Making Inks for Printable Tags

Cabot Corp. forms a new business unit to develop conductive inks for creating printed RFID antennas and, eventually, entire RFID transponders.

By Mary Catherine O'Connor

Aug. 3, 2004—Cabot Superior MicroPowders (CSMP), a business unit of Cabot Corp., launched a printable electronics business, Cabot-PEDs, at its Albuquerque, N.M., facility in January.

Printable electronics are items such as antennas and transistors that can be formed using conductive inks and polymers, rather than etched or subtracted, from pure-metal materials such as copper or silver, or silicon. In the coming years, printed antennas made with conductive inks will likely replace the solid-copper antennas used in RFID tags on a large scale, offering tag makers a tremendous savings in production. In the longer term, printable electronics could have an even more profound affect on the RFID industry by allowing for the full RFID transponder—antenna and processor—to be printed, and even produced straight into packaging or products.

CSMP was formed last year when Cabot, a $1.8 billion global specialty chemical and materials company headquartered in Boston, purchased advanced materials company Superior MicroPowers (SMP) in a $16 million deal. Aside from its work on printable electronics, CSMP manufactures and develops advanced materials for a variety of applications, including fuel cells and hydrogen generation. It formed Cabot-PEDs in order to streamline all of CSMP's resources to develop materials for printable electronics and printable display screens, which also have circuitry that is printed on instead etched or wired. Cabot-PEDs' mission is to develop, produce and sell materials and technology to enable the printing of low-cost disposable electronics, such as RFID tags.

RFID antennas are typically made by taking a sheet of copper and etching away the metal until you get to the desired thickness. This is an expensive, time-consuming process that creates chemical waste that is expensive to dispose of and harmful to the environment.

Printing antennas, instead of etching or stamping them, is not only less wasteful, it also could lower the costs of RFID tags down from 20 to 60 cents each to 15 to 30 cents each, with the potential for even lower costs as efficiencies increase. A printed antenna can also be attached to a microchip and turned into a complete transponder up to 10 times faster than transponders made with pure-metal antennas (see Start the Presses).

But printed antennas will be a viable alternative to etched ones only if the conductive inks being produced by Cabot-PEDs and other specialty-ink companies, such as Precisia, Paralec and Coates Group, will function in existing industrial presses, using established printing processes, such as roll-to-roll processes, screen, inkjet and thermal transfer. That's because the capital outlay required to install newer printing equipment would be too high for industrial printing companies to enter this market on a large scale, according to Toivo Kodas, who cofounded SMP in 1997 and serves as co-general manager of CSMP.

"We're not reinventing printing approaches; we're making materials that can be used in existing printers.

We're working on some low-cost printable conductors with performance that's appropriate to use in RF tags," says Kodas.

Cabot-PEDs is producing nanoparticle inks, for which Cabot holds a patent. This material contains metallic particles that are extremely small. When they're heated up, these metal particles essentially weld themselves together, forming a highly conductive ink. Other conductive inks are not as conductive, according to Chuck Edwards, formerly of industrial ink-jet equipment manufacturer Litrex Corp. and now general manager of Cabot-PEDs.

He says an ink DuPont makes uses thin silver flakes that lay on top of each other. The silver is not actually welded together, it's just being pushed together, according to Edwards. These inks require a binder, or glue, to bind the flakes. This binder lowers conductivity by insulating the flakes and restricting the flow of electricity from particle to particle. Cabot-PEDs nanoparticle ink does not require a binder, says Edwards. He also notes that the size of the flakes prohibit the DuPont ink from being used in ink jet printers, because the flakes would clog the printer. He says the nanoparticle ink that Cabot-PEDs is creating can be used in ink-jet printers.

But even when made with highly conductive inks, printed antennas, overall, are less capable of conducting electricity than pure metal ones. Research has shown that the conductivity of printed antennas is comparable to that of solid-copper ones at ultra-high frequencies (860 to 960 MHz) and microwave frequencies (2.45 to 5.8 GHz). Printed antennas are not as conductive as pure-metal ones at the high-frequency band (13.65 MHz), however. So for use at this frequency, printing antennas will incur extra costs.

If they are produced in a screen-printing process, antennas can be printed at an elevated thickness, which would increase the conductivity, says Edwards. However, thicker inks require more ink, which pushes cost up. Another way to boost the conductivity of printed antennas is through electroplating. This means a significant investment in equipment and materials. It also slows the manufacturing process of the printed antennas. Electroplating involves immersing the object in a solution and using an electric current to deposit a coating. Elevating the temperature is another way to boost conductivity of printed antennas, but the low temperatures needed to print on most substrates would limit how high temperatures could be elevated.

In addition to the issue of conductivity, other key elements must also be addressed. One of these is the temperature threshold of the materials used in RFID tags. Flexible, disposable materials, such as paper or polymer films, will be damaged if exposed to temperatures exceeding 150 degrees Celsius. That means that conductive inks most remain below that temperature during the printing process. "Good conductivity at 150 degrees Celsius is our goal, and experimentation is looking good. Our goal is to have a product for ink-jetting by the end of year," says Edwards.

Another factor to consider is the amount of time that conductive inks require to dry, or "cure." Edwards says that the screen-printing process allows ample time for inks to dry. But a slower drying time is not desirable in terms of quantity of output. Lithography is a faster printing process, but also leaves less time for the conductive inks to cure. Flexography is both faster than screen-printing and works well with conductive inks, but flexographic presses are less common than both lithography and screen-printing machines, he says.

Each printing process differs in terms of how inks are applied, what characteristics the inks must possess, and how quickly or slowly the inks dry. Edwards says that Cabot-PEDs is working to develop formulations specific to each type of printing and is working to create inks that will not require significant retrofitting or additional printing steps.

Cabot-PEDs is also developing the technology behind printable transistors, so that entire RFID tags could be printed. In this process, the silicon that is conventionally used in transistors is replaced with a printable, and potentially recyclable, polymer. For RFID tags, this polymer would be a plastic that behaves similarly to silicon, in terms of its use as a semiconductor. But before these tags come to market, tag makers have to overcome the same temperature, dying time and conductivity issues that users of conductive ink are facing. Another hurdle will be retrofitting printers in order to produce the thin, intricate lines required to print circuits.

But as with conductive inks, Cabot-PEDs' interest is in finding collaboration partners to produce printable electronics such as RFID tags. Specifically, Cabot-PEDs would produce the ink for the conductors and dielectric. Edwards says Cabot-PEDs would be interested in working with partners, such as large plastics manufactures 3M or DuPont, to provide the semiconductive polymers needed for the transistors.

Regarding its conductive inks, Kodas says that Cabot-PEDs is already in discussions with a number of OEM companies that are looking to produce items with conductive inks, such as RFID tag antennas.

"We're more interested in developing the technology than in bringing it to market ourselves, so it makes more sense for us to work with partners," he says. Because OEMs have established relationships with target buyers and users of conductive inks, OEM partnerships will provide Cabot-PEDs with a channel to reach end users of the technology.

"We're a materials company," says Edwards, "and not interested in being a systems integrator. We don't want to compete with people further down the value chain."