Introduction

Over the last fifteen years, there has been rapid adoption of contact, contactless and dual interface smart card technology in advanced national identity card and e-passport programs.

Heightened security concerns, high traffic border crossings, and growing requirement for streamlined government services delivery are just some of the factors influencing this change. Governments and national organizations are now increasingly likely to leverage ID programs as an opportunity to increase efficiency as well as protect and ensure the identity of the holder. This has given rise to projects calling for powerful multi-purpose ID credentials that operate on many levels, maintaining the highest levels of security while addressing additional objectives such as entry to secure facilities, faster border crossing, or access to health and social services.

As a result, government agencies worldwide are prescribing smart card-enabled applications and IC chip-based documents with growing frequency to achieve these goals. The demand for chip-based ID card technology and advances in materials science have driven substantial progress in card construction, giving rise to more sophisticated solutions that better meet the complex requirements for program security, reliability, efficiency and the increasing multi-functionality delivered in a single credential.

While the concept of a multi-functional card is simple, the reality is difficult to achieve. Considerable design, technical and manufacturing expertise must be employed to ensure that the end result conforms to international standards in terms of size, security, functionality and durability. Nevertheless, such cards are ultimately a more cost-effective, efficient option than multiple single-purpose credentials, and they enable the program specifiers to ensure a uniformly high standard of security across designated functions.

A key factor in delivering these objectives is ID durability. Modern ID documents are required to stand up to many types of stress, ranging from attempts at physical alteration to years of inconsiderate handling in a variety of environments and weather conditions. Polycarbonate, due to its unique properties, has won the trust of governments as the material of choice for durability and tamper resistance. Cards constructed from polycarbonate are also stronger than Polyvinyl Chloride (PVC) cards. Key characteristics include the extreme robustness, flexibility and strength of polycarbonate as well as its capabilities as a platform to support the high quality optical features of high security printing.

The use of this material along with the incorporation of multiple on-board technologies and security features into a multi-layered, single ID platform require considerable expertise in the lamination of complex structures and the appropriate application of diverse materials. The industry has now found that the addition of onboard technologies such as RFID or contact and contactless chips may create unexpected stresses in polycarbonate structures. Innovative new technologies such as anti-crack prevention are therefore required to protect the structural integrity of the credential, while conforming to international standards.
This paper will examine HID Global’s unique crack prevention feature which protects both the polycarbonate and the IC module. This solution optimizes the reliability of smart cards by enabling manufacturers to maintain the original advantages of polycarbonate – now threatened by the insertion of an IC chip - and extend the life of the credential. HID Global’s innovation is now used in more than 10 million cards for a major European national eID program, the most deployed in any advanced ID card program in the world.

**Polycarbonate: Behind Its Success**

**Document Integrity, Fraud Resistance and Feature Compatibility**

It is not by chance that polycarbonate has become the most suitable material for today’s secure ID documents. When used in its pure form and not mixed with other plastics, the different layers of polycarbonate that make up an identity document fuse together to form a single, mono-block solid card body. This characteristic preserves the integrity of the document, preventing disassembly and making it highly fraud-resistant.

Polycarbonate is also compliant with most security features available on the market, such as offset security printing, optically variable or fluorescent inks, and holograms. This makes it a perfect commercial match for the requirements of today’s most popular security technologies.

The main advantages of polycarbonate include:

- Temperature resistance: It can resist high temperatures (over 180°C), enabling its use in extreme weather and climatic conditions.
- Tamper proof structure: When a card is made of 100% polycarbonate, its mono-block characteristic makes it impossible to separate the different layers without destroying the card itself.
- Irreversible personalization: Laser engraving is one of the most popular methods of personalizing ID documents; polycarbonate is a highly suitable material for this irreversible process.
- Optimal platform for security features: Because of the optical quality of polycarbonate, it is compatible with the main security features available on the market.
- Durable: Polycarbonate is highly durable and flexible.
- Neutral environmental impact: The impact on the environment is less dramatic than that from PVC. Combustion of polycarbonate produces carbon dioxide and water, and no toxic gases are generated.

The combination of these unique properties have made polycarbonate the material of choice for large scale ID programs in the Government ID sector, including national ID, e-passport and driving license programs.

**Optimizing the Life Span of Next Generation Smart Cards**

A central assumption about polycarbonate is that after lamination of the card, the card becomes a monolithic piece of polycarbonate. However, in contactless RFID documents, this assumption does not hold true. The card contains electronics, which are surrounded by and melted into the plastic. It is known that inclusions – for example, extraneous materials such as IC chips - in plastics cause stress, creating areas of material weakness that often are starting points of material break up.

In other areas of the plastics industry such inclusions are avoided where possible. Any cavities or inclusions that are indispensable are round-cornered, or are moved to an area of the plastic where
they can be expected to cause the least stress, or other measures are taken. Such practices are not used in the production of standard polycarbonate cards.

As a consequence, the polycarbonate begins to crack around the IC module as the polycarbonate ages over time, and also as a result of a significant difference in the thermo-mechanical coefficients between the IC module and the polycarbonate.

In fact, polycarbonate cards are under high stress from the very beginning. After lamination, polycarbonate is under extreme tension around the IC module and any thermal or mechanical stress can have a destructive impact on the cards. Therefore, when the cards are subjected to mechanical stress such as everyday wear and tear, tension is released in the form of small micro-cracks in the polycarbonate surrounding the IC module (which consists primarily of a metallic frame and resin mold cap or top protecting the chip).

Micro-cracks are often invisible to optical inspection, and will continue to progress undetected inside the cards, migrating from the module area to the surface of the card. This process destabilizes the card over time and contributes to its premature aging. Cracking may also be accelerated by mechanical stress such as bending and twisting that occurs naturally during the life of the card.

**HID Global Crack Prevention Feature: An “Airbag” Solution**

HID Global has built an exceptional level of technology-inclusive expertise in the secure ID credential arena, based on years of innovation and development for agencies that depend on the highest levels of security, quality, durability, and reliability. The company’s expertise in the lamination of complex structures and the application of diverse materials to protect the structural integrity of the credential, while complying to international standards, has resulted in many industry innovations.

HID Global has been working to address the cause and prevention of micro-cracking in order to restore the full promise of polycarbonate cards, including their extraordinary reliability and the target lifespan of up to 10 years. During the course of almost three years, HID Global R&D worked to develop and patent a new “crack prevention feature” (CPF) that prevents the development and emergence of micro-cracks.

Materials and manufacturing experts at HID Global focused initially on determining where cracks originate – a challenging task since the opaque card material and layered construction around RFID chips conceals the existence of potential cracks – and also required an understanding of how and why they spread. HID benefited from a skilled R&D team with a track record in the field of packaging of microelectronic components.
Proximity to the testing labs, including those that simulate aging, of a local semiconductor manufacturer for automotive applications also proved to be beneficial as durability in a rough environment is a key feature in every automotive application.

HID’s solution, achieved after extensive experimentation and tests, involves the creation of a cushion around the chip. While addressing the cracking problem, which required the addition of a further layer of material into the card, the result presented new challenges. Further experimentation was required to produce a credential that could incorporate the CPF, yet comply with stringent international standards limiting the size and thickness of machine-readable electronic ID cards. In the development process, nearly 100kg of ceFLEX™ material was consumed. This is a significant amount given that a card weighs only five grams.

The first credentials containing the CPF feature were initially deployed in 2008 in a major European eID card program. Originally developed for polycarbonate ID cards containing RFID chips, the crack prevention process has more recently been adapted to meet the special requirements of e-passports. After the successful deployment of pure polycarbonate ID cards throughout the world, polycarbonate is now also increasingly used for passport datapages and HID Global has adapted the crack prevention for this purpose as well.

How Does CPF Work?

The crack prevention feature is part of the card’s RFID inlay, which serves the entire industry by bringing the advantages of crack prevention to every polycarbonate card manufacturer.

The anti-crack technology protects the polycarbonate and the IC module by effectively deploying itself as an airbag. In a step near the end of the card manufacturing process just prior to lamination, the CPF ‘airbag’ is built inside the foils. The CPF develops its function only in connection with the appropriate lamination process. The necessary uniform temperature profile and vacuum is provided by HID’s professional large-scale lamination systems.

In brief, the patented CPF process separates the IC module from the polycarbonate using HID Global’s ceFLEX material in order to prevent contact between the two areas during the lamination process. No stress or tension can build as tension is absorbed by the ceFLEX material, securing and protecting both module and polycarbonate (see picture below). Once the card and the chip have passed through the lamination process without stresses being created, the ceFLEX turns into a highly bonded but flexible bearing for the chip inside the card. This provides both a firm connection to the card body and complete lack of damaging tension within the card throughout its lifetime.
The shape of the chip module is an important parameter in the CPF manufacturing process. HID analyzes each new module that comes onto the market and adapts the CPF to the module with its own solution.

A recent chemical study on crack emergence/prevention by Smithers PIRA of the UK showed the premature aging of polycarbonate cards (report published 16 May 2012 Ref: 12-115268). PIRA tested two batches of polycarbonate cards, one with HID’s CPF and one without, by immersing polycarbonate cards in a 5% Sodium Hydroxide solution for one hour. The solution was used to accelerate the aging of the polycarbonate card and amplify the development of cracks if micro cracks were already present. If there were no micro cracks, then nothing changed.

In the picture below we can see the impact on cards of the Sodium Hydroxide test solution on a standard pure polycarbonate card after one hour:

In the photo below, some cracks have appeared around the resin mold cap area.
PIRA reported that all of the standard polycarbonate cards showed cracks, ranging from slight micro-cracks to very severe ones. In contrast, the population of cards with HID's Crack Prevention Feature (CPF) did not show any evidence of cracks that would normally be evident after years of aging.

The process uses no release agents. Such solutions can be found on the market and they can cause severe problems when wax or oil is migrating in an uncontrolled way. HID Global never uses these substances and has banned them from their inlay manufacturing factories. This ensures the stability and high quality of the product supplied to card manufacturers.

Conclusion

Governments around the world are building increasingly layered, secure and efficient eID programs to improve proof of identity, access to e-government services and enhance critical activities such as secure and efficient border crossing. To achieve these goals, organizations are choosing to deploy a new generation of secure credentials containing IC chips, often in combination with other technologies.

As a result, the durability of the ID credentials at the core of these eco-systems has become a major industry focus. A highly durable and reliable credential with a long life span improves a government’s return on investment since far fewer cards must be replaced or reissued. Long lasting credentials better serve card holders, government agencies and tax payers alike. For suppliers, the availability of card technologies that function consistently -- regardless of weather and climatic conditions -- improves the industry's overall manufacturing cost structure and efficiencies.

Polycarbonate has proven to be a viable material for the production of many of the most important ID cards issued today. As more governments opt for smart cards containing IC chips for a multitude of applications, HID Global’s CPF solution is already helping to extend the life-span and durability of many types of polycarbonate-based cards as proven by their use in more than 10 million cards in a major European national eID program.