As bio-monitoring and fitness-tracking devices gradually become a part of everyday sports equipment, 'wearables' seems poised to become a mainstream market. For e-textile and electronic component manufacturers, this signals the need to scale up production to address a market estimated to reach $6 billion by 2016.

Smart textiles pick up pace

Speculation on project Google Glass is keeping the web abuzz and a series of market reports on wearable devices, by IMS Research, Forrester Research and Juniper Research (see box), seems to indicate that they are the next big thing. Many of these devices require smart textiles to function. In this positive context, electro-textile, electronics and sports apparel manufacturers are ramping up industrial processes.

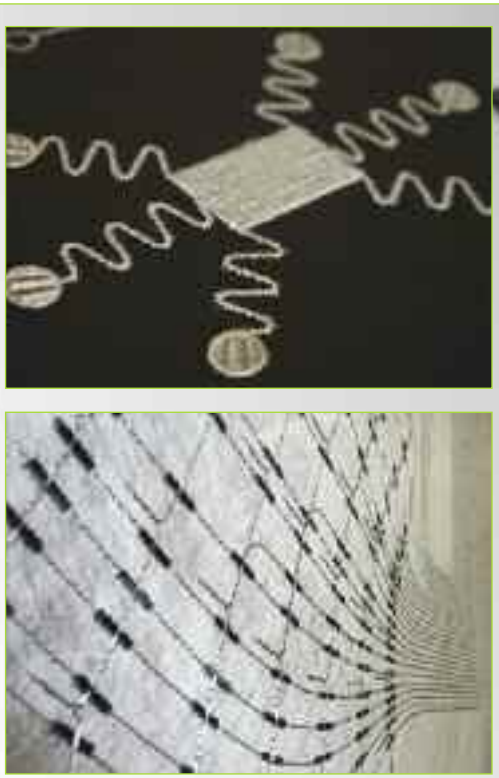
After a first generation of products containing heating panels or heart rate monitoring devices, new developments offer data on muscle movement using electromyography sensors or provide information on possible injuries via impact sensors. MC10's stretch sensors now equip a skullcap made by Reebok-CCM to be launched this June. The smart sensors are embedded directly in the fabric and the Head Safety skullcap emits a yellow or red light depending on the severity of impact.

Sensoria smart socks are yet another wearable device that is near market-ready. Made by Heapsylon, a company based in Redmond, Washington, the socks are knitted with e-textile sensors that count steps, speed and pressure as well as measure weight changes to offer runners insight into their technique. The sensors are connected to an electronic anklet containing a Bluetooth device and battery. Close to industrialisation, the company is currently



Running specialist Ronhill has integrated iLume modules made by Fibretronic on running jackets and backpacks.
Ronhill / Fibretronic

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Because of its ability to combine varied materials into a robust, flexible and functional unit, embroidery can be considered a smart way to make wearable devices. Shown here are a sensor (top left), electrical circuitry (bottom left) and a heating panel (above) made by Forster Rohner Textile Innovations (FRTI), a new division of Swiss embroidery manufacturer Foster Rohner.

FRTI

evaluating a crowd-funding campaign.

In development for five years, SenseCore is yet another smart device to be launched this September. The device is the result of a research project conducted jointly by CSEM and Sports Unit of Innovation (SUI), both of Switzerland. Production of the first 1,000 pieces has been launched, says SenseCore CEO, Alexandros Giannakis. The concept is based on a pair of water-resistant devices weighing 15 grammes each that clip onto different types of compression garments for running, swimming or cycling. After having experimented with textile sensors, Mr Giannakis says the company opted for dry electrodes that capture higher-quality data, including ECG (out of which heart rate, calories, and Excess post-exercise oxygen consumption, or EPOC, are extrapolated), true respiration, body temperature and kinetics (to track speed, distance, cadence, acceleration, and activity). The hardware is manufactured in Germany and the fabrics come from France. SenseCore is currently working on optimising cloud software and work has already begun on a second-generation smart device.

Though not technically a textile, BodyMedia's Vue patch, developed with a division of Avery Dennison, is due out in the second half of 2013. The disposable waterproof monitor is designed to be placed on the upper arm and measures calorie burn, activity and sleep patterns. Weighing 11 grammes, it includes a three-axis accelerometer, heat flux, ambient temperature and galvanic skin response sensors and transmits the data to a smartphone. The company is in the process of being acquired by Jawbone, a maker of wireless audio and fitness-tracking devices.

Comfort and wearability

These new fitness and wellness tracking accessories introduce a fresh series of options to the now almost classic market for heart-rate monitoring straps and bras. One of the leading makers of heart-rate sensors for straps and bras, Clothing+ claims to have delivered three million items in 2012. The Finnish company has recently improved the wearer comfort of its straps to make them less prone to chafing. "If a product is in any way uncomfortable, it won't be worn



The Head Safety Skull Cap by Reebok's hockey division CCM can be worn under any helmet and is made with MC10's stretch impact sensors.

Reebok-CCM

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The BioMan bike shirt developed by AiQ Smart Clothing, a division of the Taiwanese textile conglomerate Tex-Ray, is based on a sensor located on the upper arm instead of the thorax.

AiQ Smart Clothing Inc.

unless prescribed for medical reasons," says product and marketing manager, Mikka Malmivaara. Of all the products currently available, he believes sports bras are the "no-brainer" of the lot because "they eliminate the discomfort of wearing two adhesive sensors." In addition to heart rate monitoring, Clothing+ has developed electromyography (EMG) sensors that now equip Myontec's smart garments,

Working on wearable devices since 1999, Italian e-textile specialist Smartex started selling its Wearable Wellness Shirt in 2009. Close to 100 units are said to have been sold. The knit compression shirt includes an electrocardiograph (ECG) and sensors that pick up respiratory and body movement signals. "From the data obtained, we can extrapolate heart rate variability, activity classification, energy expenditure and a number of other parameters depending on need," says R&D director Rita Paradiso. Designed for long-term monitoring, the smart shirt is considered a more comfortable solution compared to disposable patches. "A person wearing the shirt tends to forget it, so though the data picked up may be less precise, it is enough to indicate if something is wrong," says Ms Paradiso. Filtering out the noise, or the artefacts, is a complex matter: if the sensor's sensitivity is set too high, the data will be lost in the noise, she says. Sensors work best if the garment fits snugly on the body. The development of compression apparel has helped make wearable data monitoring more practical and precise.

Finnish company Myontec believes embedding sensors in garments is the best option for several reasons. The sensors stay in place, they avoid the discomfort of adhesives, they provide reliable data, and a single battery can power several devices, says Myontec CEO, Pekko Tolvanen. After the MyOnWear Sensor Clothes made for professional athletes, Myontec is now working on a consumer product to be launched later this year.

Upscale Italian brand Zegna continues to explore smart devices that target uses other than the data-hungry athletic market. In 2007, the company released a jacket with a solar panel inlaid in the collar and a new smart jacket is being launched in the autumn-winter 2013 collection. The Icon jacket is equipped with a microphone and joystick controls to manipulate a smartphone; wireless Bluetooth connectivity makes it possible to operate the device at a distance. The smart components were developed with German electronic component manufacturer InterActiveWear. As an added perk, the waterproof-breathable Sympatex membrane jacket is lined with a body-shielding fabric to protect the wearer from electromagnetic waves.



Bodymedia specialises in sensor-based body monitor patches that send data to a smartphone. The disposable adhesive modules are made to be worn for one week and measure various parameters, including calorie burn, sleep patterns and activity.

Bodymedia

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Heating and lighting

Compared to the smart biometric devices being developed, conductive textiles used for heating panels and lighting modules could be considered basic features, yet they continue to run into trouble-shooting issues. Columbia Sportswear's Omni-Heat Electric jackets and boots were recalled last autumn due to excess heat. The entire range is now said to have been suspended. The companies interviewed for this piece believe that hot spots can be avoided with the right selection of materials and construction.

AiQ Smart Clothing, a division of Taiwanese textiles conglomerate TexRay, which has developed a wide range of smart wearable devices, uses conductive stainless steel wires, made by sister company King's Metal, for its heating modules.

InterActiveWear uses litz wires that consist of multiple, individually insulated strands of copper. If one strand is damaged, the others continue to conduct electricity. "The level of current will drop, but no hot spot will develop," says InterActiveWear CEO, Andreas Roepert. "Heating modules are better suited to small surfaces, for gloves, shoes or neck-warmers, whereas jackets require larger and heavier batteries." In all cases, Mr Roepert recommends that heating features only be used for short periods.

"A well-built system should shut off before burning," says Jan Zimmermann, head of Forster Rohner Textile Innovations (FRTI), a newly formed division of the hundred-year old Swiss embroidery specialist Forster Rohner. For e-textiles, embroidery is said to present a number of advantages, including the possibility of producing at any scale (large, medium or small) and presenting few limitations in combining multiple materials and components. FRTI claims to work with a portfolio of 150 electrically active materials to connect varied devices, including sensors and batteries. InterActiveWear supplies much of the hardware and software that FRTI "e-broiders". "Components are the simple part of electro-textiles. What has kept smart fabrics from taking off is obtaining an end product that possesses the properties one expects from a textile in terms of comfort, washability and durability," says Mr Zimmermann.

Like heating, lighting is a power-hungry function that requires fine engineering to reduce battery weight and size. Many suppliers, including InterActiveWear and Fibretronic, have opted for clip-on systems considered easier to integrate into a garment. Improvements have been made in lithium-ion batteries and the light effect doesn't have to last all day, says Mr Zimmermann at FRTI. He recommends choosing multifunctional batteries that can also be used to recharge a smartphone, making their added bulk more acceptable.

Power plays

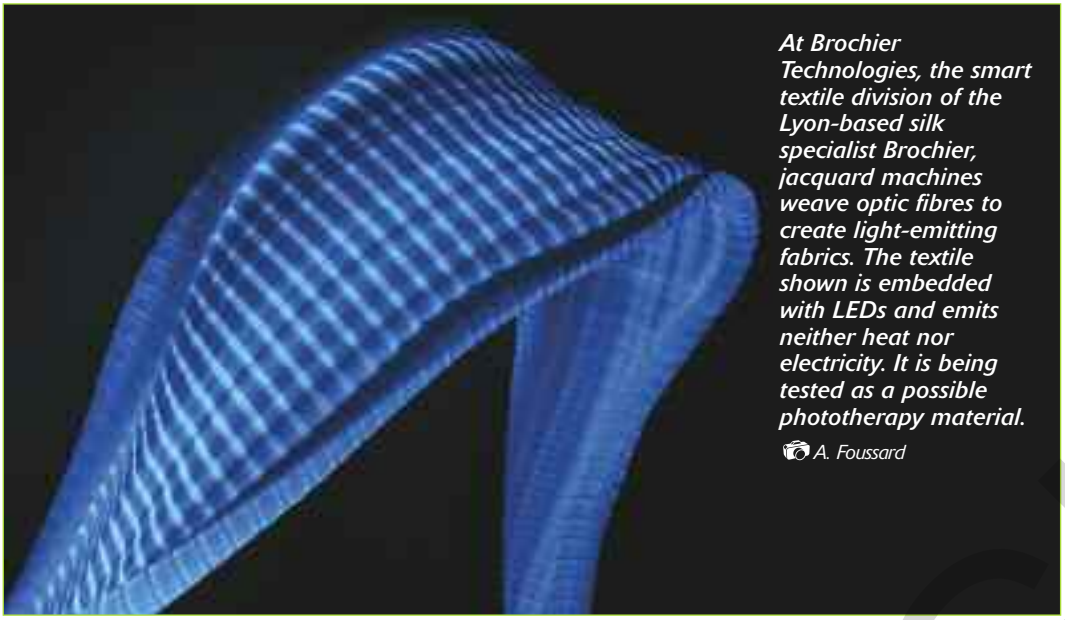
While signal clarity and hot spot management have yet to be optimised, electro-textiles face yet another design hurdle when it comes to powering the devices. Most companies consider batteries to be the number-one difficulty, not only because they are cumbersome, but also because of their cost. The battery element is said to represent 50% of the cost of a finished smart garment.

The main strategy currently applied is to tailor the battery to its intended use. At AiQ Smart Clothing, luminous modules made for joggers and cyclists are designed to run two hours a day for seven days before requiring recharging, notes sales manager, Nadia King.

Alternatives to conventional batteries have yet to come of age, says Andreas Roepert, at InterActiveWear: "There is a



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At Brochier Technologies, the smart textile division of the Lyon-based silk specialist Brochier, jacquard machines weave optic fibres to create light-emitting fabrics. The textile shown is embedded with LEDs and emits neither heat nor electricity. It is being tested as a possible phototherapy material.

A. Foussard

lot of talk about energy harvesting devices, but they won't be able to power a device other than a digital watch." He believes that in 2020, rechargeable lithium-ion batteries will still be the only, if not the ideal, energy source.

Printable batteries could be a solution, but they have yet to be transposed from paper to textiles. Progress may be on the way, if developments seen at Ardeje, a French company based in Valence, come through. The inkjet printing specialist is working on printing conductive materials on fabrics, glass and plastic. Ardeje is specifically working on luminous, sensor-based, RFID antenna and photovoltaic textiles. Dracula Technologies, a spin off of Ardeje, already proposes photovoltaic fabrics whose cost is €1 per watt of energy produced, according to company documents.

The photovoltaic fabric currently in development is said to have a supple handle. "We are careful to keep the textile's properties intact in terms of elasticity and breathability for wearer comfort," says Ardeje R&D manager, Michael Barret, who estimates that the process will be market-ready by 2015. The company is currently looking to make a water-resistant solar-panel fabric for use on tents or backpacks.

Though hurdles remain, technical glitches are progressively being ironed out of electro-textiles, a sign that after years of research and development, and countless prototypes, the market could be on the verge of reaching an industrial stage. The widespread use of smartphones, apps and Bluetooth connectivity is considered a positive evolution by Andreas Roepert at InterActiveWear. Market acceptance moves forward at a fast pace too. "Electromyography used to be considered science fiction, and it is already becoming a standard feature," says Mr Malmivaara at Clothing+. He believes that sooner rather than later, people will come to expect that everything can be measured, automatically and seamlessly.

Wearables by the numbers

IMS Research estimates:
14 million wearable tech devices were produced in 2011.
170 million wearable devices are forecast to be shipped in 2016 and could reach $6 billion in sales.

Juniper research estimates:
Mobile wearable devices and smart glasses could reach sales of $70 billion by 2017.

"Smart Body, Smart World", a Forrester Research report on wearable technologies by senior analyst Sarah Rotman Epps, investigates the broad market that is opening up but also points out some of its weaknesses, including data reliability: "Nike+ FuelBand users have noted that they get more "fuel" points for arm-intensive (but not fitness-inducing) activities such as eating pizza than they do for walking up a flight of stairs."



Made by Finnish company Myontec, MyOnWear Sensor Clothes are wired with conductive textile electrodes. The company is working specifically on electromyography (the study of muscle movement) to help athletes measure and improve their technique.

Myontec

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