



INDUSTRIAL + Specialty Printing

# Industrial Printing Gets Smart

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# Printing Smart

■ ■ ■ Gail Flower and Katie Brooks

The ability to store, transfer, report, and secure information is coming to more products each day, all thanks to smart technology. Read on to find out about some of the exciting applications for it.

Smart technologies are gaining traction in consumer goods, packaging, finance, military operations, and other applications as new solutions for enhancing products and streamlining and securing processes emerge. They've evolved from the magnetic strips on debit and credit cards to complex integrated circuits (**Figure 1**) that interact with customers and computers, textiles that function as communication systems, packaging that aids in inventory control, and much more. As you'll discover, the potential for smart technologies to reshape the development and marketing of goods and services is very real.

## SMART CARDS

Smart cards offer a more secure way for business transactions to occur in many parts of the world and often replace cash in purchases of all sizes. In the future, smart cards will offer more complex and diverse functions. Imagine the support for animated graphics, dynamic content delivery, and interactivity. Also keep in mind that the technology is transferrable to sensors, packaging, quality control, and

more. You can have movie or concert tickets loaded with information about parking, refreshments, and local attractions; food packaging that monitors and reports spoilage; devices that share vital information about a hospital's blood supply; and new ways to combat passport counterfeiting and identity theft.

A smart card can be printed on a flexible, plastic substrate with embedded integrated circuits, a power supply, an electrochromic display, a microprocessor, and volatile and non-volatile memory storage. Smart cards with embedded and printed functionality are most often used for identification or financial transactions (**Figure 2**). They may also feature an embedded hologram to prevent counterfeiting. A smart card can transfer data to and from a central computer and be programmed to self-destruct should the wrong password be entered too many times.

No-contact smart cards are becoming popular for payment without ticketing. For example, some states issue the EZ Pass, which uses RF-induction technology and requires only close proximity to an antenna

to complete a financial transaction for highway travel.

For all of its benefits, the smart card hasn't met with much acceptance in the U.S. However, Alain Briancon, Ph.D., chief of technology at Radnor, PA-based NTERA, predicts a change of heart in America. "Wal-Mart stated last May that it will make all payment terminals in the U.S. compliant with smart-card-based technology," he notes.

"As far as we are concerned, a signature is a waste of time," says Jamie Henry, Wal-Mart's director of payment services. He explains that Wal-Mart's P-O-S hardware is 100% chip-and-PIN capable, the reader hardware is in place, and the software needs some work before smart-card usage will be fit for implementation.

The use of contactless smart-chip technology is a growing application in the smart-card industry. Contactless smart-chip technology is mainly used for the protection of personal information, fast delivery, and secure transactions. Available in forms such as plastic cards, watches, documents, and other handheld devices,

contactless smart-chip technology uses an embedded, secure microcontroller with internal memory and a small antenna. Contactless chip technology is designed for user convenience, high durability and reliability, usability in harsh environments, and application flexibility.

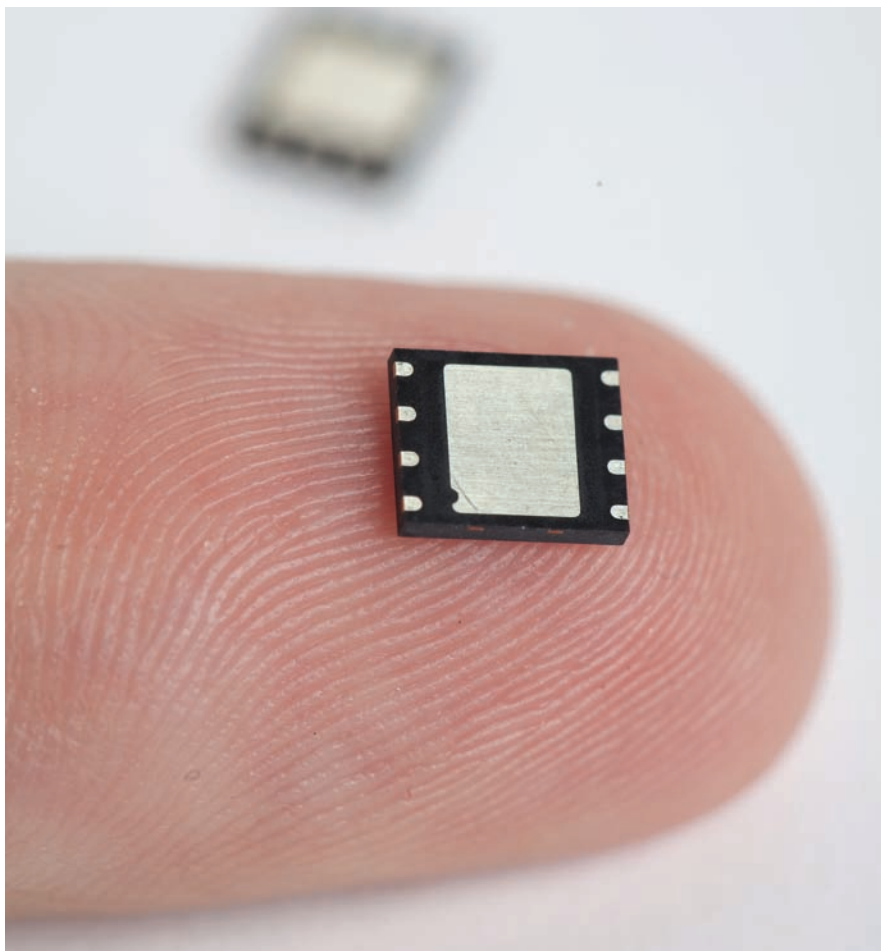
### PRINTING SMART CARDS

A multi-year license and material-supply agreement between NTERA ([www.ntera.com](http://www.ntera.com)) and GSI Technologies, LLC ([www.gsitech.com](http://www.gsitech.com)), has cleared the way for GSI, a printer with industrial and functional products in mass production, to use NTERA's NanoChromics technology in the manufacture of printed-electronics products. GSI uses sheet- and web-fed printing systems for NanoChromics-based projects.

A short while ago, GSI revealed that it was in the final stages of scaling production for smart-card components such as antennas, circuit assemblies, and displays. Last July, GSI and NTERA demonstrated hot-laminated display-card modules using NanoChromics display technology (**Figures 3 and 4**). The solution is printed on a flexible substrate and driven by an off-the-shelf microcontroller chip. It's compatible with industry-standard hot lamination and has been demonstrated in conjunction with a smart-card manufacturer. The card has a high-contrast display, a white background, and a fully functional six-digit, seven-segment display card that fits the smart card market. Applications include two-factor authentication security, such as one-time pass codes, financial credit/debit, transportation, and more.

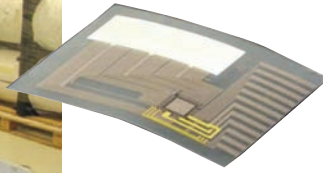
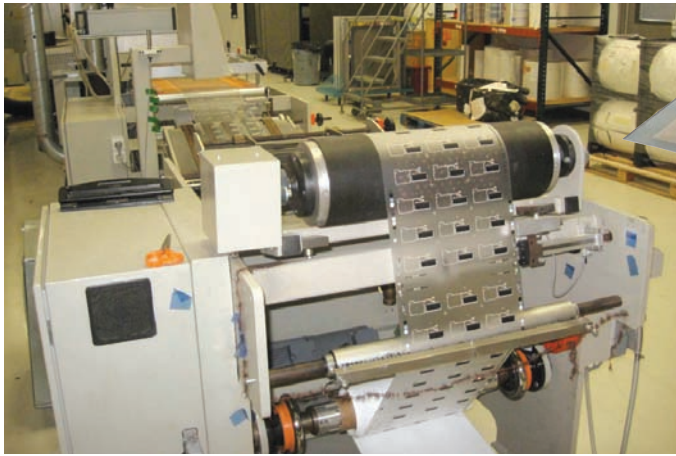
GSI prints the displays onto the same flexible substrate with an attached microcontroller. "Through this process, which we refer to as *printegration*, our customers can reduce the number of components and manufacturing steps in products," says NTERA CEO David Corr.

"It takes a lot to make a smart card," adds NTERA's Briancon. He explains that PET or polycarbonate sheets are required on the outside and a memory or logic controller, a switch that's triggered by a user, a battery or the ability to draw energy from a reader as in RFID, and a display on the inside. The lamination press applies pressures of 30 psi for one hour, during which time the card goes from 72-266°F.



**Figure 1 (top)** Microchips add functionality to smart cards.

**Figure 2 (bottom)** The Ezio Pocket reader authenticates cardholders for remote banking and e-commerce. It provides an alternative environment for entering the users PIN code other than the workstation keyboard, which is considered a vulnerable environment. After inserting the smart banking card into the device and entering the PIN code, a one-time password (OTP) is generated and displayed by the reader to authenticate both the smart card and owner.



**Figure 3 (far left)** Printing smart cards on flexible plastic substrates

**Figure 4 (left)** Hot-laminated card module using a NonoChromics display



Most of the connections between devices are screen printed. Some can be inkjet printed as well.

#### RFID

According to a recent survey conducted by IDTechEX, the RFID printing market will grow to \$5.6 billion this year. In countries such as China, where new applications are constantly being developed, RFID provides solutions across many markets—retail, logistics, healthcare, and aviation, for

example. In market areas such as global airport and airline RFI baggage tag-

ging market, RFID provides a method for baggage identification. RFID is an important element in the smart-card area. With low power provided by the reader, the RFID antenna of the smart card can pick up signals and exchange the handshake of information with the reader wirelessly. Companies such as Kovio Inc. ([www.kovio.com](http://www.kovio.com)) are leveraging their printed-electronics technologies to make RFID solutions affordable. Vik Pavate, Kovio's VP of business development,

says the choice between screen and inkjet printing of RFID antennas depends on which method is the most cost effective.

Kovio plans to transform conventional, passive displays in advertising, entertainment, and education markets into dynamic, interactive signage with wireless interfaces. Advancements in pharmaceutical and healthcare industries, like printed biosensors, intelligent labeling, and smart cards, can also benefit from the low-cost printing of RFIDs.

#### ANTI-COUNTERFEITING CAPABILITIES

Several companies are involved in printing the electronics and inlays for protecting the identity of a passport owner. Smart Packaging Solutions ([www.s-p-s.com](http://www.s-p-s.com)),

## Interpreting the Smart Card Market

Smart-card applications at present are dominated by SIM cards in smart phones, with 3.4 billion shipped in 2009, but the market is expanding beyond smart cell phones to machine-to-machine applications with specialized printing and branding required. The second biggest sector is ATM/credit/debit/prepaid cards. And the market is flourishing with 770 million smart cards issued to end users last year alone.

There's a wider market for magnetic strip cards in the U.S. today, but chip-and-PIN applications are the biggest now for smart cards worldwide and touchless is the next wave. With touchless or contactless cards, the card is tapped or waved to secure an RFID connection wirelessly with the reader.

EMV Co. (Europay, Mastercard, and Visa) controls standards and regulations for chip-and-PIN and contactless smart cards in Europe and worldwide. JCB International Credit Card Co. Ltd. of Tokyo is also a group member. EMV sets standards and regulations for the actual hardware for the card and acceptance at point of sale. Because Europe has migrated to EMV standards, there have been a growing number of instances of U.S. travelers not being able to use their mag-stripe cards while in Europe—or retailers not accepting them.

#### WHY DON'T WE HAVE MORE SMART CARDS IN THE U.S.?

That's just the way the market developed. There's low adoption, but

it's picking up speed now. Canada uses EMV smart cards. The U.S. is more susceptible to fraud if it doesn't eventually switch to smart cards with chips to protect valid users. Upgrading is expensive. The cost would have to be weighed against the effects of fraud.

#### HOW SECURE IS A SMART CARD?

With smart cards you have a protective memory processor within the card that is able to better protect the data stored within it. Encryption and algorithms stored within the card restrict any illegitimate access. Additionally, the network allows you three attempts to enter your PIN code before it refuses interaction. And there are different levels of encryption within the card that are being stepped up again to make it more difficult to hack.

#### WHO ARE THE BIGGEST PLAYERS?

In 2009, the four largest card providers accounted for 70% of the overall smart-card market. Gemalto ([www.gemalto.com](http://www.gemalto.com)) is the world's largest smart-card manufacturer. Oberthur is the number two company for making smart cards. Giesecke Devrient ([www.gide.com](http://www.gide.com)) takes position number three. Finally, Morpho ([www.morpho.com](http://www.morpho.com)) takes the number four spot.

When considering the chips, Infineon has the biggest dollar share market revenue. These chips have active ID and are produced in high

for example, provides passport inlays in international e-passports. Called E-Booster Technology, it is based on a specific electromagnetic coupling between an RFID antenna module (E-Pastille) and a specific antenna (E-Booster). It can be integrated in paper and may be inserted in passport covers. Electronic passports using this technology are designed to resist damage, tampering, and environmental influences.

Other companies, like Oberthur Technology ([www.oberthurcs.com](http://www.oberthurcs.com)), a provider of smart credentials to the U.S. federal government, are supplying first responders with Federal Information Processing System (FIPS) 201-compliant physical and logical access Personal Identify Verification (PIV) to assist in disaster response. These smart cards are used by physicians, paramedics, and first responders to gain access to emergency facilities and hospitals linked in a Web-based database updated daily to confirm cardholder identity and response capabilities.

#### SMART TEXTILES

Smart textiles can function as communication devices, displays, sensors, or as

thermal-management controls. Examples of optical fibers, electroluminescent elements, and LEDs with apparel are already hitting the market. Clothing made of smart textiles can monitor the temperature of the wearer using an array of biosensors as reported by the Swiss Centre for Electronics and Microtechnology, coordinator of the BIOTEX project. The technology of adding intelligent responses will change in time from simple sensors to multifunctional devices.

One example of adding intelligence to flexible, lightweight devices is the work being done at Arizona State University's Flexible Display Center. Through \$50M of research funding, the U.S. Army, along with many other industry consortia members and academia, has created smart, lightweight, flexible (foldable, wearable, rollable) electronics. The army's intent is to create tiny computers and display screens that could be sewn into uniform sleeves, thereby cutting down on the weight soldiers carry in the field, yet giving them better, less power-hungry, more affordable intelligence.

So far, scientists at the Flexible Display

Center have produced 4-in. flexible displays that fit into a person's palm. General Dynamics is working on a PDA-size mission briefcase, a device incorporating an electronic-paper display made by E-Ink Corp. ([www.eink.com](http://www.eink.com)). This device incorporates Universal Display Corp's organic light-emitting diode (OLED) flexible display technology into a computer designed to be worn like a wristwatch. By supplying intelligence through flexible, printed objects, a soldier can have maps showing the location of friendly forces, photos of wanted persons, a building before a raid, and general positioning/mapping. Flexible displays will also be incorporated into Army vehicles as a result of this ongoing research. ●



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volumes. They're used for pay TV, banking cards, and other high-volume applications. Samsung supplies the largest volume of chips (SIM cards) for this market.

#### WHAT ARE SOME EMERGING TRENDS?

Some manufacturers print their own cards. Gemalto, for instance, has some plants for making the cards in North America. They produce the electronic and biometric (the chips that have fingerprint and facial-recognition data within them) passports, though this is not an operation exclusive to Gemalto. Much of this detailing/personalization is conducted locally to help meet security regulations and guidelines.

The passport market (and for national ID, etc.) uses a wide range of secure printing techniques. The first deadline, April 2010, mandated by ICAO, has passed for all passports to be machine readable (MRP). Some passports also have a secure smart-card chip and an RFID antenna within a thicker page so that they can store personal data and biometric information and be read without contact at points of entry. We will see increased biometric passports with encrypted information in the future.

New printing techniques are in development to address environmental issues, smart-card printers are becoming more competitive, cards are becoming increasingly personalized, and card issuers are

looking at new techniques and features to make cards more attractive to end users. Overall, the smart-card sector is an area in which there is a lot of change occurring, which signals the creation of new opportunities.

#### WHAT DOES THE FUTURE HOLD FOR SMART CARDS?

In 2010, chip revenue will increase by 14% (\$1.95 billion). Overall, volumes are also continuing to rise. The general trend is for upward growth in revenues and volume. The three largest markets for smart cards are government and healthcare, SIM cards, and payment cards. In 2009, the market for smart-card chips was \$1.7 billion with unit volumes at 5.2 billion cards. ●



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# Applications of Smart Printing in Food, Drug, and Security

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Innovative, intelligent packaging systems are essential in the food industry and related healthcare sectors, where there have always been concerns regarding food safety and loss reduction in perishables and other temperature-sensitive products in the supply chain. It appears that public awareness of benefits offered by smart packaging is still not as heightened as it should be and, unfortunately, this has historically affected the uptake of these technologies in the industry.

The food and drink market, along with personal care and over-the-counter healthcare, are among the sectors that can benefit from advanced smart packaging, with features beyond the shelf-life extension or spoilage protection. Product differentiation through advanced food-safety monitoring and traceability, while accounting for environmental issues, can tremendously impact consumer products in the near future. This will be especially crucial in the food-and-drink market, where freshness, labeling information, quality, and more up-to-date safety systems will play important roles in such a competitive space.

## CHRIS GIACOPONELLO

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NTERA's NanoChromics Ink Systems can be used to print displays on a variety of flexible substrates (Figure 5) using standard printing techniques and equipment. These electronic displays have the capability of being integrated into products such as plastic cards, packaging, smart labels, and RFID systems. NanoChromics Ink Systems are compatible with existing sheet or web-fed screen printing, flexography, and inkjet printing. In addition, the ink system can be combined with other printed-electronics technologies and traditional inks on the same substrate.

Our printed-electronic displays, along with current security capabilities, will help take the security of smart packaging to the next level. With counterfeit and theft on the rise, printed security features like microtext, hidden images, and holograms will play a role in the effort of controlling anti-counterfeit solutions.

The future of smart packaging will give consumer companies a greater set of options for their products and offer brand protection, authentication, and the ability to create an interactive display with sensors or low-cost electronics.

## BOB GOLDSMITH

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SIRA's Food Sentinel System was developed as a response to the worldwide imperative to guarantee safe food, pharmaceuticals, and biologicals. The Food Sentinel System barcode (Figure 6) is a

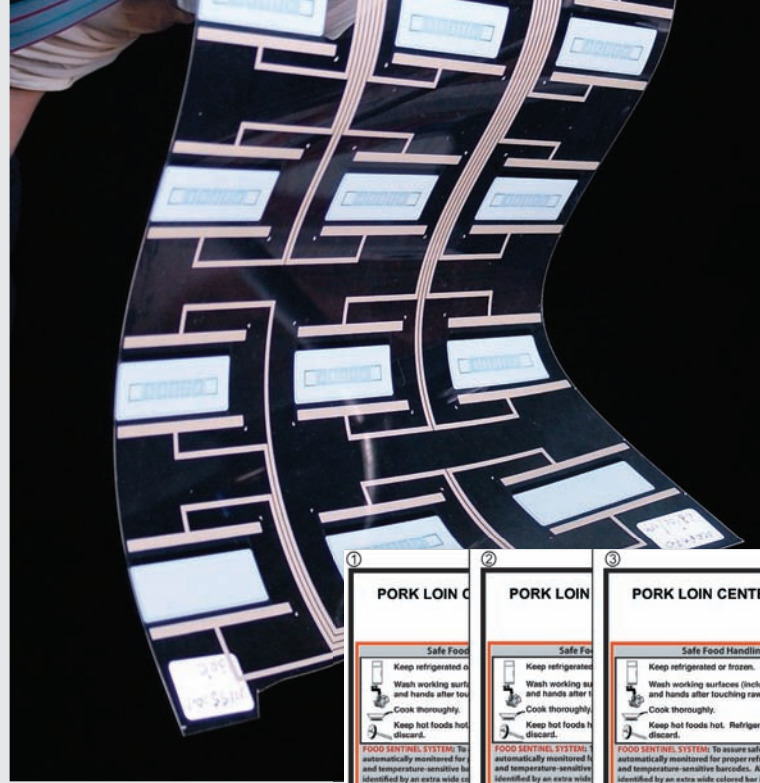
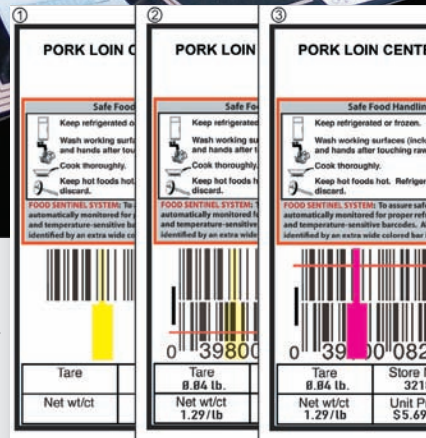


Figure 5 Nanochromics ink on a flexible substrate

Figure 6 A time- and temperature-sensitive label for food that is actually two barcodes produced with thermochromic ink



time- and temperature-sensitive label that is actually two barcodes, a SIRA code and the normal product code that can adhere to any typical, perishable item. The SIRA code will become unreadable and unable to transmit any kind of data when scanned when the thermochromic ink that has been incorporated into the barcode is activated.

The ink automatically modifies the ordinary coded data when exposed to an altered temperature level. Thermochromic ink can be used on standard printing presses and printed onto any substrate used for labels, packages, or cartons. It cannot revert after it has reached its trip point. Once a product has reached its packaging stage, the ink is activated or switched on so that is able to react when exposed to varying temperatures for too long a time. The unique capability of the label-activation process is what allows the inks to be printed in normal printing environments on ordinary presses without affecting their functionality before they hit the shelves.

When the ink is incorporated into the barcode, it is a very pale yellow—nearly invisible. Once the ink recognizes contamination, it changes to a very dark magenta or black so customers can rely on their own judgment to determine the safety of the product. The ink has a hot and cold component that can monitor 40°F and 180°F. Eventually, the product will be able to cover the entire spectrum. The combination of a global barcode-data-collection infrastructure and these thermochromic inks can turn any barcode into a time-and-temperature monitor. ●