New Polyurethane Application to Encapsulate Computer Chips in Smart Cards

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ABSTRACT

This paper presents equipment and process technologies to achieve the secure encapsulation of computer chips and associated electronics into Smart Cards and other portable devices such as Key Fobs (like the ExxonMobil SpeedPass), Electronic Passports, MultiMedia Cards (MMCs), and Secure Digital (SD) cards. Reaction Assisted Molded Process (RAMP) is a proprietary, patented process developed by CARDXX, based in Englewood, Colorado. First, computer chips and electronic components are positioned in a mold between two sheets of film, typically Polyvinylchloride (PVC) or Polycarbonate, that serve as the top and bottom surfaces of a conventional credit card. The polyurethane mixture is then injected at extremely low throughput between the two sheets of film to completely immerse the electronic elements. When the polyurethane cures, the electronics are completely encapsulated within a continuous core of material.
The elastomeric properties of polyurethane protect the delicate computer chip and other fragile electronic elements including antennae. Processing temperatures are low enough that damage does not occur during molding. Polyurethane provides superior heat and chemical resistance. In addition, physical access to the chip electronics is difficult to obtain without destruction or severe damage to the chip.
Although Smart Cards are used extensively in Europe, they are just beginning to take off here in the United States replacing credit cards, health insurance cards, identification cards and wireless cards. The Smart Card is similar to a credit card in size, but has an embedded computer chip that stores, processes, and communicates data to upstream systems. Smart Cards improve the security of transactions by providing powerful encryption and secure physical storage of private information

1. INTRODUCTION

Reaction Injection Molding (RIM) technology has recently been extended and refined to enable the production of “smart cards” and other small devices containing computer chip modules. Smart cards are the size of conventional credit cards and contain a computer “chip” or module that provides memory and processing functions. Smart cards have been used extensively in Europe for applications in telecommunications, transportation, and banking. For example, most Visa and Mastercard cards in the U.K. are so-called “chip cards”, and they contain computer chip modules that improve security and reduce fraud by requiring a four-digit Personal Identification Number (PIN) with each financial transaction.

Smart Cards generally come in two varieties: Contacted and Contactless. A “Contacted” Smart Card has the computer chip embedded in the card body with exposed contact areas. Contacted Smart Cards must be inserted into a reader to operate. When the card is inserted in a card reader, certain contacts on the smart card allow power to be delivered to the chip and other contact areas allow the chip module to communicate with upstream systems such as credit card or employee databases. Contactless Smart Cards do not need to be inserted into a reader; they contain an antennae embedded within the card that provides power and communication functions. If a Contactless Smart Card is located near a Contactless Reader, the electromagnetic field produced by the reader will “induce” a current in the antenna that is sufficient to power the computer chip module, and to

transmit and receive radio frequency waves that support communications with upstream systems.

In May, 2005, J.P. Morgan Chase announced their “Blink” credit card, which utilizes the Contactless Smart Card technology described above. This card enables cardholders to “pay with a wave” at a point of sale terminal by simply holding their card within a few inches of a contactless payment Point of Sale terminal. Market research has shown that consumers, retailers, and card issuers all realize substantial benefits of “pay with a wave” Contactless Payment technology using Radio Frequency (RF)-based devices such as key fobs, contactless smart cards, and cellular handsets equipped with a contactless chip. RF-based contactless payment is simple for both the consumer and the retailer. Consumers use a payment card or a key fob that is equipped with a chip and antenna that securely communicates consumer account information via radio frequency to the retailer’s payment terminal. The payment terminal then connects to the appropriate financial networks or other back-end processing systems to authorize the transaction. Once authorized, the consumer completes the transaction – in a fraction of the time required by cash, traditional credit, or debit transactions that require a card to be swiped through a reader.

The Radio Frequency (RF)-based contactless payment device is creating excitement among consumers as the newest trend in payment technology. These key fobs allow consumers to quickly and easily pay for transactions “with a wave”. The RF-based contactless payment devices are easy to use; consumers like the increased speed and control of transactions, and will increasingly use the devices instead of cash. In addition, retailers are seeing better revenues as consumers spend more per transaction and purchase more frequently

The CardXX Reaction Assisted Molded Process (RAMP) enables smart cards, contactless key fobs, memory cards, and other electronic devices with small form factors to be manufactured using a variation of Reaction Injection Molding equipment.

2. RIM TECHNOLOGY REFINEMENTS FOR ELECTRONICS PACKAGING

Reaction Injection Molding (RIM) technology has steadily evolved over the past two decades to address an ever-expanding range of applications. The Reaction Assisted Molding Process (RAMP) used by CardXX to manufacture smart cards is just one of the most recent examples of innovative applications of RIM technology. RIM is a two chemical process for molding urethanes and plastics that mix and meters raw materials and then injects them into a mold cavity. RIM equipment and the molding process uses considerably less energy to make the same product as injection molded thermoplastics and requires less equipment and floor space. In addition to high strength and low weight, Polyurethane RIM molded products exhibit a high level of dynamic properties such as heat resistance, thermal insulation and dimensional stability.

The development of the RAMP process depended on locating the proper RIM equipment. For this, CardXX utilized existing reaction injection molding techniques, along with customizable dispensing equipment from Gusmer | Decker to

accurately dispense the minute quantities of urethane required in RAMP applications.

Gusmer l Decker, a leader in the reaction injection molding equipment market, develops metering machines and mixing heads for processing multi-component polyurethane and hybrid urethane chemicals. Gusmer l Decker's RimCell Select Series metering and dispensing units are particularly suited for RAMP applications because of their ability to be customized for mixing that yield flow-rates as low as 0.33 lb. per minute—necessary to minimize the forces that might disrupt the high-precision placement of electronic components within smart cards.

CardXX’s custom tailored RimCell Select, high pressure 20 Unit was coupled with the L Style MixHead. This machine was designed with dual switch station, which allows the operator to pour offline for prototyping without interrupting the RAMP production line. The L Style MixHead is a direct impingement self cleaning mixing head which reduces pressure spikes and continuously purges the interior passages of any mixed material. This state-of-the-art equipment provides the unique ability to deliver small,

gram-level quantities of reaction injection molding material reliably and accurately.

The RimCell Select molding system allows a wide variety of shot sizes and fast cycle times while assuring metering accuracy within strict tolerances. Such RIM technology helps polyurethane-product manufacturers avoid waste from overfilling parts. The ability to provide low-temperature delivery, also necessary for RAMP applications, enables high production volumes because of minimized cycle time.

3. ENCAPSULATING COMPUTER CHIPS IN SMART CARDS WITH RIM

The Reaction Assisted Molding Process (RAMP) has been adapted from traditional RIM technology by creating special molds with extremely small yet precise form factors (e.g. credit cards are about 30 thousandths of an inch in thickness). Successful production of products such as smart cards requires molds with highly specialized venting and flow characteristics that enable delicate electronics to be securely integrated into the card body.

Reaction Assisted Molded Process (RAMP) is a proprietary process developed by CARDXX, based in Englewood, Colorado. First, computer chips and electronic components are positioned in a mold between two sheets of film, typically Polyvinylchloride (PVC), Polyethylene-Glycol (PET-G) or Polycarbonate, that serve as the top and bottom surfaces of a conventional credit card. The polyurethane mixture is then injected at extremely low pressure between the two sheets of film to completely immerse the electronic elements. When the polyurethane has cured, typically in less than one hour, the electronics are completely encapsulated within a continuous core of material.

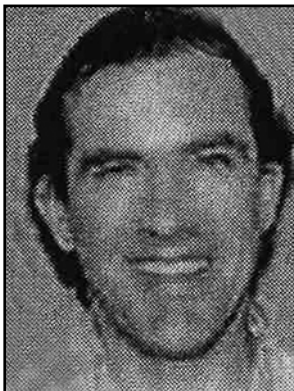
The elastomeric properties of polyurethane protect the delicate computer chip and other fragile electronic elements including antennae. Processing temperatures are low enough that damage does not occur during molding. Polyurethane provides superior heat and chemical resistance. In addition, physical access to the chip electronics is difficult to obtain without destruction or severe damage to the chip.

The RAMP process has been employed for producing a wide range of miniature electronic devices including: 1) Electronic Passports with computer chips and antennae embedded in the passport bookcover, 2) Key Fobs that attach to a key ring with embedded chips and antennae, 3) RFID tags containing chips and antennae for use with inventory management and animal tracking, and 4) Contactless Payment modules for incorporation in cell phones so that consumers can use their cell phone to “pay with a wave” at checkout counters.

4. FUTURE DIRECTIONS

As electronics and computer chips continue to become miniaturized and “micro-miniaturized”, electronic devices will continue to decrease in size and proliferate in our daily life. One new technology that will soon become widespread is “Radio Frequency Identification” or RFID. RFID tags operate in basically the same way as Contactless Smart Cards – they contain a tiny computer module and antennae that allows the device to receive power from a Contactless Reader field and then to send and receive data using radio frequency communications. RFID tags contain a unique identification number and they are typically attached to objects that need to be tracked, such as defibrillators in hospitals. These instruments are extremely important for reviving heart attack patients; however, they are often left in patient rooms, hallways, and other locations where they are not readily accessible. By attaching an RFID tag to a defibrillator and installing a network of RFID readers in the hospital, the location of a defibrillator can be instantly determined and displayed on a map of the hospital environment.

Walmart and the Department of Defense have initiated programs to use RFID for inventory management. RFID tags are expected to eventually replace the ubiquitous “bar code” that is now found on virtually every consumer product found in stores today. RFID provides substantial benefits over bar codes because RFID tags do not need to be manually scanned with the “line of sight” properly aligned; instead, RFID tags can be read automatically by simply placing them in a reader field, and their data is automatically transmitted to the reader and then to appropriate software applications available in the data network. With today’s RFID technology, it is possible to drive a forklift or truck loaded with boxes containing thousands of articles equipped with RFID tags through a gate containing an RFID reader, and each of the thousands of individual RFID tags will be registered and their data recorded by the reader – without any human intervention (other than driving the forklift through the gate).



The potential applications of

RFID are limited only by the human imagination; they enable "the automation of everything" and they will enable "smart objects" to automatically store and transmit all kinds of information. RAMP technology has been proven to be extremely efficient and effective for producing rugged, durable, low-cost RFID tags and devices in a wide variety of form factors.

5. CONCLUSION

The application of RIM technology to electronics packaging with the RAMP process has allowed production of a new generation of advanced computerized devices with extremely small form factors, such as smart cards. The low viscosity of the RIM mixture allows delicate electronic components to be completely immersed and surrounded by polyurethane with minimum damage. The elastomeric properties of polyurethane provide outstanding protection, security, and durability for the electronic devices. For many applications such as key fobs and RFID tags, ruggedness and security are critical requirements for a successful product.

The high performance characteristics of polyurethane combined with the exceptional adaptability of the RIM process have been key elements for enabling this new application. CardXX and Gusmer | Decker have teamed together to deliver a state-of-the-art solution enabling a new generation of electronic products ranging from Electronic Passports to Smart Cards to Contactless Payment Key Fobs.

BIOGRAPHIES

Paul Reed
Paul Reed is Director of Business Development at CardXX where he has performed engineering and business development functions for two years. Previously, he was a Distinguished Member of Technical Staff at Bell Laboratories for 18 years. He received a Ph.D from the University of California, Santa Barbara in 1984.

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