nanoWorldnews™

NOVACENTRIX™

REPRINT from 23 Feb 2009

Printed Electronics Development and Manufacturing is Accelerated with Nanotechnologies from NovaCentrix

Designers have more options for cost and performance

Feb 23, 2009

By Stan Farnsworth, NovaCentrix

In comparison with traditional circuit manufacturing, the appeal of printed electronics is strong. The use of additive printing methods to deposit the functional electronic materials only where needed allows the use of low-cost flexible substrate materials such as polymers and even paper. Especially in comparison with traditional etch-based subtractive manufacturing, printing electronics is also very environmentally friendly. And while subtractive manufacturing processes are well understood and entrenched in industry, so to are printing methods including inkjet, screen, flexographic, and gravure. From both efficiency and environmental aspects then, printed electronics as a manufacturing method is very compelling.

The value potential of current and future products produced by printed electronics methods is in the hundreds of billions of dollars, and the dollar investment in efforts to reach that potential has also been significant, across a number of markets. Entire new generations of thin film, flexible photo-voltaics, low-cost and adaptable RFID tags, new flexible displays, and even smart, functional packaging are predicated on the availability of new materials and manufacturing techniques. Product visions range from solar cell panels that are unrolled when needed (some are already on the market!), semi-disposable cell phones and media players that are seamlessly woven into fashion clothing, light-weight durable high-definition displays that can be rolled up and easily transported, and even new space flight vehicle designs incorporating light-weight control systems.

Creating and Printing Functional Inks

In reality, though, several challenges must be overcome before the promise of widespread macro-scale additive manufacturing can come to fruition, enabling new classes of functional electronic products. Nanotechnology is a primary enabling vehicle for helping to overcome these barriers.

For starters, printed electronics requires printable electronic materials. Conductors, semiconductors, and dielectrics must be in a form that can be rendered into inks to be applied using print methods such as inkjet, screen, flexo, and gravure. Inkjet printing is especially desirable for many applications due to the precise ink placement possible as well as the versatility provided by the ease of changing the print patterning. The challenge with inkjet printing is to keep from clogging the inkjet nozzles, which can be 50 microns and smaller. The largest particle clusters must typically be less than 1/10 of the nozzle diameters, and the smaller the better. Not only are nanoparticle inks required, but additional anti-agglomeration agents must often be employed to keep the agglomerate sizes below the clogging thresh-hold.

Processing Printed Inks

Even nanoparticle inks, however, must ultimately have excellent particle connectivity after printing in order to achieve what is the ultimate goal of functional inks: functionality! The ink particles or flakes must establish effective physical connection with one another after printing on the desired substrate. The problem is that this need is in direct conflict with the requirements of printability. Printable, stable inks are formulated in a carrier fluid such as water or alcohol, typically have a stability additive to control settling prior to use, and may even have additives to promote adhesion to the target substrate. Not only are these components required for the printability of the ink, they are used precisely to keep the particles from coming into contact with one another and thus are in conflict with the inks final performance requirements.

Thermal Mismatch
Heating the inks to drive away the formulation components leads us to yet another adoption barrier for printed electronics. Substrates used for printed electronics are often not capable of withstanding the high temperatures required for driving away the ink formulation components. One common substrate, PET, is capable of sustained temperatures of only ~150oC. If processed at these reduced temperatures, inks typically cannot achieve compelling performance.

Nanoparticle-based inks take advantage of depressed melting temperatures to achieve a sintering response, and so can in some ways overcome the thermal limitations of polymer or paper substrates. Temperatures as low as 150oC are sometimes cited as being sufficient for reaching some level of sinter-enhanced conductive performance. Even with such nanoparticle inks, however, much higher temperatures are still needed to achieve maximum conductivity- temperatures beyond the reach for many substrates.

NovaCentrix Solving Problems with Nanotechnologies
NovaCentrix has developed specialized responses to address these issues for printed electronics, drawing on the company's nanotechnologies expertise. MetalonTM JS-015 silver-based inkjet ink from NovaCentrix solves the inkjet printabilty problem through a combination of ultra-fine particle sizes (<25nm average), special particle manufacturing methods to reduce the silver clustering tendency (<40 nm average), and the addition of friendly formulation components to maximize the printability of the ink. The result of using nanotechnology in the ink is a high-conductivity, workable inkjet ink capable of printing on a wide range of porous and non-porous materials.

NovaCentrix addresses the need to process printed inks by providing another major printed electronics product set: the PulseForgeTM family of processing tools. The technology of these tools is derived from the method NovaCentrix uses to produce nanoparticles, and so has nanotechnology roots. PulseForge tools very rapidly heat the printed inks to very high temperatures- enough to drive away the volatile solvent carriers used in the inks, such as water, alcohols, or even ethylene glycol as for screen inks. Considering that the carrier can be as much as 90 mass % of an inkjet ink, the carrier removal is non-trivial. Additionally, PulseForge tools heat the inks enough to drive away the surfactants, stabilizers, and excess adhesion agents. The result is maximum particle-to-particle contact, and optimized functional response in the final product. In this way, the use of PulseForge tools allows the inks to be formulated for maximum printability, and still enables the inks to reach maximum functional performance.

The PulseForge tools from NovaCentrix also resolve the ink/substrate thermal mismatch problem. The tools isolate and heat printed inks, even on low temperature substrates like PET and paper, to high enough temperatures to remove the organic formulation components and leave only the inorganic functional components. In fact, PulseForge tools have the capability to ablate even the metal or semiconductor ink components right off of the low temperature substrate, far beyond the temperatures actually needed for optimum electronic functionality.

The PulseForge tools are capable of drying, sintering, or annealing roll-to-roll web-based materials at line speeds greater than 100 meters per minute, and with the release of the PulseForge 3300 in 2009, will be able to attain speeds approaching 300 meters per minute. The tools improve the performance not just of the Metalon inks, designed for use specifically with the PulseForge tools, but also for any functional electronics ink. The use of the fast-acting PulseForge tools also allows product designers to use copper-based inks, which are typically performance hampered because of the oxidation that results from traditional oven processing. In this way, the tools are directly enabling the fully scaled manufacturing of advanced printed electronics devices.

The Metalon inks and PulseForge tools from NovaCentrix are two examples of how nanotechnology resolves fundamental challenges facing printed electronics and creates value for designers and manufacturers of next-generation products. So be on the lookout: these next generation products are closer than you might think!

About NovaCentrix.
NovaCentrix, based in Austin, Texas, is a leader in emerging printed electronics manufacturing technologies. Their PulseForgeTM process development and manufacturing tools sinter functional inks in milliseconds, including on low temperature, flexible substrates such as paper and plastics. PulseForge tools can process a wide array of metal-based conductive inks, as well as non-metallic and semiconductor inks. NovaCentrix also offers MetalonTM metallic inks, specially suited for maximum performance with PulseForge tools.

PulseForge 3100

For more information about NovaCentrix, Metalon inks, and PulseForge tools, visit www.novacentrix.com or call 512 491 9500 x210.