

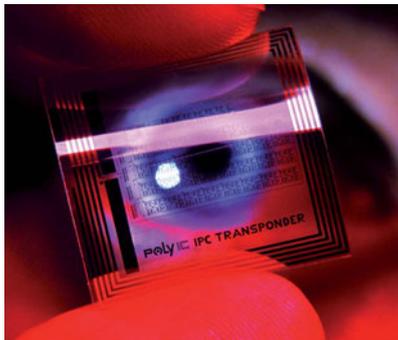
PRINTED ELECTRONICS

All the content that's fit to conduct

Electronics sprayed onto paper as part of a normal print run might sound more like science fiction than real world reality, but the pace of progress is blurring the gap. The limiting factor is less likely to be the technology but rather the familiar problem of translating that potential into profitable application.

The claims made for printed electronics are enough to make your head spin. According to manufacturers, the latest generation of circuits that can be printed directly onto existing materials (including paper) are transparent, inexpensive, robust, fault-tolerant, disposable, environment-friendly, biodegradable, reliable, accurate, and even edible. Research from IDTechEX values the print and thin-film electronics business at US\$ 1.18 billion today and predicts that it will grow to be a US\$ 5.06 billion industry by the year 2011 and become a US\$ 300 billion behemoth within 20 years. Printed electronics are already proving their worth in packaging where printing an RFID chip onto a product is fast becoming as easy and cheap as printing a barcode. The question is what can they do for newspapers? More on that in a minute.





Above: Model of a polymer flexible RFID tag. Left: By application of a roll-to-roll printing process, it is possible to produce large volumes of printed electronics, such as these RFID tags, at a low cost.

Photos courtesy of PolyIC

First, what is it?

Printed electronics can be printed directly onto polyester, paper, card, glass or steel. A wide range of electronics, including solar cells, mobile phones, RFID, and even displays can be applied in this way. The material best suited for a particular application depends on the process conditions, surface roughness, thermal expansion and barrier properties but barrier layers can be used to render otherwise unsuitable surfaces ready for print. The key is that in many cases not only does it use commonplace materials (card, clothes, etc.) but also that existing printers can handle the electronic "ink."

The technology

"Printed electronics" means the techniques used to print electronically functional elements onto materials such as paper and cardboard using traditional printing processes such as offset lithography, screen-printing, and gravure. The term is often used in conjunction with the phrase "organic electronics," which denotes that the electronic molecules being used are carbon based, rather than traditional inorganic conductors such as copper and silicon. That move to carbon molecules rather than copper conductors brings with it the flexibility to create "electrographic" inks that carry the conducting molecules in a solution. Printed in

the correct pattern onto a surface these conducting inks form circuits which in turn make it possible to print resistors, capacitors, RFID chips and even batteries. These inks can theoretically be used in any number of print processes though at the moment inkjet is the most popular delivery technology because it is the most forgiving of uneven substrates.

The newspaper question

Sci-fi fans already have an idea of what is to come. In the 2006 film "Ultraviolet," the model / actor Milla Jovovich punches a button on a vending machine to receive a cardboard phone she then folds to shape and makes calls with. Now in 2008 the US\$ 10 cardboard disposable phone is about to launch.

It's only a small leap to a more slimline version – say a single-use phone with a pre-programmed number – printed onto a newspaper page. That would give you an immediate response mechanism to an advert or a channel for citizen journalism. Combined with the concept of the RFID chip, in which the chip identifies itself using power drawn from an external reader and you could have a phone that automatically identifies itself, and its precise location. That location could easily be the news kiosk, the vending machine, or a store taking part in a promotion. Alternatively, an RFID voucher could be printed into a page meaning the reader automatically and seamlessly gets a discount at the till point – as long as they brandish their copy of the paper.

Printed battery technology already exists, albeit with limited power. It is enough however to enable medication packaging that reminds the user to take their pills and so if printed onto a newspaper it would allow such functions as simple voice messages (think of talking adverts, voice picture captions or quotes), or a mortgage calculator printed directly onto the page into which the user can enter their personal details with their fingertips.

The world of e-books has also introduced us to bi-stable electronic print which once displayed no longer needs power to

In a nutshell

What is printed electronics?

Electronic circuitry printed directly onto paper using existing printing technology but specialised "inks."

Hope or hype?

The technology is pretty well proven and the industry is set to grow hugely but the question remains as to whether it will be more than a gimmick for special advertising supplements.

Applications

Calculators, speakers, RFID chips, even telephones.

Key to media market acceptance

The speed at which circuitry "inks" reach an acceptable price point, the suitability for a wider range of printers (currently inkjet is the favoured technology), willingness of advertising clients to experiment with a new medium.

remain legible. Printing a panel of such electronics onto the page could potentially allow for sections of the paper that displayed one set of copy until refreshed (most likely by passing by the news vendor), at which they magically show updated content that then itself remains stable. With a little imagination, that



Klaus Hecker,
managing
director, Organic
Electronics
Association

"We found that the technology is mature enough to enter the market with first, relatively simple products, addressing interesting market segments. But we also realise that mass markets can be reached in the near future when the expected developments in the fields of material, equipment, processes and device design will be successful."

Translating into practical printing



Professor Rajendrakumar Anayath is head of the Print Media Academy in India.

IFRA: How will graphic presses have to be developed?

Anayath: Graphic presses do not have to be specially designed to print electronic devices. Specialised drying systems are needed. Special inks for printed electronics are already available and research is on to further improve them. Inking roller composition has to be redesigned to suit the requirement.

IFRA: How will the printers of today's world adjust to these changes?

Anayath: They have to gain more application knowledge. The chemistry and engineering behind the technology has to be well understood. The days of the skill-based print industry are ending and it will be knowledge-based from now on. The printer has to understand this and change accordingly. If he is not willing to do this, he will not be able to compete in the international market.

could have applications for competitions, or for self-updated news, such as daily financial reports or sports statistics.

Printed electronics won't transform the humble newspaper into an e-book – that would be too costly and complex, not least since there are limitations with such features as memory, meaning that it is currently hard to picture a newspaper storing any complex electronic content on its pages. That said, if prices continue to drop and applications prove their reliability, printed electronics could be bringing a new dimension to newsprint near you sooner than you think.

First applications

Disposable-battery testers integrated into the product or packaging were one of the first widely used printed-electronics applications. You've probably seen them yourself on Duracell AA batteries which show how much "juice" the battery has left by a charging indicator printed on the battery which becomes visible when you squeeze the two ends of the battery between your fingers. The Swedish company Cypak produces "smart" pharmaceuticals packaging that checks whether the user is taking their medication. The Cypak IPP (intelligent pharmaceutical packaging). The system records the time

and number of pills removed from the package and only has to be placed on a Cypak reader to confirm those details. The package can even prompt a patient that it is time to take medication or ask and record the answers to simple questions about symptoms or state of mind.

Electronic paper is another area likely to be affected by advances in printed electronics. Electronic paper works on the principle of microparticles which form patterns when charged in certain ways. Being what is known as bi-stable they hold these patterns until/unless they are recharged again in a different way that makes it possible to have a surface that displays certain information but can be updated by recharging it. Printed electronics offer the promise of making electronic paper out of existing materials



Klaus Schmidt,
director marketing,
KBA

"Printed electronics in newspapers is still far away from the technical and cost point of view.

However, if a practical solution can be found in the foreseeable future it could strengthen the interactivity between printed and electronic media."

including, conceivably, a newspaper page. Existing presses are capable of handling the required materials, for example, MAN Roland offset presses are able to produce micro-structures. These structures can be precisely reproduced at high speed using conductive or standard inks on PET films by Mitsubishi Polyester Film that enhance printing by using special primers.

Early adopters

There are about 1500 organisations working on printed electronics, 50 percent business and 50 percent academic. Some of the major organisations researching and developing the technology include IDTechEx, Motorola, Hewlett Packard, Matsushita, Canon, Konica, Minolta, Hitachi, Pioneer, IBM, Xerox, Samsung, DuPont, Eastman Kodak, Siemens, Philips, BASF and many other giants, as well as (as yet) lesser known names such as Plastic Logic and Printed Systems. T-Ink, a pioneer in the field, is using printed-ink, touch-activated applications to put switches, lights, buttons, and speakers onto educational children's toys.

The future

Although printed electronics may not reach the sophistication of silicon-based circuitry, many applications exist in which adding electrical components can create new markets. The beauty of printed electronics is it lends itself to mass-produced items and so raises such possibilities as interactive communication between product packaging and "smart" newspapers.

According to a roadmap charted out by the Organic Electronic Association (OE-A), Germany, new possibilities for applications and products in printed electronics include organic photovoltaic cells for mobile and stationary use (first commercial applications likely this year); organic memory devices for consumer use (with larger storage capacity and non-volatile random access memories); printed RFID for brand protection and logistics (will soon develop into RFID tags for automation); flexible batteries to power mobile

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devices (will be improved in capacity and integrated directly in textiles and packages); organic TFT backplanes for displays (large-screen colour displays based on OLED technology is the future); and organic sensors for single-use devices (will be combined to embedded systems enabling intelligent sensor systems). Some of these applications can be combined to become smart objects such as an animated logo, large-area game boards, or smart cards. Products such as a mobile phone with a rollable display, or flexible solar cells are in development. On the health care front, printed electronics could be used to automatically deliver drugs via smart skin patches with sensors.

While the predictions for the future stray, inevitably, back into what is currently science fiction territory, it is important to note that many of those prognosticators accept that applications based on flexible paper or polymer substrates offer the biggest opportunities for printed electronics because of low cost and large volume. Which means that while it could be some time before your pants power up your iPod, the electronically-enhanced newspaper could be among one of the earlier offerings of this burgeoning industry.

Sashi Nair (sashi@ifra.com) co-ordinated this report, and Dean Roper and Steve Shipside contributed.

Web references

More on this Flashlight

www.ifra.com/flashlight

Printed Electronics World

iframagazine.com/electronics/ref1

Ink on the brink

iframagazine.com/electronics/ref2

Printed Electronics market

iframagazine.com/electronics/ref3

Organic Electronics Association

iframagazine.com/electronics/ref4

Beyond graphic communication

Manfred Werfel
Director of Research, IFRA



At the annual conference of the IARIGAI research organisation last fall, one of the speakers said there exists a single area in printed electronics that can be used today to earn a lot of money: organising conferences on the subject of printed electronics. All other applications are still a long way away from any economic utilisation. This rather ironically, but accurately, describes the status of this still young, but rapidly developing area of research.

For 500-plus years, printing served to distribute graphic information. Besides graphic communication through text and image, the last decades have seen the development of electronic communication, initially on magnetic data carriers, then online via the Internet, which is entering its mobile stage. And suddenly, it emerges that it is indeed possible to produce electronic means of communication with the aid of printing.

Besides the graphic level, other levels of communication technology have emerged in printing – new and unaccustomed. Electronic and sensor modules, storage media can be printed today, at least on a test scale and under laboratory conditions. There exist RFID tags whose antennae are printed. Even batteries of active RFID tags with a relatively long range can be printed today. Two years ago, I had the opportunity to toy with the prototype of a games keyboard printed on a Cornflakes box. First videos of printed colour displays are now being shown at conferences. The trend in development points to a situation in which it will be possible in future to print increasing numbers of electronic components, encouraging researchers to envision a day when all components required to build computers can be printed. Naturally, today's presses are not

optimised for printing electronics, but for printing graphic information with a resolution of 80 lines per centimetre. The register precision of conventional presses has not yet reached the required level to produce miniaturised multi-layer processors. In addition, today's design of electronic and sensor components is not suitable for their production by printing processes. So there is still a lot of work to be done.

This coming together in the development of printing and electronics could culminate in the beginning of an entirely new information technology with standard devices produced at unimaginably high speed and low cost. Computers could become products for one-time usage. Electronic devices would be inserted as ad supplements into magazines and newspapers. We could have electronic identification chips glued to packaging and used to control the entire value added chain. Information tags on the products would draw users' attention to special characteristics or recommend buying similar products. And much more.

Newspaper specialists and printing plant managers should investigate the new developments in the area of RFID tags, which are becoming increasingly cheaper and more efficient. This brings us closer to the day when these successors to the electronic barcode will be used throughout the entire production logistics chain. IFRA has published a Special Report (04.2006) on this subject, and will continue to monitor this. In future, greater numbers of low-cost electronic components will be used in application technology. Then new forms of advertising based on printed electronic components and new distribution control methods will become feasible.