

Electrically powered textile heating systems for garments are programmed to deliver just the right amount of warmth when and where it is needed. Mastering this simple function is far from easy, involving many different textile, electric and electronic options, arguably making it a blueprint for next-generation wearable electronics.

# Smart thermal solutions

by Sophie Bramel

**W**hen temperatures drop, it is now possible to turn up the heat directly inside one's clothing. Though this is far from a widespread function, the number of companies offering "plug and play" on-demand heating solutions for integration into clothing is on the rise. The long development process that they have dedicated to devising safe and efficient systems is also contributing valuable knowledge to the field of conductive textiles. A number of these presented their products at a panel discussion held at Performance Days in Munich last November.

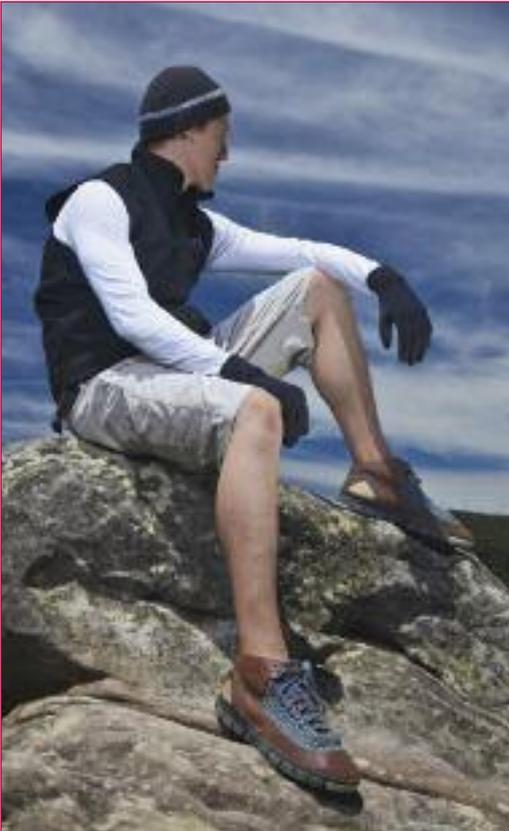
Though each company has developed its own technology, they all combine three basic elements: a conductive material to provide heat through resistance, a switch to turn the system on and off, a process that can be outsourced to a smartphone app, and a source of energy, here again often entrusted to an off-the-shelf power bank.

Metallic fibres remain the most common conductive material used but non-metallic solutions, such as carbon and graphene, are also being tested. WarmX, a company based in Apolda, Germany, has been manufacturing

*Based in Lyon, France, Clim8 has designed smart thermoregulating panels that are easy to embed in a base layer. The electronics and smartphone app adapt warmth to need. Once the body starts to generate heat, the Clim8 panels will turn off automatically.*

 Clim8





*AiQ believes smart heating functions may become more popular thanks to progress in battery technologies and widespread power bank ownership.*



heat-generating underwear since 2002. It uses a silver-coated polyamide yarn, regarded as more comfortable than metallic wires. "WarmX heated clothing is designed to be worn directly on the skin, where the system can provide a huge effect with very little energy," says company CEO Christoph Müller. French start-up Clim8 has also chosen to make its smart thermoregulating panels in a knit containing a silver-based yarn. These are then laminated to a base layer and include sensors to allow the system to adapt to changing temperatures.

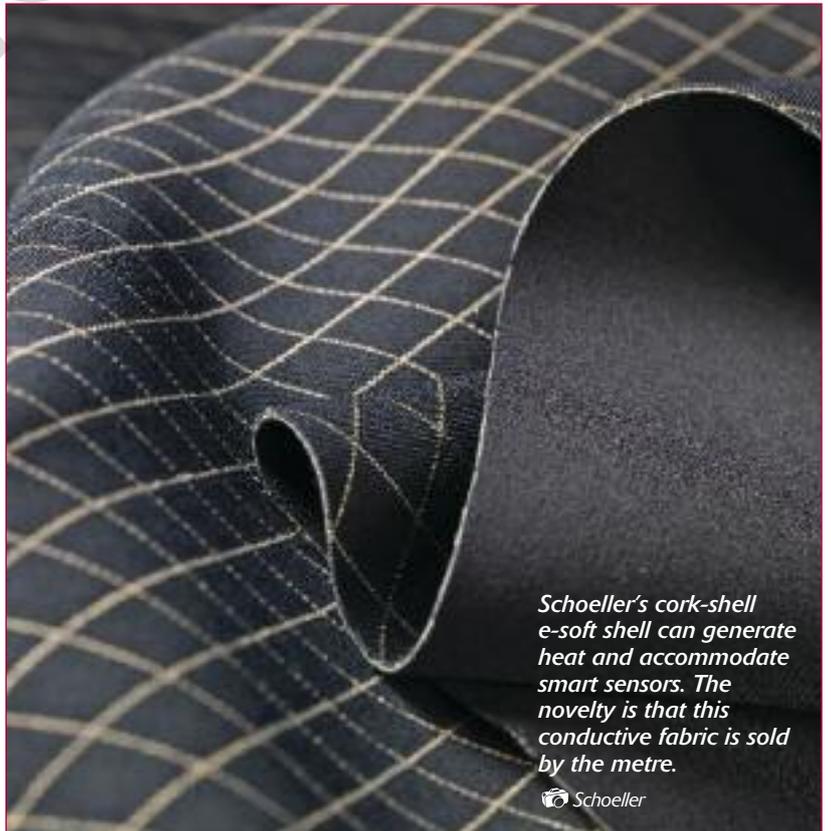
Unable to find a yarn suited to the humid microclimate of feet, Swedish start-up Inuheat developed and patented its own conductive yarn with the help of the Swedish School of Textiles in Borås and the Swerea IVF Research Institute. The research programme found stainless steel to be the best option. "We looked at all available materials and needed a safe solution for socks as the combination of sweaty feet and electric current is quite challenging," Stefan Carlsson, Inuheat CTO and co-founder, explained at the panel discussion. Taiwanese company AiQ, a division of Tex-Ray, has also opted for a stainless steel fibre, which is coated with copper to enhance conductivity, as executive director Steve Huang told WSA.

In addition to knitting, embroidery is being used to create conductive textiles, as seen at Interactive Wear, a company based in Starnberg, Germany, and a partner of Swiss embroiderer Forster Rohner. Embroidery makes it possible to offer a highly flexible yet sturdy system, says Andreas Röpert, Interactive Wear CEO and founder. The company has a long experience in the field, and is now working on scaling up production to reduce cost and make its heating panels "commercially acceptable also for mid-range brands," he says.

### Conductive yarns, films and prints

Recently, a new series of conductive materials has come to market. Swiss textile manufacturer Schoeller has introduced an e-soft shell, a conductive knit fabric that can be cut and sewn to size and is sold by the metre. It is produced by Eschler, the company's knitting division, and has a layer of insulating cork based on the company's cork-shell technology.

Those looking for alternatives to metal can turn to Nanogy, a brand introduced by Frankfurt-based Acanthurus that represents Chinese manufacturer J-Nova. Its conductive panels are made with a carbon nanotube coating applied to a membrane or film. "This technology is very stable, it can be washed upwards of 100 times and can even be stitched. If torn or punctured, it will remain conductive," says Carsten Wortmann, Nanogy founder and CEO. As opposed to knitted or embroidered



*Schoeller's cork-shell e-soft shell can generate heat and accommodate smart sensors. The novelty is that this conductive fabric is sold by the metre.*



systems, it is not designed to be worn next to the skin but requires a lining layer.

Taiwan-based Formosa Taffeta (FTC) has also opted for a membrane with printed electric and electronic circuits developed in collaboration with DuPont Intexar. "FTC's smart thermal technology utilises advanced electronic printing techniques which are the result of a two-year collaboration with DuPont," James Lee, president of Formosa Taffeta, said ahead of the official Ispo product launch.

Many heating and conductive solutions are now available to brands. Though diverse in nature, they all share one intention, which is to offer a simple-to-integrate system, whether off-the-shelf or made-to-measure.

### Powering up

To connect the panels to a source of energy, most of these systems rely on USB plugs that can be used with any power bank. This is the case for Nanogy, Interactive Wear, AiQ and other Asian suppliers such as FTC or Asiatic Fiber Corporation (AFC). WarmX and Clim8 have developed their own battery modules that snap on to the heating panels. "As a clothing manufacturer, snap buttons were a simple choice. Fifteen years later I still feel it is the best solution as it is durable and easy to use," says Mr Müller. Inuheat has designed a simple yet sophisticated system in which the battery and electronics casing is held by a strap label and a magnetic connection powers the system.

### App-controlled comfort

While early heating panels required switches to control the level of heat generated, newer products come with their own smartphone apps that streamline and automate the heating functions, and make it possible to develop other smart features. "We have added sensors that monitor the user's temperature, analyse their profile and automatically provide warmth when and where it is needed," says Florian Miguet, Clim8 CEO and co-founder. Users provide a certain number of personal parameters, sensors pick up ambient data, and these are fed to an algorithm that will then deliver the ideal level of heat. "Our intelligence is in anticipating the user's needs. It is designed for active, not static use," he adds. Korean K2 licensee has already integrated the system and is selling the first Clim8 powered smart thermoregulating base layers this season.

"Our system detects motion and adjusts power output accordingly. The user controls the amount of heat, but we also monitor battery usage. A time control function makes it possible to adapt power usage to context. If the ski lifts close at a specific hour, we can adapt power usage to the ski lift schedule," says Mr Carlsson at Inuheat.

Nanogy's system offers automatic functions. "It is designed to reach a certain temperature quickly and maintain a steady level throughout use. In sleeping bags, for instance, the technology works as a kick-starter: it heats up and when it reaches a certain level of warmth, it shuts off automatically," says Mr Wortmann.

*For its seamless patented tights, WarmX has placed the conductive heat resistance on the upper side of the foot, which it says will be more effective at delivering warmth. Its silver-plated yarn will also reduce bacteria and odours.*

 WarmX



WarmX has yet to offer adaptable climate control, but is working with two research institutes on the matter. "Automatic systems are quite sophisticated and dependent on many factors," says Mr Müller. "In the summer, 5°C will feel cold, but in the winter, 5°C can be considered warm and will affect sweating."

### Smart sensing

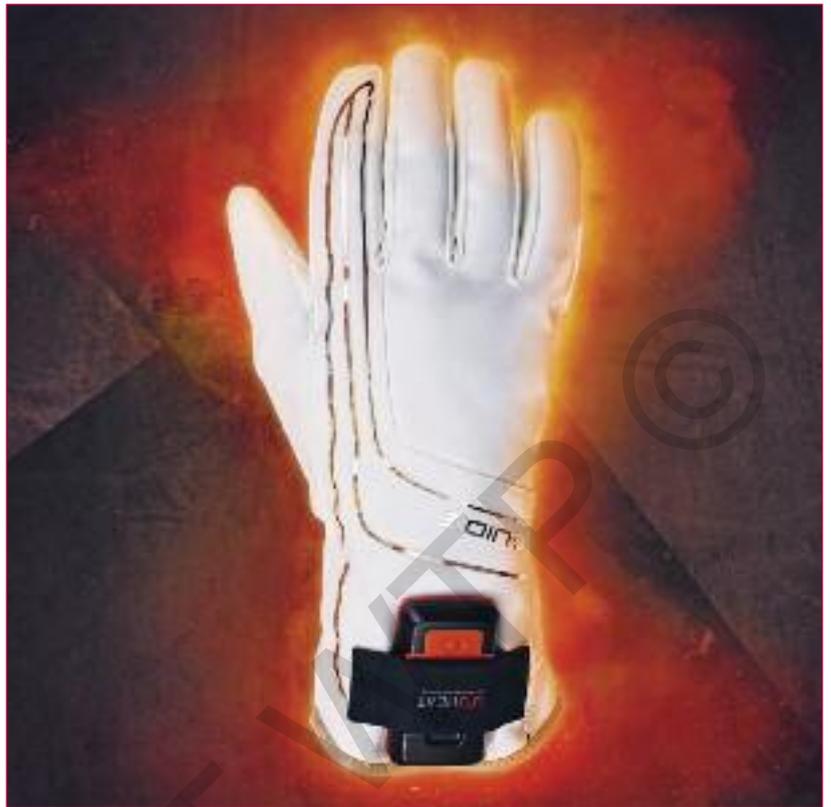
To be "smart" today means to be "connected" to the cloud and to offer data analysis to provide information to a service provider and improve the consumer experience, says Steve Huang at AiQ. For this reason, he sees heating and lighting functions as less important than bio-sensing. He also points out that heating is a power-hungry system, "as few watts actually directly transform electricity into heat". A sensing system, he says, requires just a few milliwatts thanks to progress made in low-energy Bluetooth, wifi and data processing chips.

Other suppliers are also looking to expand data collection to provide additional services. WarmX is working on a textile pressure-sensing module. "It is currently being tested by wheelchair users who are seated all day long. Our system provides a complete profile over time. It can see how they move, where they move, and identify hot spots," says Mr Müller.

An NFC chip (Near-Field Communication) is embedded in Inuheat's device and is used to monitor manufacturing processes but can also be programmed to provide brands with data on how the product is being used. "This information is generally difficult to obtain from consumers," says Mr Carlsson, adding that the data collected is anonymised.

Inuheat will be presenting a new brand platform at Ispo at the end of January and has upgraded its electronics to offer brands additional services. The company initially targeted high performance uses, allowing professional skiers to wear very fine clothes without suffering from cold feet during training, for instance. "We would now like to attract lifestyle and urban brands," says Mr Carlsson. The company has invested in a new ASIC (Application-Specific Integrated Circuit) chip that is much smaller while offering increased computing power. Among the possibilities this upgrade can allow is to fine-tune the delivery of warmth based on a wider set of parameters. In addition, Mr Carlsson says, "the decision to make our own chip will enable us to meet the price points necessary to enter the lifestyle market." The company has also improved the efficiency of its battery which now has double the power of the former version (15 V compared with 7.4 V).

InteractiveWear has also recently developed a smaller heat controller that can be operated via a smartphone app. It measures only 2 x 2cm



and is flat and the new capacitor switch requires only a "light touch" to be activated, says Mr Röpert.

### If warm, then cool?

As progress continues in making these devices smarter and slimmer, the quest to go one step further and provide coolness on demand is on many companies' to-do lists. But if resistive heating has been challenging, providing the opposite effect is proving to be even more so.

"Cooling is much more complicated than heating," says Mr Carlsson. "For heating, all you need is a source of resistance, a battery and a switch. It is not possible however to generate coolness; the only solution is to remove heat. We have done feasibility studies that are so promising we have decided to produce a prototype. We have built a test rig and the goal is to have a thin and smooth working prototype for wearable cooling during 2018. It is energy-efficient and can be powered and controlled by the same power packs we use for heating clothes."

J-Nova, Nanogy's Chinese partner, is investigating cooling functions as well. "We are optimistic that we will find a solution, but it is quite far down the road," says Mr Wortmann. Among the new features already combined with heating, he cites lighting, camera and data transmission functions.

On-demand warmth could then be just the beginning of next-generation interactive and conductive textiles, the foundation on which other smart functions will be built, in time. 

*First used in a range of heated socks by Seger, the Inuheat platform is now being introduced in gloves by Swedish workwear brand Guide. The next step is underwear.*

 Guide / Inuheat