The adoption of printed electronics technology

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Imagine you are a manufacturer. Your customer emails you a circuit component design with a few changes in a desired attribute and wants you to produce it for them. And, by the way, they need the first 100,000 components out your door tomorrow. Simple.
You print out the prototypes on your desktop printer, test them, send the data to your customer to confirm compatibility with the customer’s system, receive acceptance and alter your manufacturing line to produce these items by the afternoon shift, rolling them off your line by the hundreds of thousands per hour.

You have redefined JIT manufacturing and solidified your position as an ultra-responsive supplier to your customer base. Now imagine doing that for a myriad of different components, from RFID to printed circuit boards.

This scenario began Cima NanoTech’s editorial in Pira’s 2005 Profit Through Innovation publication. The editorial outlined the major value propositions driving the shift towards additive, rather than subtractive, manufacturing methods. In particular, there was a specific focus on items relating to printed circuit boards, RFID and electronic displays. It pays, one year later, to look at the progress made in the move towards actualisation of this value proposition, the mainstreaming of printed electronics manufacture and the activities of the past year contributing to the widespread adoption.

These activities include:

- A convergence of different industrial skill sets into joint activity;
- The development of standards and protocols to communicate a common language for certain portions of the value chain;
- The advancement of ‘real world’ testing and development to facilitate the move towards production floor action.

As we move forward, it is important to keep in mind that the development of printed electronics does not follow a step function model. Rather, it is one that will be introduced more and more as the value proposition matures and components, such as materials, become more readily available to enable the widespread adoption e.g. RFID tags are being used today in a variety of applications, but the move towards the ultimate goal, that of item-level tagging and tracking, still requires significant work to become reality. The focus of this piece is on the ‘ubiquitous’ adoption of printed electronics technology.

Convergence of skills
The first piece, the convergence of the different industrial skill sets into joint activity, is occurring as technology, in particular items surrounding nanotechnology, mature. Companies are solidifying their value proposition, and therefore are able to better understand the skill sets needed to complete the offering suite to show electronics OEM a practical and realisable approach to the value proposition. This can be seen very clearly, especially in arenas like digital manufacture of circuitry. Inkjet head manufacturers are teaming with materials providers and system integrators to more efficiently solve the challenges facing the digital manufacture of circuits and bring a solution to market in the most efficient manner possible. This is starting in areas such as quality control and pinpoint circuit repair, gradually moving forward into the actual electronic equipment manufacture. In the case of higher-speed gravure printing processes, OEMs are looking at the close collaboration between gravure cylinder manufacturers and material providers in order to understand the best configuration/design of the cylinder to enable the fine feature printing demanded e.g. to enhance the printed electronics value proposition.

Standardisation
The second item that is driving printing of components towards the mainstream of electronics manufacturing is the standardisation of testing protocols and procedures to enable OEMs and supply chain participants to be speaking a common language with reference to product characteristics and attributes. Quite a bit of these efforts are focused on the novel materials that can enable the widespread adoption of printed electronics manufacture. ASTM has significant efforts underway to define the characterisation protocols to dictate how these materials are tested and understood, and more industry-specific efforts like SEMI and IEEE have standardisation work groups focused on the development of these standards.

An example of this is IEEE’s recent announcements concerning the standard characterisation of carbon nanotubes.

This standardisation effort is certainly not confined to North America. The Pacific Rim, seat of the leading OEMs of electronic components, has significant efforts underway, along with the European Union, so that we are increasingly speaking one global language when it comes to printed electronics evaluation. Once the electronics are manufactured there is also the need for standardisation in the global ‘languages’ spoken by the information infrastructure to enable the widespread adoption of printed electronics. In RFID, for example, the ability of an item to be read and to communicate information to readers in the Kansas City Airport must be the same as the ability to read the same information when the package arrives at Tokyo’s Narita Airport. This is just one example of the global necessity to speak a common ‘language’ on most facets of electronics manufacture, from the basic materials that are used to make the end product to the final shipping and usage of the products, and the electronics involved in those supply chain steps as well.

Detailed qualification

The third important effort underway is to understand the ‘real world’ operation and behaviour of electronics that are printed. The most basic tests of electrical conductivity and other attributes that get you in the door towards qualification are evolving to encompass all aspects that make something ‘manufacturable’. These include, amongst others:

- Component lifetime testing;
- Shelf life of materials;
- Temperature and humidity environmental testing;
- Industry-specific characteristics (e.g. optical qualities in the display industry).

One of the most important facets of this effort is the evolving drive to understand not just how a manufactured component behaves in isolation, but how it behaves in concert with the other materials and processes necessary for the final product. For example, nanomaterials are offering new opportunities to enable low-cost substrates, higher performance and reduced overall system costs, as outlined in last year’s editorial. But how do these materials perform when they are connected to restive circuits, chips, busbars (and the like) that are necessary for a fully-functioning printed circuit board? These items, such as contact resistance, shrinkage and other factors, are necessary to determine and to be accounted for in order to realise the believed value proposition of widespread printed electronics adoption. The materials and manufacturing are now moving to this stage and beyond, driving the value proposition of mainstream printed electronics forward.

All this can be summed up to say that the move towards printed electronics as a replacement for subtractive manufacturing processes and the introduction of novel materials into current printed electronics manufacturing is getting into the nitty-gritty details of what it takes to actualise the potential of lower-cost systems, digital anufacture, finer resolutions and new capabilities enabled by novel materials. Markets such as electronic displays, RFID and printed circuit boards are moving past the prototyping stage and into beta testing and beyond. The significant investment that continues in printed electronics is paying off, and industry forces are picking up steam to deliver these next generation solutions to market today. The expectations are being honed and forecasts are being detailed, all leading towards market introduction that will enable the scenario outlined last year and repeated at the beginning of this article to, once again, not be not so fanciful after all.