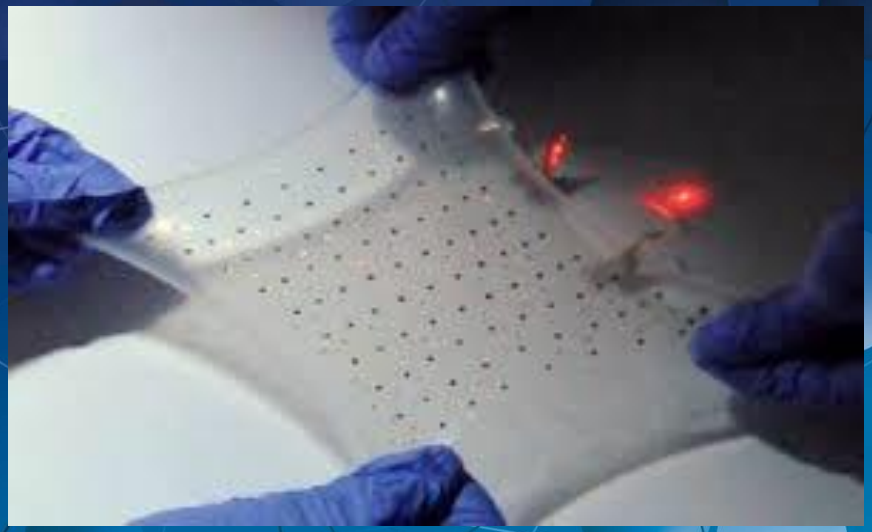
Sensor Technology (TechVision)



Stretchable Sensing

Wearable Sensing Devices Poised to Impact Motion Capture and Other Applications

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Sensor Technology Innovations in Stretchable Sensing

Innovations in Flexible, Soft Motion Capture Sensors

StretchSense Limited, Auckland, New Zealand

Wearable Motion Capture Sensors to Measure Stretch, Pressure, Bend, and Shear

- StretchSense developed soft sensors (available in fabric and silicone) to measure complex movements of people or soft objects.
- The change in the sensor's geometry (due to stretching, squeezing, or deforming the sensor) results in a change in capacitance.
- The technology is applied to fabric stretch sensors that can be sown into garments, pressure/force sensors, bend sensors to show how an object bends, and shear sensors to measure how much an object slides on the body.
- StretchSense plans to launch a generator enabling sensors to be powered by human motion.

Competing Aspects

- Sensors can be comfortably placed on the body for motion feedback.
- Provides very accurate information about body movement and deformation of the sensor

"Using body motion to control the environment is one of the huge market opportunities for the technology," noted Shin Park, Head of marketing, StretchSense.

Technology Readiness Level

1 2 3 4 5 6 7 **8** 9

Presently, provides sensors mainly for evaluation, R&D or product creation to about 150 customers.

Attributes of Innovation

- Able to capture complex motions unobtrusively
- Beneficial for measuring human body motion
- Less prone to drift than resistive sensors
- Very easy to integrate into the client's product or application

Market Readiness and Commercialization Strategy

Within about 2 years, their sensors are envisioned to appear in mass-produced commercial products. They work with clients to integrate the sensors into the latter's products or applications.

Impact & Opportunities

Commercialization/Wide-scale Adoption Year

The technology has opportunities for significant market adoption within 2-3 years.

Impact on Industries/Specific Apps

The technology will impact applications that benefit from ease of motion capture (e.g., wearables for sports, fitness, healthcare, virtual reality, entertainment, gaming), automotive, industrial, aerospace. Heddoko is integrating sensors in body suits to track athlete body movements.

Market Potential/Opportunity

The technology has keen opportunities to enhance motion capture applications and help increase the connectivity of people, products, and processes.

Technology Convergence

The technology can help drive more ubiquitous sensing, the quantified self, and Internet-of-Things connectivity.

Pairing of Chewing Gum and Carbon Nanotubes to Manufacture Stretchable Sensor

University of Manitoba, Canada–Stretchable sensor for healthcare and consumer electronics applications

Wide-scale Adoption

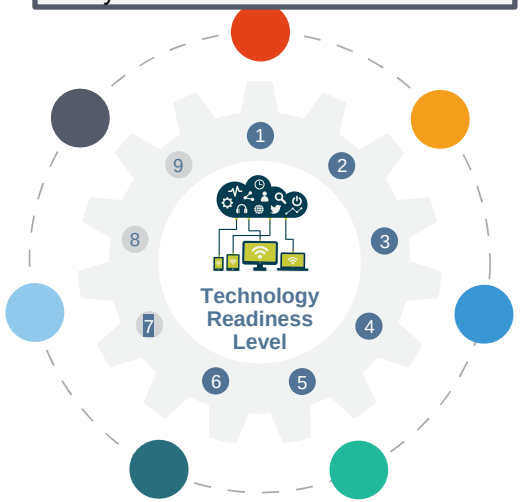
The capability of sensor to be customized in any form offers opportunities for adoption in numerous applications, such as biochips or miniaturized sensors. It is expected to be commercialized in two years' time.

Tech. Profile

The University of Manitoba has developed a stretchable sensor by paring a chewing gum with carbon nanotubes. Gum is used as the stretchable material and a carbon nanotube is employed for sensing. With the help of a multiple folding and stretching technique on the chewing gum, carbon nanotubes are distributed uniformly.

Market Opportunity

The technology has the opportunity to be used as sensors in wearable devices to monitor bendable parts in the body, which is a concept attracting keen interest in the healthcare domain.



Competing Aspects

The sensor can withstand strain up to 200% and can be used to detect strain of approximately 530%. The sensor is highly durable and sensitive. In addition, by employing gum, the sensor can be customized in any desired form. It is also cost efficient,

Technology Convergence

The technology has the capability to converge with Internet of Things, energy harvesting, predictive analytics and many more.

Innovation Attributes

Able to capture slow motion and breathing with high accuracy. The sensor also has the ability to capture humidity changes with a fast resistance response rate.

Market Entry Strategies

The successful development of stretchable sensors will drive the opportunity of a new wave in the sensing industry in conjunction with the Internet-of-Things and wearable applications. The university is expected to license its technology to the new participants whose product portfolios are driven by using unique materials and manufacturing processes.

Smart Stretchable Sensor Patch

L'Oreal–Smart patch to monitor UV exposure and reduce the chances of skin cancer

Tech Profile

L'Oreal, in collaboration with MC10, which developed the stretchable electronics platform, and PCH, which designed the sensor, has developed a smart stretchable skin sensor to detect the amount of exposure to UV rays which is a major issue for nonmelanoma skin cancer. The smart peel-and-stick sensor is comprised of five layers, that is, photosensitive dyes, an adhesive for holding everything together, near field communication (NFC) array and an encapsulating layer and a medical grade adhesive to stick the sensor on the skin.

Competing Aspects

- Easy to use
- Free of cost
- Can be supported with the help of iOS and Android applications
- 50 micrometers thick and one square inch in area
- Unique and attractive design

Innovation Attributes

The disposable smart skin sensor is capable of detecting UV exposure accurately. The photosensitive dyes on the patch will change its color once exposed to UV rays, suggesting that the user checks the percentage of exposure with the help of a mobile application. The thin and light structure helps the user to wear it efficiently. It is wash proof and can last for 5 days.

Market Entry Strategies

- L'Oreal is expected to release the sensor in 15 different countries, including the US and UK.
- The sensor will be available at nearby salons free of cost.
- Brand awareness will help the company to increase the database of users.

Technology Readiness Level 1 2 3 4 5 6 7 8 9

Impact & Opportunities

Wide-scale Adoption

✓The companies strategy to distribute its sensor free of cost will help to expand its database. In addition, the nonmelanoma cancer threat will further boost usage. It is expected to be commercialized by the end of 2016.

Market Opportunity

✓ By enabling applications in iOS and Android phones, the company is expecting to get the maximum number of downloads in a short span of time which will further help to get return on investment.

Technology Convergence

✓The technology will converge with near field communication (which enables communication between two portable electronic devices) and is expected to drive the trend of Internet-of-Things.

Ultra-Stretchable Piezoelectric Nano Generator

Korea Advanced Institute of Science and Technology–For powering sensors and self powered wearable and biomedical applications

Tech. Profile

Researchers at KAIST have developed a hyper-stretchable elastic composite generator with the help of stretchable electrodes made from long silver nanowires.

Innovation Attributes

With large elasticity of approximately 250% and durability of over 104 cycles, the stretchable piezoelectric generator can produce a high power output of approximately 4V.

Technology Readiness Level

1 2 3
4 5 6
7 8 9

Competing Aspects

Mechanical energy is available in a variety of forms such as vibration, sound, and so on. Devices with elastic energy can be very useful to harvest mechanical energy by stretching the elastic material.

Market Entry Strategies

This technology can be applied to a wide variety of biomedical devices, such as e-skin and in consumer electronics with flexible Displays.

Impact & Opportunities

Wide-scale Adoption

✓It is expected to be commercialized in one to two years' time

✓The next-generation ultra stretchable skin sensor is expected to be developed and create an impact by 2018.

Market Opportunity

Stretchable nano generator will be driven by many applications:

✓Consumer Electronics

✓Medical

✓Transportation

Technology Convergence

The end product, such as a wearable or just a sensor, is expected to converge with Internet-of-Things, predictive analytics, and a range of other contextual and support technologies, opening new application opportunities.

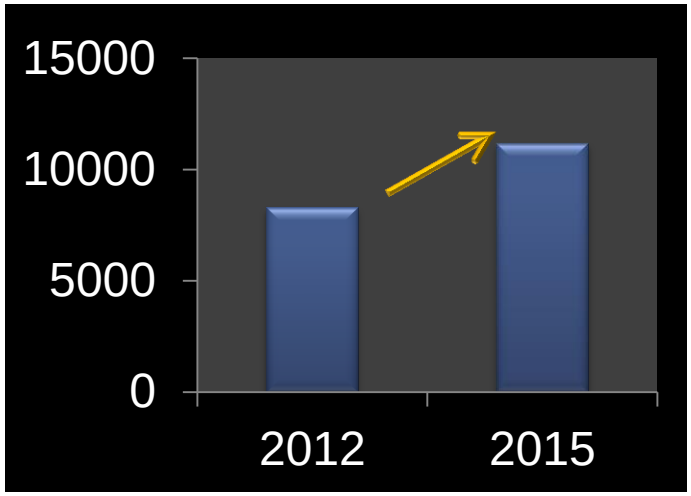
Strategic Insights

Strategic Insights

Technology Roadmap

2016	2017	2018	2019	2020
Fitness tracking bands, smart watches, patient monitoring devices	Smart devices with flexible display, bendable phones	RFIDs, sensors for industrial purposes for packaging	Development of connected devices (including those in textiles) housing smart sensors, motion sensors, sensors for biological parameters (such as heart rate) and collection of information using sensor fusion	Development of smart glasses and AR glasses, leading to heads-up display for military purposes

Intellectual Property (IP)



- According to the patent filing trends, consumer electronics and healthcare are currently the largest applications for stretchable sensors. They are currently driven by applications, such as mobile phones. In the medium term, it is projected that Internet-of-things (IoT) will spur the growth of the market.
- In the consumer electronics and healthcare domains, stretchable sensor patent activities are gaining significant traction. In the coming years, wearable stretchable sensors are expected to witness significant patent filing activity. The highest concentration of patent activity can be seen in USA, followed by the Japan, China, and Korea
- Some of the participants investing in R&D of stretchable sensors are Thin Film Electronics, StretchSense, MC10, and many more.

Strategic Insights

Drivers

- ✓ New product development
- ✓ Strong R&D efforts
- ✓ Advancements in wireless sensing and energy harvesting technologies
- ✓ Advancements in smart materials
- ✓ Technology advancements
- ✓ Environmental friendly solutions
- ✓ Increase in demand for products

Restraints

- Ẋ Requirement of external protective layer coating to protect organic materials is expected to increase the cost.
- Ẋ Challenges of manufacturing flexible components
- Ẋ Low level of acceptance due to the presence of existing technologies

Focus Areas

- ○ Improving performance by developing suitable (more flexible yet precise) materials
- ○ Move toward development of ultra-thin, flexible electronics
- ○ Expanding the application scope
- ○ Scaling up of production capacity

Funding

- ○ Funding support by government and venture capitalists is expected to accelerate the commercialization of prototypes and products. Technology developers would be able to bring innovative ideas to the market with financial support.
- ○ To develop novel manufacturing processes (including flexible electronics), the UK Government has allocated up to 4.75 million pounds (about US US$6.7 million) to universities, research institutions, and companies under the Technology Strategy Board (which is now renamed as Innovate UK) Manufacturing Electronic Systems of the Future Program.

The 2020 Scenario

- ❑ Helped by the Flexible Hybrid Electronic Institute venture in the US, which over 5 years is earmarked to get $75 million in DoD funding over 5 years and $90 million in matching funds from the industry, academia, local governments, stretchable sensors are expected to impact the military sector in the long term in applications such as wearable health monitors or structural health monitoring.
- ❑ The flexibility of solar cells can be expected to open up various applications, such as integration on wristbands for energy harvesters.
- ❑ In the long-term, the US is projected to witness significant growth, driven by the large-scale manufacture of stretchable sensors for the IoT, consumer electronics, military, and medical sectors..

Key Patents and Industry Interactions

Key Patents

No.	Patent No.	Publication Date	Title	Assignee
1	**WO/2015/172897**	19.11.2015	SILICONE COMPOSITE SENSOR FOR MEASUREMENT OF HEART RATE	KONINKLIJKE PHILIPS N.V.
	Silicone composite sensor for measurement of heart rate The present invention proposes the use of a silicone composite material for measurement of heart rate or other small changes of pressure or force. The composite material has an electrical resistivity that changes when force is applied on the material. The conductive material may be carbon black or other electrically conductive particles like graphite, carbon nanotubes etc. The material is flexible and stretchable. The material can be made by injection moulding. An optional embodiment consists of a silicon composite material that contains liquid silicone rubber mixed with conductive particles like carbon black.			
2	**WO/2015/166447**	05.11.2015	MEASURING DEVICE, SYSTEM AND METHOD FOR MEASURING A WRAPPING FORCE	AETNA GROUP S.P.A.
	Measuring device for detecting and measuring a wrapping force (F) of a stretchable plastic material film (50) wrapped around a load (100) comprising a first angular element (2) that is associable and fixable to an edge (101) and/or a flat wall (102) of the load (100), at least one force sensor (10) fixed to the first angular element (2), a second angular element (3) fixed to, and supported by, the force sensor (10) and a control unit (5), connected to the force sensor (10) and arranged for receiving therefrom a signal related to a wrapping force exerted by the film on the second angular element (3) by the film (50) that is wrapped around the load (100) and around the measuring device (1); a system for detecting and measuring a wrapping force of a stretchable plastic material film (50) wrapped around a load (100) comprising one or more measuring devices (1) associated with, and fixed to, the load (100) at edges (101) and/or at flat walls (102) of the load (100) and an external receiving unit (45) that is arranged for receiving signals which are transmitted by the measuring devices (1) and related to a wrapping force (F) exerted by the film (50) wrapped around the load (100) and around the measuring devices (1).			

Key Patents (continued)

No.	Patent No.	Publication Date	Title	Assignee
3	**WO/2015/163151**	29.10.2015	TACTILE-SENSE PRESENTATION DEVICE	MURATA MANUFACTURING CO., LTD
	A tactile-sense presentation device (101) is provided with a stretchable film (20), a diaphragm (40), and a touch panel (50). A plurality of touch sensors (80) are provided to the planar touch panel (50) at positions corresponding to a key layout. The diaphragm (40), when seen in plan view, has a first region overlapping the plurality of touch sensors (80) and a second region not overlapping the plurality of touch sensors (80). A plurality of openings (85) are provided in the first region of the diaphragm (40). With this configuration, when a user performs a touch operation, the user can obtain a sufficient click sensation due to a keystroke caused by the touch sensors (80) being pushed into the openings (85) and due to vibration of the diaphragm (40) caused by stretching and contracting of the stretchable film (20).			
4	**US20150289364**	08.10.2015	STRETCHABLE DEVICE FOR TRANSMITTING SIGNAL	Clothing Plus MBU Oy
	A stretchable device for transmitting signal between end points, such as a sensor and electronic unit, includes a conductive element, which is coupled with a supporting structure by introducing the conductive element successively through the thickness of the supporting structure to the first and second side of the supporting structure, thereby providing a corrugated structure for the conductive element, which is configured to be straighten out at least partially during stretching the device in its longitudinal direction. The conductive element is coupled with the supporting structure between first and second outer layers thereby providing the stretchable device.			

Industry Interactions

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