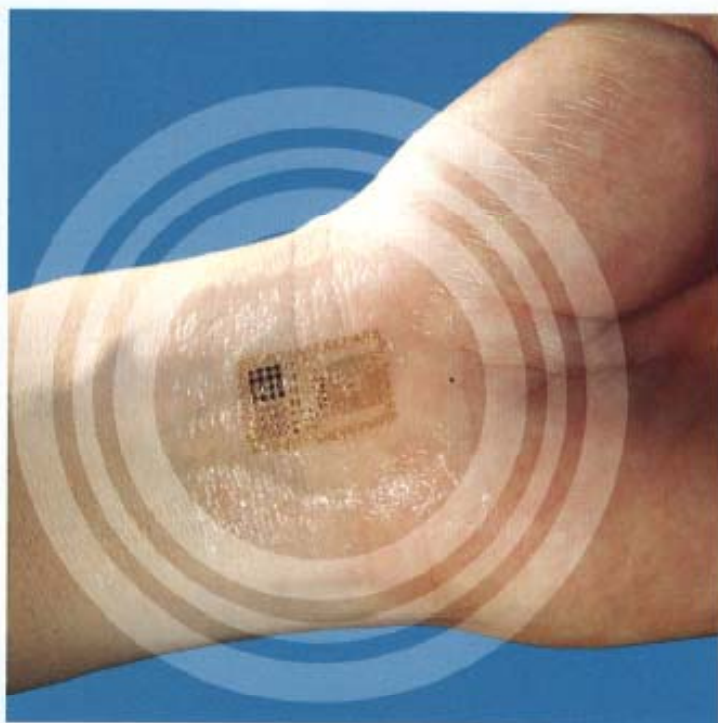


Plastic ELECTRONICS

BUSINESS AND MARKET STRATEGIES FOR ORGANIC AND PRINTABLE ELECTRONICS



ON THE PULSE

'TATTOOS' REVEAL THE
VALUE OF WEARABLE
ELECTRONICS

THE CIRCUIT

+ PHOTONICS21
ANNUAL MEETING

MARKET WATCH

+ OLED LIGHTING

STANDBY

SAMPO AHONEN, CEO,
BENEQ



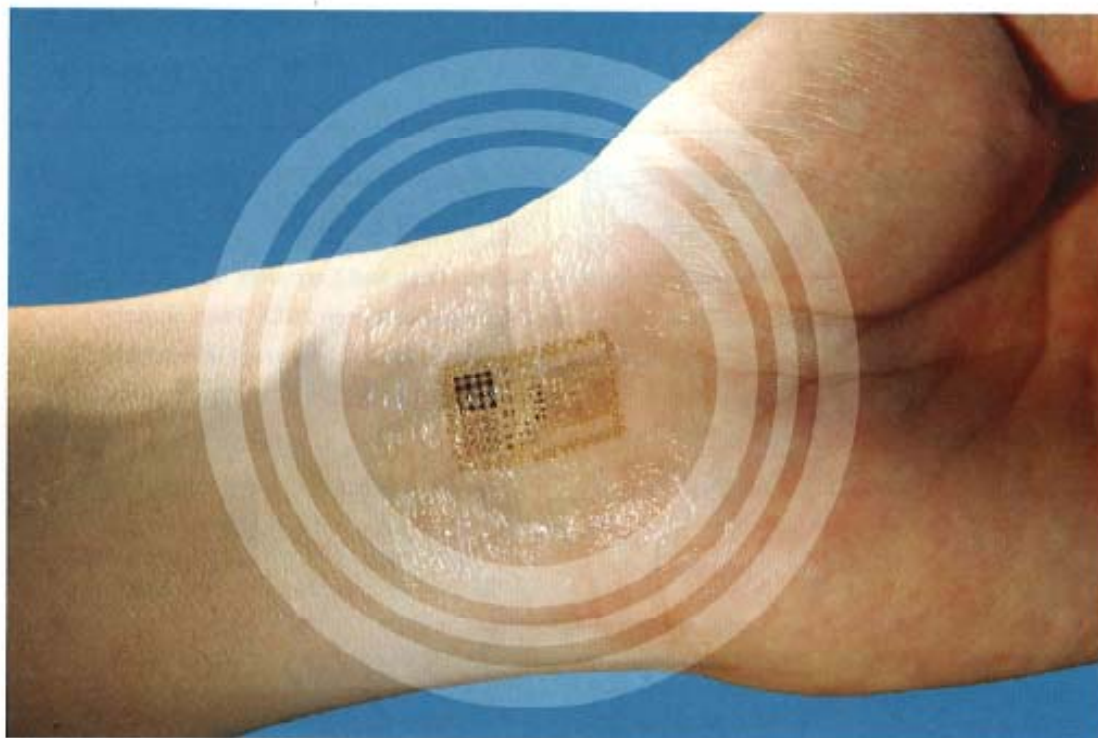
JOINED-UP THINKING

A PRINTED MEMORY START-UP BEGINS
BUILDING ITS OWN SUPPLY CHAIN



PLUGGED IN: PRINTING

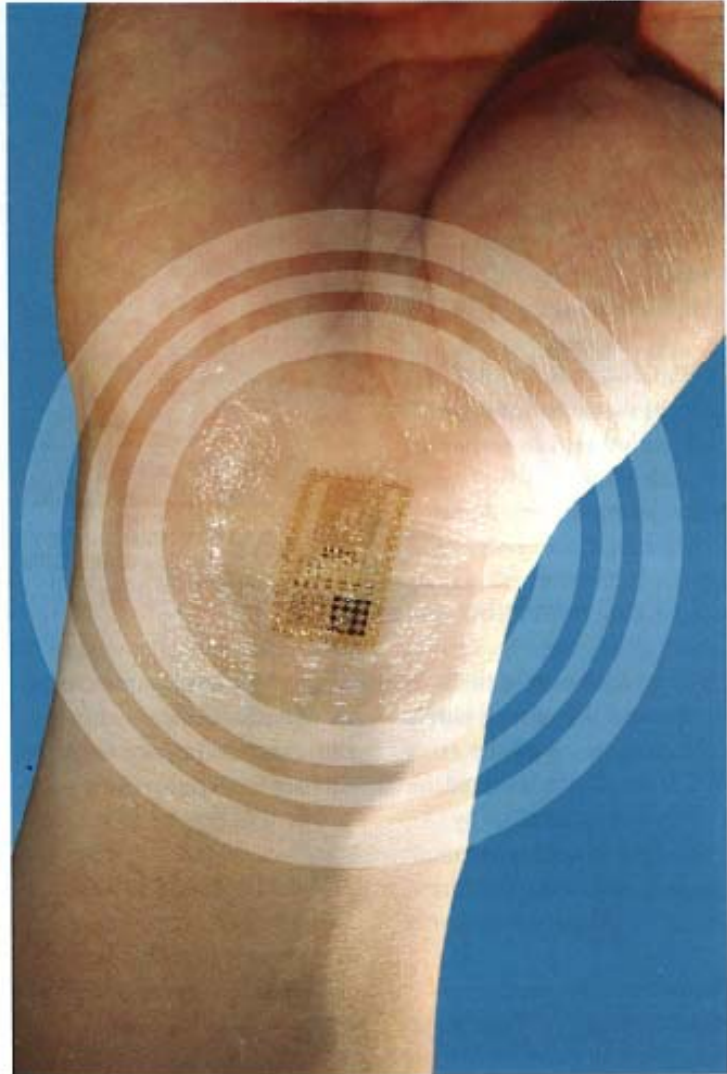




On *the* *pulse*

WORDS:
DAN ROGERS

AN ULTRA-THIN ELECTRONIC
PATCH WITH THE MECHANICS
OF SKIN, APPLIED TO THE WRIST
FOR ELECTROMYOGRAPHY – THE
RECORDING OF MUSCLE ACTIVITY
– AND OTHER MEASUREMENTS
SOURCE: JOHN ROGERS,
UNIVERSITY OF ILLINOIS



**'TATTOOS'
AND PATCHES
WILL REVEAL
THE VALUE OF
WEARABLE
ELECTRONICS**

Wearable electronics developers have for some time been attempting to tackle the problem of integrating electronic functionality into textile materials that are washable, durable and not too complex to produce in volume.

One approach that avoids many of these challenges is to eschew clothing altogether. Some developers are investigating the possibility of attaching electronics directly to the wearer's skin as a patch or 'tattoo.'

This approach caught the attention of the general public in March 2012, when the *Wall Street Journal* covered a US patent application by Nokia for a vibrating tattoo that communicates with the wearer's mobile phone.

The patent – 20120062371: Haptic Communication – suggests the technology could be used as a wearable

Some developers are investigating the possibility of attaching electronics directly to the wearer's skin as a patch or 'tattoo.'



MC10 COULD COMMERCIALISE WEARABLE ELECTRONICS FOR THE COSMETICS AND SKINCARE MARKET
PHOTO: JOHN ROGERS, UNIVERSITY OF ILLINOIS

receiver for notifications such as a new SMS or call, with differing notifications based on user settings, according to *The Wall Street Journal*.

ON-BODY MATERIALS

The concept is not a new one. UK start-up Bare Conductive has been developing inks

that make printing circuitry simple on various substrates.

The start-up launched Bare Paint in Q3 2011, a conductive and non-toxic ink that allows the user to essentially paint a circuit. The company is now working on Bare Skin, a paint that is safe for use directly on

USEFUL LINKS

- + Bare Conductive – www.bareconductive.com
- + Bare Conductive's community – www.bareconductive.com/community
- + Flexible sensors could improve heart surgery – bit.ly/JFt5T
- + mc10 – www.mc10inc.com
- + Nokia patents vibrating tattoos (*The Wall Street Journal*) – on.wsj.com/1s6FKR
- + Nokia's patent: 20120062371: Haptic Communication – bit.ly/1eQcuc
- + Reebok announces partnership with smart fabric developer – bit.ly/1ePlo8



WEARABLE PATCHES ARE LIKELY TO BE APPLIED INITIALLY FOR ONE-TIME USES

PHOTO: JOHN ROGERS, UNIVERSITY OF ILLINOIS

the body. The product will be certified as a cosmetic in the EU once it is released, according to the company.

Applications for the material range from wearable healthcare technologies to more artistic work, notes Matt Johnson, one of the founders of Bare Conductive.

Our material allows the user to turn skin into a sensor, for things like movement, an inference of body temperature, or pressure on the body

'The core of each application, whether it is medical or art, for instance, is always the same. Our material allows the user to turn skin into a sensor, for things like movement, an inference of body temperature, or pressure on the body. These functions would have very straightforward medical applications, for example,' explains Johnson.

BARE PAINT

The company is currently working on the commercialisation of its off-body ink, Bare Paint, which is designed for applications such as electronic gift cards, posters and games – among the wide variety of other uses that have been explored.

'Most of the focus so far has been on the off-body material. There has been a huge amount of interest in that,' notes Johnson.

There are still relatively few strong, functional examples in the marketplace

Sales of the off-body paint have gone well, according to Johnson. The start-up sees 40% of its income from the US and another 40% in the UK.

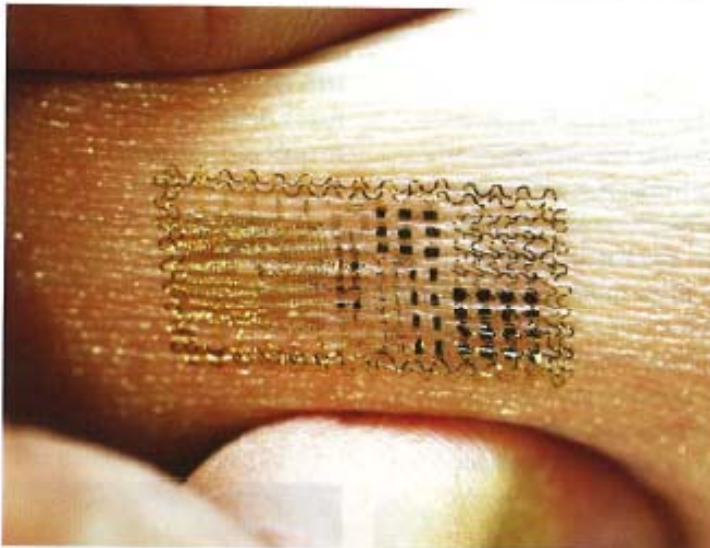
INK SUPPLY

Bare Conductive is planning to scale up its materials supply over the next two years, working with contract mixers for the ink.

'Interest with regards to printed electronics is also very strong in Europe,' he adds.



WEARABLE CONDUCTIVE CIRCUITS COULD BE INTEGRATED WITH SENSING TOOLS IN THE NEAR-TERM
PHOTO: JOHN ROGERS, UNIVERSITY OF ILLINOIS



ELECTRONICS MOUNTED DIRECTLY TO THE SKIN, WITH NO NEED FOR WIRES, CONDUCTIVE GEL, OR PINS. THEY BEND, STRETCH AND DEFORM WITH THE SAME MECHANICAL PROPERTIES OF SKIN, GRANTING THE WEARER COMFORT AND FREEDOM OF MOVEMENT
PHOTO: JOHN ROGERS, UNIVERSITY OF ILLINOIS

Though the company is still small, its ability to build a community of enthusiasts will help demonstrate the value of wearable electronics.

Bare Conductive's website hosts videos showing user output, and there is a strong demand for the materials from educational institutes too.

The movement of enthusiasts creating compelling, disruptive technologies is attracting attention. *The Economist* highlighted the Maker Faire, a gathering of 'makers,' in December 2011. Bare Conductive will be attending the biggest of the Maker Faires in San Francisco, California, US on 19-20 May.

Yet the industry of wearable electronics as a whole is held back by the lack of appealing, scalable demonstrators.

"There are still relatively few strong, functional examples in the marketplace," Johnson admits.

Upcoming products could involve some of the "tattoo" technology we've worked on

www.plusplastichelectronics.com



EPIDERMAL ELECTRONICS CAN BE MOUNTED DIRECTLY ONTO A TEMPORARY TATTOO, AS DEMONSTRATED IN THESE PHOTOS, FOR CONCEALMENT

PHOTO: JOHN ROGERS, UNIVERSITY OF ILLINOIS

In this respect, the fortunes of wearable electronics may change in 2012. US start-up mc10 has been developing wearable electronics since it was spun out in 2008 to commercialise research by John Rogers at the University of Illinois at Urbana-Champaign,

People care about their skin, so they're interested in devices that can inform them on relevant products

and George Whitesides at Harvard University.

The start-up has been developing partnerships with companies that could integrate its conformal inorganic electronics into clothing and other products.

PARTNERSHIPS

In December 2010 mc10 announced its collaboration with sportswear firm Reebok, part of Adidas. Reebok has since been working with mc10 on athletics apparel that can exploit conformal electronics (see *+Plastic Electronics* 3.4).

The technology, which avoids bulky components as part of its 'conformal' approach, is progressing to market.

A wellbeing-related application is due for release



later in 2012, according to mc10 founder Rogers.

'The technology is a dramatic improvement on the devices available today. People don't like hard electronics that are pushed against the skin,' he remarks.

'Upcoming products could involve some of the "tattoo" technology we've worked on.'



THE CIRCUITS' FILAMENTARY SERPENTINE SHAPE ALLOWS THEM TO BEND, TWIST, SCRUNCH AND STRETCH WHILE MAINTAINING FUNCTIONALITY

PHOTO: JOHN ROGERS, UNIVERSITY OF ILLINOIS

MC10'S CONFORMAL ELECTRONICS

mc10's 'conformal electronics' aim to combine the flexibility of organic electronics with the high performance of inorganic semiconductors.

The start-up combines high-performance semiconductors with its own interconnect and packaging technology.

The devices are also designed to suit standard CMOS production facilities, enabling quicker scale-up of part of the manufacturing process.

The technology is being targeted at markets including medical devices and tools, cosmetics and sportswear. The company is also exploring military applications, where lightweight, flexible power sources (such as rollable solar panels) and integrated communication devices would allow soldiers to minimise the weight and volume of the apparatus they need to carry.

In the meantime, the company has organised a sports advisory board of NFL, NBA and other professional sports veterans to inform the development of its athletic apparel products.

MEDICAL

Alongside its progress in the sports and wellbeing markets, mc10 has also made advances in some longer-term medical markets. In

January 2012 the company attracted \$2 million (€1.5 million) investment from Aberdare Ventures, a venture capital business focused on technology for healthcare. Applications in this area are expected to come to market around 2014, according to Rogers.

'We've tried to create electronics that have the same form as biological structures, that curve like the skin, or the surface of a heart or brain,' Rogers remarks.

'A device on the heart or brain could be used clinically for diagnostics during surgery, noting signs of conditions like epilepsy or arrhythmia.'

In terms of wearable tattoos or patches, mc10 has noted particular interest in the cosmetics market.

SKINCARE

'On-skin devices are getting some traction in skincare, bringing products onto the facial region. This area can provide interesting diagnostics on hydration levels,' Rogers explains.

'People care about their skin, so they're interested in devices that can inform

Semi-conductor companies like Texas Instruments and Intel want to get into wearable electronics



WEARABLE ELECTRONICS WILL ULTIMATELY NEED TO BE ABLE TO DEMONSTRATE STRETCHABILITY, WASHABILITY AND OTHER FEATURES IN A SIMILAR PROFILE TO TEXTILE MATERIALS
PHOTO: JOHN ROGERS, UNIVERSITY OF ILLINOIS

Work on patches and tattoos will show that wearable electronics are more than a hobbyist's pursuit

them on relevant products. We're now interacting with global cosmetics companies.'

Whereas the medical sector requires more time to gain approval, non-invasive cosmetics products like a facial attachment for skincare purposes could be taken to market more quickly. Rogers predicts a commercialisation in this field in Q4 2012 or Q1 2013.

INDUSTRIALISED

With a range of wearable electronics applications set to come to market in the near-term – some of which will exploit the advances made in on-skin technology – the commercial appeal of inks and materials from the likes of Bare Conductive will become more apparent. Wearable technologies may become industrialised, moving from their current hobbyist phase, which is exciting but small-scale.

'Many companies are engaged in this field, both small and large. Semiconductor

companies like Texas Instruments and Intel want to get into wearable electronics,' notes Rogers.

LONG-TERM

Companies like micro have been able to progress by combining higher-performing inorganic electronics with the conformal nature of flexible, stretchable organic devices.

Some of the more familiar wearable electronics applications, like clothing with integrated sensing or communication tools, will need further work though.

The applications being pursued by micro, like hydration tests and medical care, are one-

time-use products. To break into the markets for multiple-use products will mean dealing with the familiar problems of wear and tear, and washability.

'The challenge is less to do with the individual components of a wearable electronic device and more a systems issue – the wear and tear related to the mechanics of a worn product,' Rogers admits.

While the technology will take time to reach the level of maturity needed for multiple-use items like clothing, work on patches and tattoos will show that wearable electronics are more than a hobbyist's pursuit. +

BARE PAINT

Alongside its work on wearable paint, Bare Skin, Bare Conductive has made materials available for the simple application of conductive ink on printed media. Bare Paint has been developed to provide enthusiasts and potential integrators to test the possibilities of combining conductive ink with electronic components on substrates like paper and card.

A wealth of demonstrators can be seen via the Bare Conductive community webpage, such as greetings card designs using integrated electronics.

Johnson remarks: 'The off-body product is on sale and there is a huge amount of interest in that. Most of the focus at the moment is on off-body applications.'

A demonstrator integrating Bare Conductive's ink was recently developed by Novalia. Paper postcards were created integrating electronics to store music clips. Cards could be placed on a speaker stand to play the music.

The technology was demonstrated at the US South by Southwest Festival in Austin, Texas (see **The art of printed electronics**, p.48).