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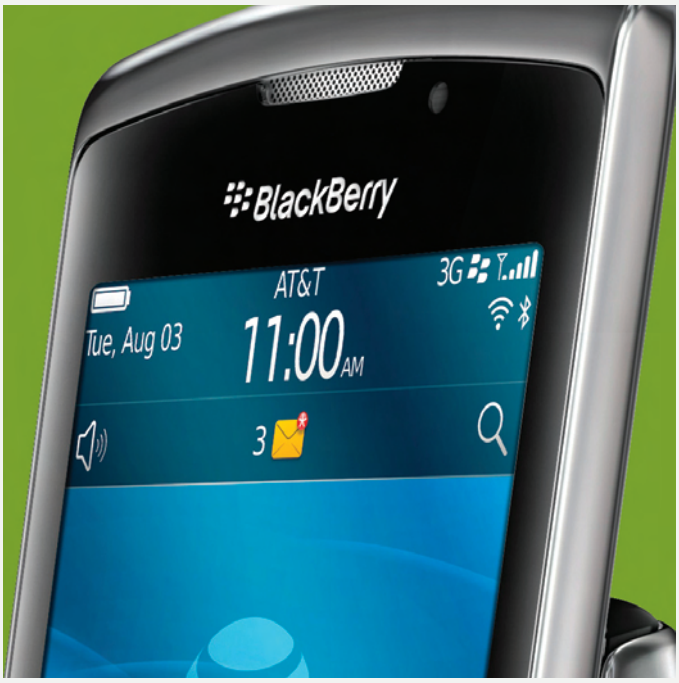
Plastic ELECTRONICS

BUSINESS AND MARKET STRATEGIES FOR ORGANIC AND PRINTABLE ELECTRONICS



CLEAR ADVANTAGE

NANOELECTRONICS ARE MAKING A COMMERCIAL BREAKTHROUGH IN TOUCHSCREENS

+Plastic ELECTRONICS

– market strategies for organic and printable electronics

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RETAIL READY

Graphene is beginning to revolutionise the market for plastic electronics

When Andre Geim and Konstantin Novoselov were awarded the Nobel Prize in Physics in 2010 for their discovery of graphene, an ultra-thin carbon material with extraordinary properties, the possibilities were staggering.

Graphene performs as well as copper when it comes to conducting electricity; it is the best known conductor of heat; is transparent, but incredibly dense; and is both the thinnest and strongest material known.

Though the research by Geim and Novoselov was published in 2004 in Science, the Nobel Prize brought the technology to the wider public's consciousness. Heralded for its potential to revolutionise the design of computer chips, consumer electronics and solar cells, as well as composite materials for cars, aeroplanes and satellites, the impact of graphene's introduction into industry was expected to be widespread.

The fact that graphene's possibilities overlap so much with the opportunities for plastic electronics underlines how important a role the material could play in the future of printed and organic electronic products. Thanks to its properties – particularly its electrical conductivity – and the plentiful supply of carbon, graphene promises to be an integral part of the plastic electronics toolkit of the future.

CONDUCTIVE INK

'Graphene offers excellent conductivity, but there are other advantages over materials like silver in conductive inks: price is one, and flexibility is another – the materials can be wrinkled or crumpled without harming the function,' says Kristen Silverberg, COO of US firm Vorbeck, a developer of graphene conductive ink.

'In plastic electronics there are lots of target areas, where applications need reliable performance, low cost, high conductivity and flexibility. This segment has enormous potential.'

The company has been preparing its conductive graphene ink, Vor-ink, for a significant commercial application in smart packaging during the course of 2011. At the beginning of 2012, security-enabled smart packages are set to appear on the shelves of some of the biggest retailers across the US, according to Michael Wade, global technical director of Natralock, a secure packaging solution, for global packaging supplier MeadWestvaco (MWV).

'We're working with a couple of major manufacturers and are beta

... graphene promises to be an integral part of the plastic electronics toolkit of the future.

THE SCREAMPAK, EMBEDDED WITH ELECTRONIC SECURITY TECHNOLOGY USING VOR-INK, WILL APPEAR ON US RETAIL STORE SHELVES IN EARLY 2012
PHOTO: WALMART

WORDS:
DAN ROGERS

THE NEW SCREAMPAK, WHICH USES VOR-INK TO INTEGRATE SECURITY-BASED CIRCUITRY
PHOTO: MEADWESTVACO

testing in a retail setting. In Q1 2012 this technology will be appearing in Walmarts, Targets and Home Depots.'

SECURITY

MWV has designed and produced a smart packaging label that envelops the product pack with a fully integrated circuit, in a product called Screampak. Two contact points are placed on the outside of the pack, allowing retailers to attach a thin and unobtrusive electronic module that completes the package's circuit. The module acts as a security tag: if it is removed, or the circuit is broken for any other reason, the electronic module will activate an alarm via an integrated speaker.

The smart packaging can also be coordinated with a retailer's in-store security system: if the electronic module passes through the security gates found at the entrances of many retail outlets, it will activate both the store's and the product's alarm. The only way to leave the store with the product is for the module to be safely removed at the point of purchase by staff.

Such technology is familiar in clothing stores; and chunky tags can be found attached to some premium products in stores. Sometimes smaller items, such as cosmetics, appear on shelves in clear plastic cases with security tags attached.

However the smart package allows retailers to integrate security simply and inexpensively, without compromising the design and accessibility of the brand owner's product.

'For over-the-counter pharmaceuticals, health and beauty products, consumer electronics, and other higher theft items, this is about making them more accessible by not having obtrusive devices attached. It's a very discreet system; it reduces store labour; it's very quick to connect; and the detachable modules are reusable, offering a lifetime of seven years,' Wade explains.

'Using commercial print labels allows the marriage of a circuit into a package to be more automated. It eliminates touch points and makes sure the pack goes together in a simple way.'

In Q1 2012 this technology will be appearing in Walmarts, Targets and Home Depots.

PRICE

The possibilities for smart packaging have been explored extensively by the plastic electronics industry. Security, animated logos and pack displays, integrated sensing technology and many other electronic functions have been considered and demonstrated by developers in the field. However the commercial application of smart packaging has so far been limited (see +*Plastic Electronics* 3.3, p.56).

One of the most significant barriers has been cost. Many packaging applications offer little room for manoeuvre with regards to additional cost per item, particularly where the electronics are disposed of after a product has been bought.

With the commercialisation of graphene conductive ink that situation has changed. Wade believes that graphene ink will not

only provide competition for materials such as silver inks; but will also make smart packaging innovations, previously held back by cost, a more feasible option.

'We worked on pharmaceutical packaging early on using a silver-based ink. This proved cost-prohibitive though. Then we came across Vorbeck's graphene ink, which was a game-changer for us, as the price point fell in line with what we needed,' he remarks.

The lower cost of graphene means that a greater proportion of products on retailers' shelves can add the new security packaging label. Although Wade cannot discuss specific products that will begin using the smart packaging in 2012, he says product ranges retailing above $30 (€21) in the US will be eligible.

For over-the-counter pharmaceuticals, health and beauty products, consumer electronics, and other higher theft items, this is about making them more accessible by not having obtrusive devices attached.

THE SCREAMPAK USED IN PACKAGING FOR AN ELECTRONICS PRODUCT
PHOTO: MEADWESTVACO

This cost-competitiveness does not come at the expense of performance.

US firm Conductive Technologies has been working with Vorbeck on a screen printable version of Vor-ink, with various printed electronics applications in mind.

SCREEN PRINT

'We primarily work with silver and carbon inks, but also use nickels and golds,' says Tim Stough, process engineer for Conductive Technologies.

'We found Vorbeck while researching graphene and requested a sample of the company's ink. We realised that it had some promise and began working on fine-tuning the ink for screen printing.

'Graphene holds promise for its low cost, but also for its performance. One of the

SECURE, SMART PACKAGE

The smart packaging innovation from MeadWestvaco (MWV) consists of a label that wraps around the product package containing unseen circuitry, printed with Vor-ink. A detachable, reusable and discreet electronic module completes the pack's circuit.

The electronic module includes a speaker and small LED, which flashes to indicate the pack is active.

If the module is removed or the circuit is broken, the integrated speaker will sound an alarm. If someone tries to conceal the product and leave the store, security gates will detect the module and will sound an alarm, as will the pack.

'Nine times out of 10 the person will drop the item if an alarm sounds,' Michael Wade, global technical director of Natralock at MWV, suggests.

The technology is an addition to existing security systems, albeit a less obtrusive and conspicuous offering.

'This is a line extension in security, giving retailers a cleaner option for packaging,' Wade adds.

One of the other major characteristics of graphene is its low cure or temperature processing, which opens possibilities in different substrates.

other major characteristics of graphene is its low cure or temperature processing, which opens possibilities in different substrates. For instance, graphene has potential for paper substrates.'

Conductive Technologies is planning to commercialise its screen print version in Q3 2011, although further versions will need to be developed for some higher-specification products.

'In screen printing there is still some bleed, or ink migration, as graphene has a tendency to want to migrate. So far it has been fine-tuned pretty well, but it is still there,' Stough notes.

Stough also suggests that finer materials will be required in ink formulations for some printed technologies: 'The resist levels are also still a little too high – we're working on getting the material down to finer mesh counts.'

The work with Conductive Technologies points to a range of future applications for printed electronics using graphene, from biomedical to new uses for integrated electronics. The company is a full print and assembly production firm that has been active in printed electronics from an early stage.

FUNDING

Vorbeck continues to develop partnerships to enhance the quality and application of Vor-ink. In

VORBECK AND ITS PARTNERS

Vorbeck Materials

Based in Jessup, Maryland, the US, Vorbeck Materials produces graphene conductive ink, called Vor-ink. The company was established in 2006 to commercialise research into a patented graphene material developed at Princeton University.

The graphene material, called Vor-x, is used in the company's Vor-ink solution, which is now being used in smart packaging products. The ink can be deposited using various printing methods, including gravure, flexo and screen printing. The ink requires no sintering and can be processed at low temperatures, making it suitable for substrates like paper, labels, and plastics.

Conductive Technologies

Conductive Technologies was founded in 1948, but became involved in the electronics industry in 1974. The US company, based in York, Pennsylvania, is a print and assembly production house, with a focus on printed electronics.

Conductive Technologies' current main product lines are electromechanical frequency interference or radio frequency interference shielding, flexible circuitry, membrane switches, panel overlays, printed heaters, and biomedical sensors and circuitry of all forms.

MeadWestvaco

Global packaging firm MeadWestvaco (MWV) provides products and services to brand owners, as well as producing its own consumer and office products, and speciality chemicals.

The company provides packaging for home and personal care products; consumer electronics; food, beverage and foodservice; healthcare; office supplies and more. Customers include cosmetics brand owner L'Oreal.

MWV, headquartered in Richmond, Virginia, the US, also has facilities in Brazil, India and China.

PRINTED BIOMEDICAL SENSOR ARRAY PRODUCT EXITING THE CURING OPERATION
PHOTO: CONDUCTIVE TECHNOLOGIES

January 2011 the company announced almost $2.8 million in series B funding from Fairbridge Venture Partners and Stoneham Partners, bringing total private investment in the company to more than $8 million.

'The primary purpose of the funding is to build a strong customer base,' notes Silverberg.

The company is working with a number of partners and customers on further testing for Vor-ink throughout the course of 2011.

'We're looking at smart cards, smart packaging, medical devices and other innovative products. In packaging we've seen both sensing and display functions. We're doing some testing now,' Silverberg adds.

Conductive Technologies notes that biomedical applications could arrive as soon as 2012. Although its forthcoming screen print solution will not offer the characteristics needed for printing biomedical devices, Stough believes improvements will be achieved to make graphene ink suitable soon.

'It could be 6-12 months of development for biomedical applications,' he comments.

'This could be blood glucose sensors, or DNA analysis or cell plate circuitry, for instance.'

RESPONSE

The company is focused on accurately depositing the conductive inks with screen printing in the coming months, to exploit the inherent advantages of a carbon-based ink.

'The surface area of carbon is a very important advantage,' Stough notes.

'Good surface characteristics mean that a biomedical device can function quicker. A blood glucose sensor could give a more precise and immediate reading.'

Finding an application in printed diagnostics could see millions of products manufactured, says Stough.

'Within five years we expect to be producing these on a regular basis,' he predicts.

Alongside other markets made possible by a low-cost conductive ink – Conductive Technologies is also working on interactive toys, based on integrating electronics for sound responses for drawing and colouring – the opportunities unlocked by graphene ink's low price point are huge.

In packaging, Wade is convinced that MWV's smart packaging will see rapid uptake from 2012.

'From the initial discussions we've had with customers there has been an overwhelming response – we believe it will have a very compelling market,' he states.

And graphene's rapid rise in the printed electronics industry is set to continue, says Stough.

He suggests: 'Its electrical properties are so far above and beyond many other conductive materials. As a conductive ink material, it has the potential to overtake silver.' +

VORBECK'S GRAPHENE INK, VOR-INK, COULD BE AN IMPORTANT TOOL FOR THE PRINTED ELECTRONICS INDUSTRY
PHOTO: VORBECK