical companies are partnering with hospitals to develop diagnostic solutions.

APAC Regions Like Japan and China Are Key Innovation Hotspots

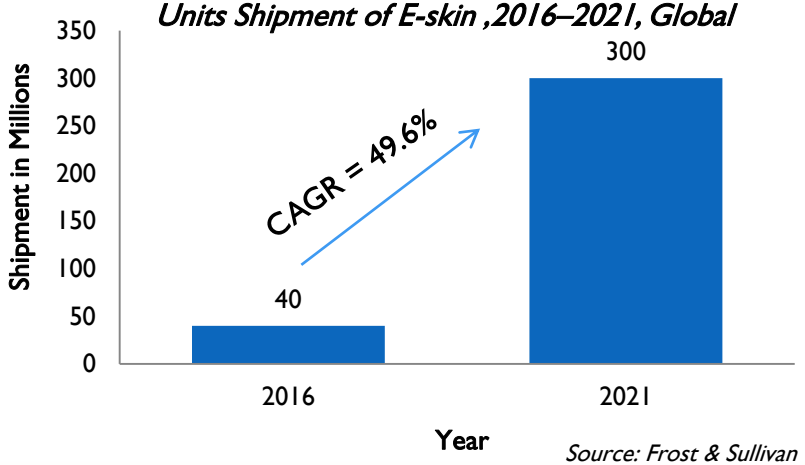
- APAC leads the world in the development of E-skin because of the presence of established flexible electronics technology developers that support development of E-skin.
- Supportive funding from the government agencies in this region has also encouraged development of E-skin.

Impact Indicator: 2017–2021 High | Medium | Low

Unit Shipment of 300 Million by 2021

According to Frost and Sullivan analysis, the number of units leveraging E-skin will grow rapidly at a compound annual growth rate (CAGR) of 49.6% in the next 5 years. The technology has the potential to be widely adopted across various industries such as consumer electronics and healthcare.

Units Shipment of E-skin ,2016–2021, Global

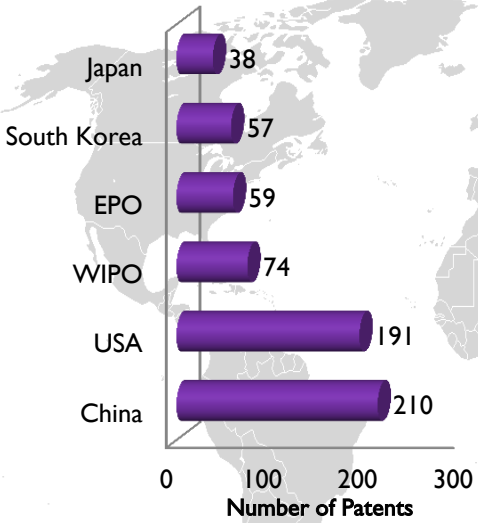


Source: Frost & Sullivan

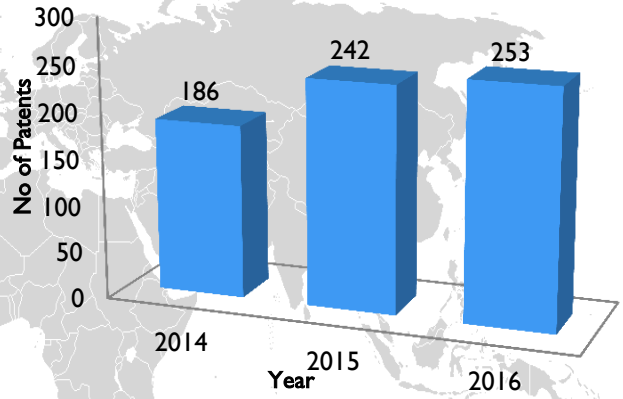
APAC Region Emerging as a Hotspot for E-skin with Local Companies Strengthening IP Portfolio

- Between January 2014 and December 2016, China registered the maximum number of patent applications followed by US pertaining to E-skin.
- A considerable number of intellectual property (IP) publication is targeted at healthcare applications. However, these innovations are also suitable for consumer applications too.
- APAC region is emerging as a global hotspot for E-skin development. Various start-up companies and research universities are working in the E-skin space and strengthening their IP portfolio.
- Development of applications using E-skin is still in the emerging stage, and various companies across industries are investing heavily on commercialization.
- The increase in the number of patents can also be attributed to the growing demand for electronic features such as miniaturized design, portability, and reliability across various industries.

Top Patent Jurisdictions
(2014–2016)



Global Patent Publication Trends
(2014–2016)



Source: Frost & Sullivan/Lens.org
Patents search range: 2014–2016

"China Leads in Number of Patents Filed for E-skin Research"

- There has been an increase in patent filings by various companies, mainly by Gentag Inc., MC10 Inc., and VivaLnk Inc. for innovations in body-worn devices and for incorporation of E-skin in their devices.
- The majority of the patents filed are aimed at the healthcare and consumer electronics sectors, which shows that over the near term, the maximum potential and adoption of E-skin are evident in these two sectors.

Source: Frost & Sullivan

Government and VC Funds Boost Innovations in Healthcare Sector

Impact on Key Mega Trends

E-skin Impacts Several Mega Trends in Diverse Capacity, Which Is a Key Factor for the High Rate of Technology Adoption

- **Social Trends:** Transformation from "wearables" to "skin patches" will encourage increased adoption of the technology by end users.

- **New Business Models:** For rapid commercialization process, e-skin manufacturers need to adopt collaborative business models to integrate the sensor technology in flexible and stretchable substrates.

- **Health, Wellness, and Wellbeing:** The smart skin patch trend is expected to drive this megatrend as it enables real-time healthcare solution and drug delivery system.

- **Connectivity and Convergence:** E-skin technology is an example of convergence of various technologies. It can also enable greater connectivity by acting as a mobile internet hotspot.

Source: Frost & Sullivan

Funding Trends

"Opportunities in Healthcare Sector with High Government and VC Funding"

There is high potential for advanced sensors, enabling high accuracy and efficiency in the E-skin market. As a result, companies with technologies targeted at such markets are gaining increased funding.

Recent Key Funding Deals

The European Commission, CORDIS, funded Ecole Polytechnique Federale de Lausanne (EPFL) under the FP7-IDEAS-ERC funding grant for developing stretchable E-skin, which is a five-year research project (2011–2016). EPFL has developed conductive tracks that use gold and gallium alloy and can be stretched up to four times their original length.

The National Science Foundation and the Office of Naval Research have funded the project on E-skin developed by Zhenan Bao, Stanford University, US. Funding support by venture capitalists (VCs) and angel investors is expected to accelerate the commercialization of smart wearable healthcare products.

- During 2015–2016, Chrono Therapeutics received highest VC funding of about $50 million, indicating market interest toward health and wellness monitoring.
- The University of California, San Diego received most of the funding, followed by the University of Illinois at Urbana-Champaign. Several companies such as Zansors LLC, Epitel Inc., and Profusa Inc., have received federal funding.

Healthcare and Consumer Electronics are High Impact Sectors

Healthcare

In the healthcare industry, E-skin will enable the development of prosthetic applications (e.g., prosthetic limbs). In addition, they can also facilitate real-time monitoring of health parameters (such as temperature and respiration rate) and wound care.

Applications

- Remote patient monitoring
- Health monitoring
- Drug delivery system
- UV monitoring
- Skin monitoring

Robotics

In robotics, E-skin can be used for robotic arm, which senses objects using touch and reacts accordingly. Robots with E-skin would aid in surgery, including monitoring of vital parameters such as oxygen level.

Applications

- Robotic Surgery
- Robotics sense of touch

Frost & Sullivan has identified four key markets as trending sectors for adoption of E-skin. E-skin will be a significant and disruptive technology across these markets and will have the power to significantly impact medical diagnosis, drug delivery, and human-machine interaction applications.

Sectors Impacted by Electronic Skin

Impact Indicator: 2017–2021

High	Medium	Low

Consumer Electronics

Ultrathin E-skin in consumer electronics includes innovative wearable and flexible devices that monitor health parameters or physiological condition such as blood alcohol level. As the consumer electronics market is expanding both horizontally and vertically, there is high potential for adoption of E-skin in the medium term.

Applications

- Fitness trackers
- Smart watches
- Smart lighting

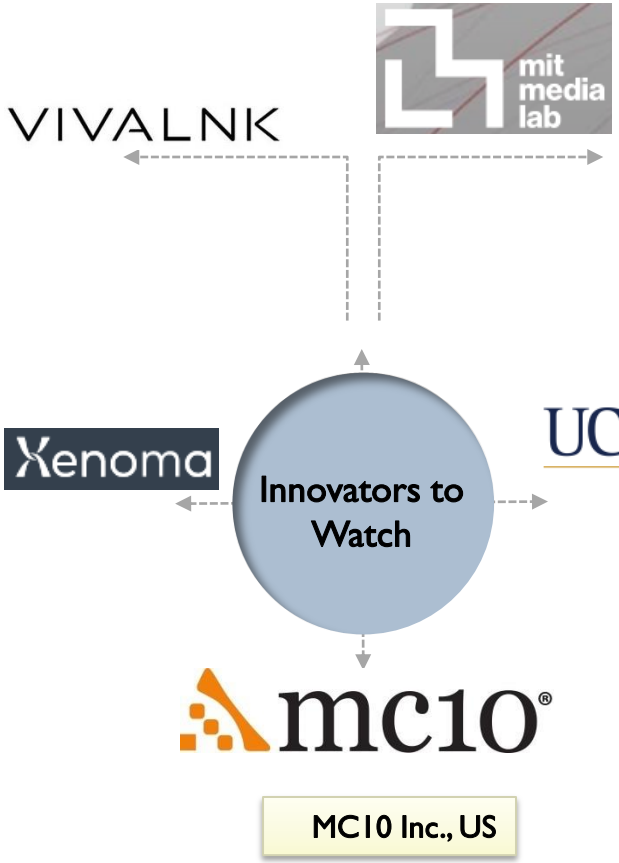
Automotive

The technology has potential to conveniently track the driver's fatigue level. The technology could be enhanced to distinguish multiple devices in close proximity and could be miniaturized for incorporation in a wrist band or watch.

Applications

- Driver fatigue monitoring
- Driver drowsiness Monitoring

Companies and Research University Innovations to Watch



VivaLnk Inc., US

VivaLnk Inc. has developed a flexible, wireless electronic skin, which are breathable patches intended for real-time healthcare monitoring applications.

Massachusetts Institute of Technology (MIT) Media Lab, US

Researchers from MIT Media Lab and Microsoft Research have developed an E-skin termed "Duo skin." Duo skin has three classes of applications: input touch device, output display device, and data communication.

Xenoma Inc., Japan

Xenoma Inc. is a spin-off from Someya Group Organic Transistor Lab, University of Tokyo as a result of involvement in the JST/ERATO Someya Bio-Harmonized Project. The company has developed an ultrathin and flexible E-skin platform using stretchable circuit technology, which can enable the integration of more than 30 sensors in the body. This E-skin platform enables using as wearable clothing, where the type and the location of biosensors are customizable, according to the individual needs.

University of California, San Diego, US

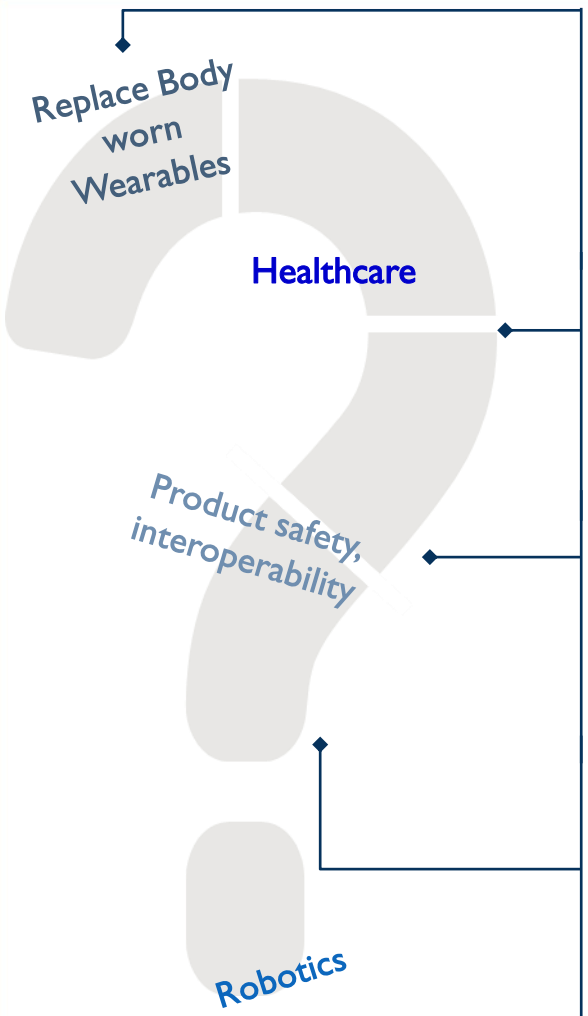
Researchers developed wearable, tattoo-like skin patch with flexible integrated sensor arrays based on plastic and silicon integrated circuits that can detect real-time alcohol concentrations in a person's sweat. The printed flexible electronic circuit board can transmit the data through Bluetooth to a mobile device in minutes.

MC10 Inc., US

MC10 has developed innovative, wearable medical tattoos for healthcare monitoring. The tattoos capture the complex physiological data which is managed by MC10's software platform consisting of a complete end-to-end system with mobile interfaces, cloud storage, and analytical tools.

Source: Frost & Sullivan

Key Questions for Strategy Planning



Should I be concerned about the disruption potential of E-skin?

- E-skin is an emerging and advanced technology which is primarily intended for health monitoring and medical applications, such as measuring and sensing of internal vital sign activities in the body.
- E-skin has created footprint in consumer electronics and robotics markets. In the consumer market, e-skin is expected to replace existing body-worn wearable devices, thus leading to creation of a new user interface device for controlling external electronic devices.
- E-skin has the potential to have high impact in robotics applications due to their ability to provide sense of touch.

What are the sectors which will be impacted by E-skin technology?

The sectors that are expected to be highly benefitted by E-skin are

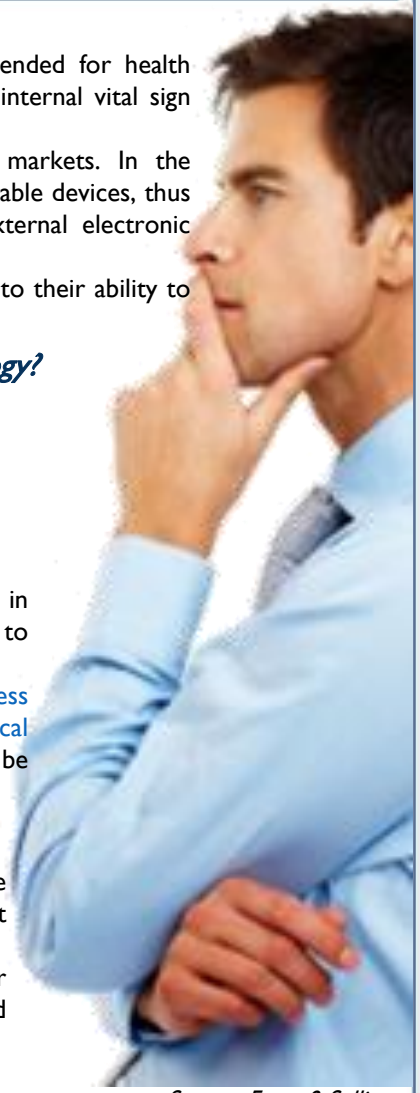
- ✓ Healthcare
- ✓ Consumer electronics
- ✓ Robotics

How do regulations impact E-skin development and adoption?

- Regulations play a vital role in the adoption of E-skin technology. E-skin in healthcare applications such as disease detection and monitoring, needs to undergo strict regulatory processes to be able to serve consumers.
- Parameters such as product safety, electromagnetic capability, wireless interoperability, privacy, and information security, energy efficiency, chemical exposure, and finally environmental sustainability of materials have to be taken care of.

What is the future for E-skin?

- The healthcare market is expected to be drive growth. The healthcare sector will continue to be highly focused on receiving real-time data about the user's health status.
- E-skin will also be significantly boosted by providing skin-based user interaction and control of home appliances, electronic devices, and consumer electronics goods remotely.
- E-skins are also poised to have a key impact in robotics applications.



Source: Frost & Sullivan

Smart Textile for Monitoring Cardiovascular Health

@-Health, France

Industry Challenge

- According to Frost & Sullivan's research, cardiovascular diseases result in approximately 30% deaths across the globe. A key reason for cardiovascular deaths is failure to detect early symptoms.
- Pathological diagnostic methods often fail to identify early symptoms of cardiovascular diseases. There is a high demand for an alternate technology enabling early diagnosis of cardiovascular diseases in order to implement appropriate treatment as early as possible.

Technology Profile

Technology Solution

- @-Health, a French start-up launched CardioNexion®, a proprietary system of sensors which can be totally integrated with a person's garment.
- The sensors monitor cardiac signals, encrypt the signals, and transmit them to the CardioNexion server via a smartphone. The server analyzes the signal with a proprietary algorithm and in case of detecting abnormal signals, the system notifies the physician/ or a person of the user's choice pre-determined by the user.
- Due care can be taken well in advance at the occurrence of early symptoms, saving a person's life.

Innovative Attributes

Real-Time Monitoring

In contrast to conventional methods, this technology enables real-time monitoring for advanced diagnosis of heart diseases.

User Comfort

CardioNexion® eliminates the need for a patient to visit doctors for measuring electro-cardiogram (ECG) signals by transmitting data over the cell phone.

Business Strategy

The company participates in leading tradeshows such as Consumer Electronics Show (CES) in order to demonstrate its technology and find potential partners.

Analyst Viewpoint

- With advancements in Internet-of-Things (IoT) applications such as point-of-care (PoC) diagnostics, smart textiles are poised to witness a surge in demand in the near term.
- According to Frost & Sullivan's research, smart textile companies, such as @-Health will benefit in the long term through licensing opportunities for their proprietary technologies.

Biometric Information Management System for Professional Athletes

Mitsufuji Corporation, Japan

Industry Challenge

- For professional athletes, monitoring biometric information, such as heart rate and breathing rate plays a vital role in managing the training and performance levels of an athlete.
- However, with multiple wearable solutions, managing biometric data has been difficult and often delays delivering important information to the user.
- There is a high demand for a sophisticated wearable as well as biometric information management solution enabling access to information on a regular basis.

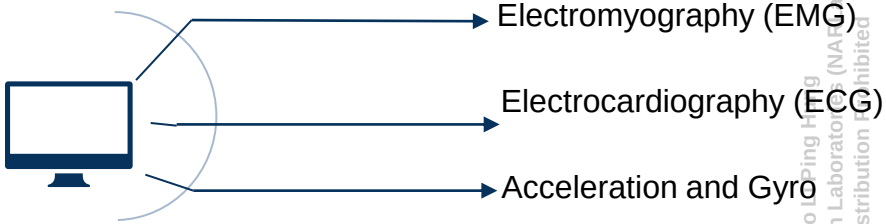
Technology Solution

- Japanese wearable IoT firm Mitsufuji has developed a proprietary biometric information management solution Hamon®, including a smart wearable, transmitter, and cloud platform.
- The smart wearable is knitted with the company's proprietary silver-metallized fiber AGposs® enabling high functionality. The smart wearable is integrated with a transmitter to transmit real-time data to the cloud for storage.
- The information can be easily accessed through a smartphone application for further analysis and assessment.

Technology Profile

Technology Solution

The technology can be leveraged to monitor various health data, such as-



Innovation Attributes

Higher Conductivity

Unlike conventional silver, AGposs leverages higher conductivity due to the large amounts of silver.

User Friendly

AGposs' silver coated thread is anti-bacterial, anti-odor, and less susceptible to skin damage.

Analyst Viewpoint

According to *TechVision*, the technical specifications of silver, such as thermal effect and electro-magnetic interference effect is poised to make silver a leading contender as a material of choice for smart textiles in the long term.

Smart Socks to Detect Foot Ulcers in the Early Stages

Siren Care, US

Industry Challenge

- Diabetic patients are prone to foot ulcers which if not detected in the early stages could result in hazardous conditions, such as amputation.
- Conventional methods to detect foot ulcers include therapeutic footwear, diabetic foot education, and regular foot exams. These methods often fail to detect ulcer in the early stages, resulting in complicated situations.

Technology Solution

- Headquartered in San Francisco, Siren Care has recently developed the Siren Diabetic Socks, which continuously monitors the temperature of feet and gives a warning in case of detection of abnormal temperature range.
- The socks are developed with the company's proprietary Neurofabric™ textile. Neurofabric is integrated with micro sensors, continuously monitoring the temperature at the bottom of the feet.
- Each sock is integrated with 6 sensors. On detection of temperature anomaly, the micro sensors send a signal to a small tag in the sock which transmits the signal to the Siren app via Bluetooth.

Technology Profile

Company Profile

- Siren Care incorporated in 2015 was founded with a vision to develop wearable solutions for people suffering from chronic diseases and aging.
- In March 2018, Siren Care raised funds amounting to $3.4 million led by Liquid2 Ventures, DCM Ventures, and Khosla Ventures. The company's leadership team is focused on developing further technology-enabled solutions through the received funding.

Analyst Viewpoint

- According to the International Diabetes Federation, approximately 415 million people worldwide suffer from diabetes.
- Conventional methods to monitor blood sugar levels are invasive and often cause user discomfort. Also, they demand regular monitoring, adding to the discomfort. Non-invasive technologies to monitor various aspects of diabetes provide high growth opportunities for stakeholders in the long term.

Silk Fibroin-carbon Nanotube Sheath Fibers for E-textiles

Current Trends and Unmet Needs

Humans are in contact with textiles about 98% of life time and textiles are increasingly becoming intelligent with integration of flexible sensors, flexible batteries and memory devices. This development is primarily driven by new possibilities in conductive yarns, conductive inks and conductive polymers. In order to retain breathability, stretchability, and softness of e-textiles, use of functional fibers with built-in electronic functionality is being explored. However, the challenge is to make fibers functional without deforming the fiber structure and strength.

Technology Attributes

Peel-resistant Flexible Patterns

The rheological properties of the SF and CNT inks are critical to achieve uniform core-sheath fibers on textile substrate. The team used SF ink made from silkworm silk to form the dielectric sheath of the fiber. This choice was made based on the fact that silkworm silk offers superior mechanical strength, biocompatibility, and triboelectric properties. Use of formic acid/$CaCl_2$ in silk cocoon dissolution process results in fibers that are flexible with excellent bonding when printed on textile.

Harvest Biomechanical Energy

A printed SF pattern and polyethyene terephthalate (PET) film acts as a triboelectric-pair generating a dipole moment resulting in electron flow.

3D printed Supercapacitors

The fibers were also used to print super capacitors on fabric. An areal energy density of 0.33μWh/cm^2 and power density of 31.85 μW/cm^2 were achieved.

Technology Profile

Researchers from the University of Tsinghua in China have developed a one-step process to fabricate fiber-based smart patterns for e-textiles using a three-dimensional (3D) printer with coaxial spinnerets. The spinneret orifices are arranged concentrically in the 3D printer so that they can make patterns made of core-sheath fibers directly on the textile. The core-sheath consisted of carbon-nanotubes (CNTs) as core fiber and silk fibroin (SF) as the sheath layer. The use of the textile as a triboelectricity nanogenerator and supercapacitor has been demonstrated.

Technology Readiness

1 2 3 4 5 6 7 8 9

Functional prototypes of the 3D printed smart textiles have been demonstrated in lab. A patent has been filed in China.

Potential Applications

- Energy harvesting and storage to power wearable electronics.
- Flexible sensors
- Electric antennas
- Smart lighting

Funding

The research work was funded by the National Natural Science Foundation of China and the National Key Basic Research and Development Program.

Future Plans

The team is working on designing printing ink combinations that are aesthetically appealing and integrates variety of electronics for practical applications.

Ease of Fabrication Enabled by 3D Printing Compatibility Create New Opportunities

27 Patents

[2016-2018]

Filed related to material technologies for 3D printing smart circuits on textile fabrics.

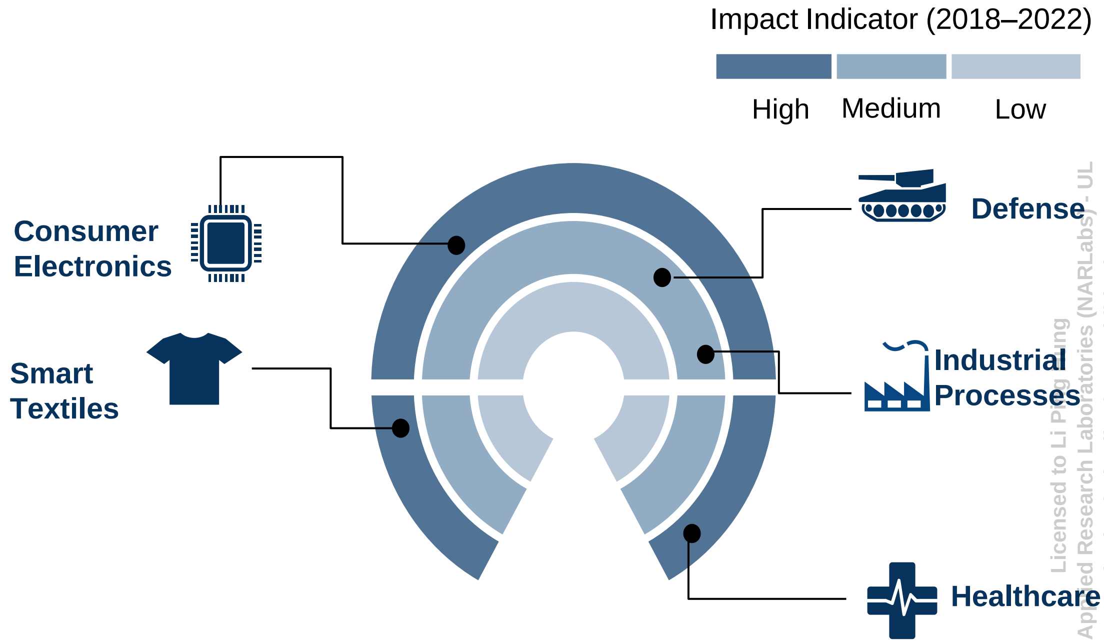
Disruptiveness

Game changing

- Versatility offered by the 3D printing compatible CNT core-silk fibroin sheath fiber is unmatched and opens new prospects.

3 Mega Trends

- Health, Wellness, and Wellbeing
- Smart is the New Green
- New Business Models



- The e-textiles value chain has witnessed progress in maturity of enabling technologies that have overcome challenges in ease of integration, breath of functionality, and functional stability thus improving alignment with customer needs.
- The textile industry is embracing the potential unlocked by combining functionality, intelligent systems and connectivity with the look and feel of textiles. Body motion capture is one area, which is considered to hold huge opportunity in terms of preventing diseases, improving road safety and reducing side effects of medicines.
- Utilizing triboelectric generators to harvest motion energy and making it available for powering sensors, displays and antennas integrated in the textile fabric can help in energy management.

Self-powered Smart Textiles with Display Module

Korea Advanced Institute of Science and Technology (KAIST), Korea

Current Trends and Unmet Needs

- Conventional smart textile solutions comprise of a power source and face moisture permeability challenge, leading to malfunction which will be the cause of inconvenience for the users during the washing of smart textile based apparels.
- With proliferation of IoT, there is a spike in demand of intelligent textile solutions for connected applications. The burgeoning smart textile industry is actively looking for solutions to power the wearables and exhibit moisture permeability.

Technology Attributes

Encapsulation

While conventional encapsulation techniques are capable of handling normal environments, in extreme moist conditions, they are not sufficient and deteriorate the performance of the wearable. By applying atomic layer deposition (ALD) and spin coating, the researchers have developed a robust encapsulation barrier for the wearable display that maintains performance of the wearable even in extreme moist conditions.

Robustness

- The researchers have found the output to be consistent post 20 10-minute cycle washes.
- The wearable's properties did not deteriorate even after it was
- being subjected to bends and washes for 30 days.

Technology Profile

- Researchers at the Korea Advanced Institute of Science and Technology (KAIST), Korea, integrated polymer solar cells (PSCs) and organic light emitting diodes (OLEDs) on fabric. PSCs consistently provide power to the display module eliminating the need for an additional power module in the smart textile.
- The self-powered fabric is capable of withstanding long wash cycles and also exhibits moisture permeability.

Technology Readiness

1 2 3 4 5 6 7 8 9

The wearable display solution is subjected to laboratory tests and being researched for further enhancements.

Research Team

Researchers from KAIST collaborated with Chonnam National University to develop the breakthrough solution in washable smart fabrics.

Funding

The research is funded by the Korean Ministry of Trade, Industry and Energy.

Future Plans

The team is looking forward to explore potential applications of washable displays across various industries such as automotive and healthcare.

Applications of E-textiles and Growth Opportunities

$11 Billion
by 2022

The healthcare and smart lighting industries are poised to witness high impact.

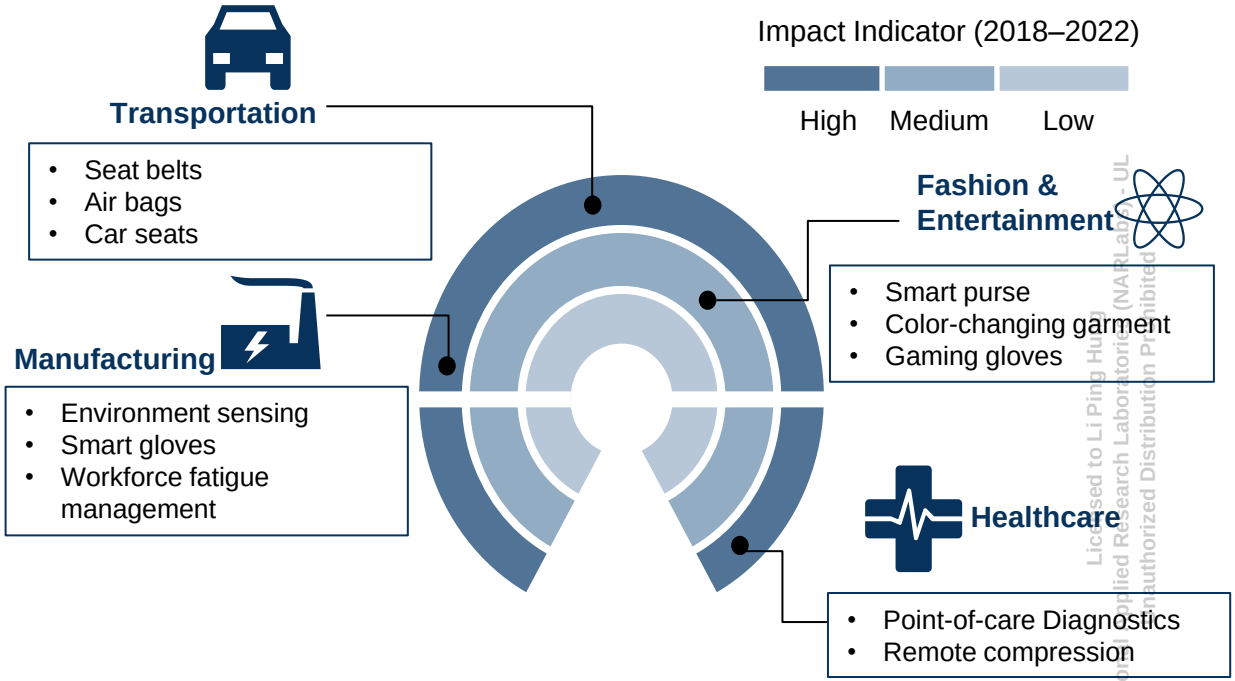
Disruptiveness

Incremental

Diversified applications across multiple industries over a period of time

3 Mega Trends

- Health, Wellness, and Wellbeing
- Connectivity and Convergence
- Bricks and Clicks



What are the opportunities beyond 2020?

In the near term, smart textiles are poised to witness wide adoption in the transportation, manufacturing, and healthcare industries. However, in the medium term, smart textiles are poised to gain traction for space applications such as real-time monitoring of astronaut's health conditions. Canada-based wearable company, Hexoskin developed a smart textile 'Astroskin' to monitor activity level and breathing rate of astronauts in real time. The wearable device was supported by Canadian Space Agency (CSA) in 2011.

Smart Fabrics Printed Using Single Step Solutions

Tsinghua University, China

Current Trends and Unmet Needs

E-textiles are those with smart fabrics or textiles integrated with electronic functionalities that augment the competences of a clothing material. However, incorporation of electronic components in a fabric will make the material more bulky and deteriorate flexibility. Development of such smart textiles with characteristics of traditional fabrics has been a challenge.

Technology Attributes

The printing of functional electronics onto fabric is carried out using co-axial nozzle, enabling the printer to extrude diverse functional inks onto the textile. The coaxial nozzle enables the smart fabric to have a compositional variety and enable in printing of complex and unique designs.

The 3D printer uses a carbon nanotube ink solution to produce the conductive core of the fiber and an ink for silkworm silk, used for the insulating sheath.

Technology Profile

Scientists from China developed have a three-printing (3D) printing technique that can produce flexible fibers with conducting materials. The 3D printer comprises a coaxial needle that has the ability to print 3D patterns on fabric using materials that can easily harvest energy and store electricity.

Technology Readiness

1 2 3 4 5 6 7 8 9

The coaxial smart fabric 3D printing process has a technology readiness level of 3. The concept, feasibility and design are still in progress and have opportunities for commercialization over time.

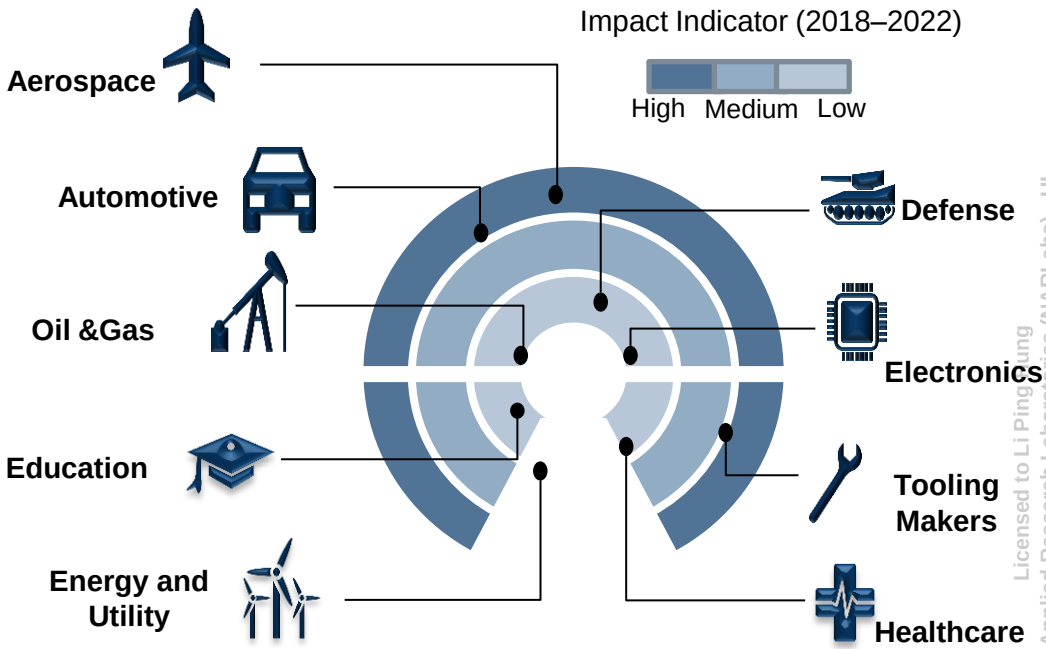
Innovation Development

The research and development was supported by the National Natural Science Foundation in China, the National Program for Support of Top-notch Young Professionals, and by the National Key Basic Research and Development Program. Chinese researchers potential to develop a truly disruptive innovation for the smart fabrics market was identified by the Chinese government.

Impact on Sectors

Disruptiveness- Incremental

Smart fabrics are commonly developed by attaching electronic components such as sensors, LEDs onto fabrics, enabling smart features. The process of incorporating the electronic components onto fabric involves multiple steps and can be tedious. Also, this increases the weight and reduces the breathability, and stretchability. Using a 3D printer as a single step solution for developing embedded electronic chips establishes a versatile platform to develop smart fabrics. Smart fabric production can be cheap, easy, and scalable when compared to conventional ways of development.



Analyst Viewpoint

Selection of different inks for the development of conductive fabrics using 3D printers with a coaxial print head will enable delivering single step manufacturing solutions that are economical. Also, the capability to incorporate the coaxial nozzle onto any printer will further enhance the adoption capability of the technology allowing parts to be scaled and produce customized smart fabrics.

Smart E-fabric Printed in Minutes

RMIT University, Australia

Current Trends and Unmet Needs

Smart fabrics is an emerging, expanding application in the textile industry. Materials with the ability to sense and provide wearers data about their health have been gaining greater acceptance and traction in the market. As the growth of wearables, such as smart watches and other accessories rise, the demand for clothing apparel with built-in sensing and monitoring capabilities, will increase. There is a need for smart fabrics that can more easily integrate energy storage and harvesting devices to ensure sufficient energy. At present, the majority of fabric manufacturers are producing fabric and integrating it with electronics and sensing technologies separately, making the operations a tedious task.

Technology Features

The following attributes make this quick and cost effective manufacturing technique unique:

- Ability to print 10 cm ×10 cm fabric in 3 minutes.
- Smart fabric embedded with a supercapacitor that is stretchable, easily washable and can be combined with energy harvesting technology.
- The solar cell enables self-powering of electronics, addressing the potential limitations of battery power, as energy is stored for a longer time. The ability to laser print electronic components directly onto textiles can also reduce harm to the wearer from short circuits or a malfunction when in contact with sweat or moisture.

Company and Technology Profile

RMIT University, Melbourne, Australia researchers have recently developed a manufacturing technique to fabricate smart textiles based on conventionally available techniques. The cost-efficient technique allows manufacturers to embed energy storage devices into fabrics to produce smart fabrics with energy harvesting technology. The researchers used laser printing to create textiles embedded with energy storage devices (for example, a graphene supercapacitor) that can be readily combined and integrated with energy harvesting devices (for instance, a solar cell).

Technology Readiness

The solution for manufacturing smart textiles is in the proof of concept stage. The smart textile's performance was found to be stable across various mechanical, temperature, and washability tests.

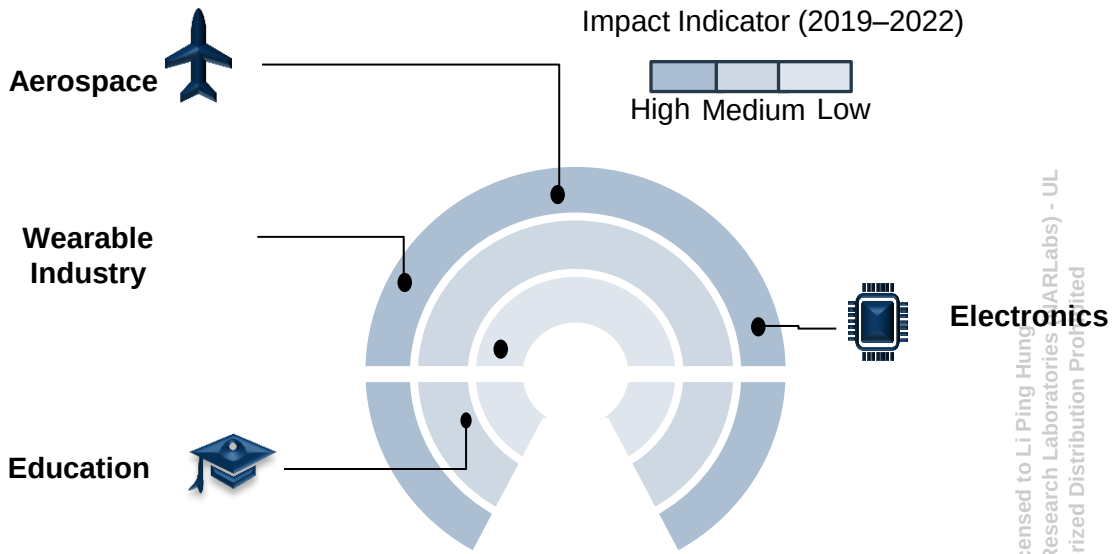
Funding

The concept was developed with aid from the RMIT University Seed Fund and grants from Design Hub projects. Further, the researchers have applied for a patent for the technology to safeguard their invention and intellectual property.

Impact on Sectors

Disruptiveness-Incremental

The health monitoring industry is shifting toward incorporating vital signs monitoring capability in various forms of smart clothing and textiles. RMIT University's safe wearable clothing signifies that fabric materials with energy storage electronics can be produced more efficiently and cost effectively.



Analyst Viewpoint

The ability to embed energy storage electronics into textiles more rapidly and cost effectively can enable real-time storage of renewable energy for textiles. This will open up opportunities for greater adoption of smart textiles in applications such as healthcare as well as consumer electronics devices. The combination of roll-to-roll fabrication and advances in laser printing leveraging machine learning can further enhance the speed, efficiency, and scalability of embedding energy storage devices in smart fabrics.

1Mega Trend

- Smart is the New Green