

Printing the electronic future

Printing of electronics is an escape route opening up for some in the troubled printing industry. It involves many passes of very different new inks such as fine silver conductors, ceramic dielectrics, copper doped phosphors, and both organic and inorganic semiconductors and passivation layers. It uses improvements to many different printing technologies and it will be an industry of hundreds of billions of dollars yearly within twenty years, creating from disposable ubiquitous lighting and electronics, moving colour billboards, wallpaper television, electronic books and more.

By Dr Peter Harrop
IDTechEx, Cambridge, UK
p.harrop@idtechex.com

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In the USA, much of the printing industry is in free fall as a result of the internet and changing lifestyles. For example, the young prefer television, the i-pod and the computer to the newspaper or magazine. There is some growth in sectors of the packaging industry such as polyester packaging and in the labelling industry in the form of self-adhesive labels but neither of these industries is particularly prosperous either. Printing spans them all. For example, only 5% of barcodes are created in the form of labels any more. Instead of the label industry providing a barcode applied to packaging and products, the barcode is now printed directly at almost zero cost when other printing takes place. Feeble pickings there for the industry.

So are the centuries of sophisticated development of the science and production technology for printing ending in a whimper? Are the ink makers, machinery suppliers and others variously specialising in flexo, litho, ink jet, screen, gravure and other technologies looking like the steam engine experts of one hundred years ago? The answer is probably not. Certainly there is a fascinating escape route opening up for some. It is the printing of electronics.

The argument goes like this. The silicon chip is the clever bit of almost everything electronic. It subsumes transistors, diodes and many other small components and the myriad of wires, connections and therefore failure modes previously involved. By making the features on the chip smaller

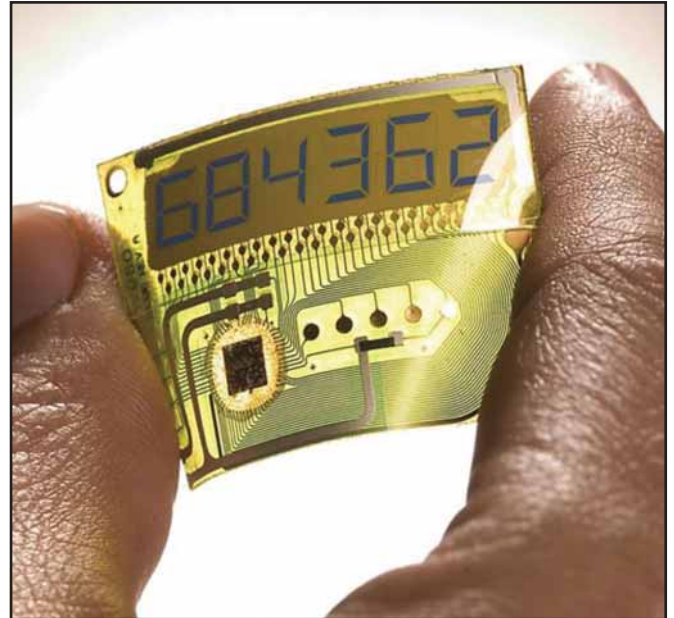


Figure 1. Aveso flexible printed electrochromic display with printed interconnects and battery. The logic is a silicon chip until the printed alternative is available.

and smaller, more and more complexity can be provided with little or no increase in cost. However, the silicon chip has subsumed all it can and that means that it has to be connected in the good old fashioned way to large components such as displays, batteries, actuators, antennas and even the larger capacitors and resistors. This is all with added cost and plenty of failure modes in the interconnects. Indeed, the size of the finished device exhibits no benefit from the smallness of the chip and that may mean it is too large for the required purpose such as smart packaging.

There is more. The cost of the simplest silicon chips has not changed for decades and the exponential increase in cost of chip making factories - now three billion dollars each - and of the cost of supporting

research and development bodes ill for the future. We need disposable thin electronics for a myriad of things from smart skin patches that deliver drugs without error, disposable blood, insulin and pregnancy testers with clear human interfaces, self-adjusting use by dates that take note of whether we opened and/or heated the food or medicine, wallpaper television, controllable wallpaper lighting and so on. It would be safer if the whole of the outside of a car glowed in the dark and that surface doubled as large indicator lights and so on. The laminate across the whole of the outside of the car could all flash red in an emergency, having stored its power from the sun. The silicon chip is a poor route to all of this. While silicon chips are used for energy production in the form of photovoltaic panels,

these brittle structures are not leading to the kilometres of low cost electricity generating tape we need down motorways and on buildings. In short, we need much cheaper, more flexible, thinner electronics and electronics combined. We need printers.

It is true that making silicon chips involves so-called photolithography but that is an optical and etching technology that has nothing worthwhile in common with the printer's reel to reel lithographic process. The new form of electronics and electronics commonly called printed electronics involves modification of existing forms of flat bed, ink jet and rotary printing. All the traditional skills are dearly needed so we can truly have pervasive electronics in our clothing, packaging, books, medical treatment and much more besides. Printed electronics will kick the silicon chip out of the talking gift card as well as the discrete components and wires to which it is attached. But that is the least of what it will do.

The film Minority Report showed it giving us the moving colour display and voice over on the cornflake packet. Interactive games on disposable paper packaging have already been demonstrated in real life but more serious uses will also drive printed electronics forward.

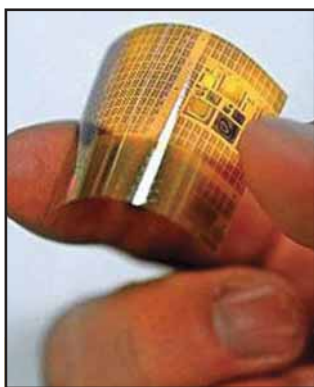


Figure 2. Printed memory of 100 MB and potentially 1 GB .Source - Thin Film Electronics AB

Table 1.

Company	Application	Printing technology	Status
Omron	Antennas on high volume RFID labels	Gravure	In production
ACREO MeadWestvaco	Chipless RFID RFID enabled packaging recording time and amount of medication taken	Screen Screen (sensors and interconnects)	In trials In production
Sony	Keypads	Screen	In production
Dai Nippon Printing	Organic Light Emitting Diode OLED moving colour displays on flexible substrates	Gravure	Experimental
Aveso	Electrochromic colour displays	Screen	In production for gift cards, smart cards etc.
Avery Dennison	Chipless battery testers in Duracell batteries	Screen	In production
Thin Battery Technologies	Printed CZn batteries	Screen	In production
PolyIC	Chipless transistor circuits on flexible substrates	Flexo, gravure and litho	In trials as RFID
Plastic Logic	Chipless transistor circuits on flexible substrates	Ink jet	In trials as active matrix backplanes for printed flexible displays
Elumin8	Moving colour electroluminescent billboards using thin flexible plastic	Screen	In production
Power Paper	Iontophoretic skin patches for delivery of cosmetics and drugs	Screen	Licenses in production soon
VTT Technology	Thermochromic displays, switches and interconnects in games on paper packaging	Screen and other.	Prototypes demonstrated

Source IDTechEx

So how is it progressing and how is the printing industry getting involved? The table below gives some examples including large flexible moving colour billboards that replace conventional printing with something more compelling. Later the same will occur with most packaging. The printing industry therefore has both carrot and stick to make it take an interest in these new applications of printing.

In most of these cases we are talking about many passes of very different new inks such as fine silver conductors, ceramic dielectrics, copper doped phosphors, and both organic and inorganic semiconductors and passivation layers. Low temperature curing, better definition, thinner layers and continuity are among the challenges. However, well over ten billion such constructions, mostly on polyester film or

paper, have already been sold and the potential goes all the way up to ten trillion barcodes

being replaced with printed chipless RFID every year. Yes, the barcode replacements will

Table 2.

Partly printed tags for items	\$4.4 billion
Fully printed tags for items	\$1.1 billion
Partly printed tags for other uses	\$3.55 billion
Tags without printing, for other uses	\$1.8 billion

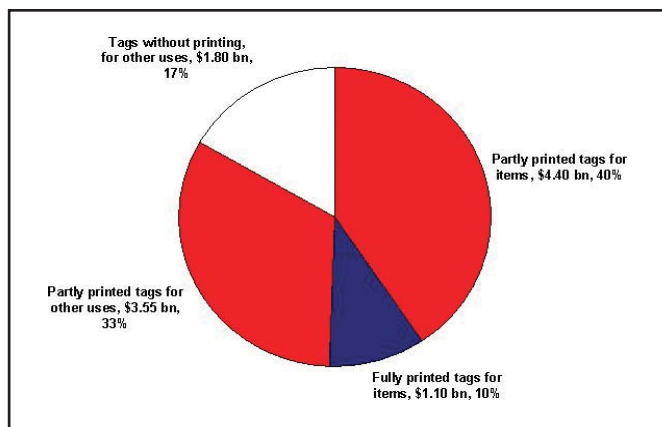


Figure 3. Projected global market for RFID tags 2016. Source IDTechEx.

mainly be printed directly onto things - the money will not stretch to labels in those volumes.

Below is the IDTechEx projection for the global market for RFID in 2016 in billions of dollars with the impact of printing technology.

Little wonder then that the suppliers of traditional printing inks such as Sun Chemical and the manufacturers of traditional high volume printing equipment such as MAN Roland are heavily into the printed electronics world.

They know that it will go far beyond silicon and be a far bigger market eventually, encompassing even laminar fuel cells and antistatic shielding and its impact will be mainly in creating new markets, not replacing silicon. In fact, the silicon chip industry, like the button battery industry, may not notice being kicked out of gift cards. They have other things to do.

Dr Peter Harrop PhD, FIEE, FCIM is Chairman of IDTechEx Ltd. He was previously Chief Executive of Mars Electronics, the \$260 million electronics company and Chairman of Pinacl plc, the \$100m fibre optic company. He has been chairman of over 15 high tech companies.

He has written 14 books on technical subjects, these being published by the Financial Times, John Wiley and others.

He lectures and consults internationally on smart labels and smart packaging. Peter also specialises in electric vehicles. www.ev-data.com

To guide you through these various technologies and their application, IDTechEx will bring it all together at the second annual Printed Electronics Europe 2006 conference in Cambridge, UK on 20-21 April 2006. Printed Electronics World will be held in Phoenix on 5 - 6 December 2006 and Printed Electronics Asia in

January 2007. Please see www.printelec.com for more details or contact Chris Clare at c.clare@idtechex.com

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