Since the introduction of the first booklet-type passports almost a century ago, passports have evolved into high-tech products with security features such as printed or laser engraved photographs, optical and electronic elements, laminates, watermarks and machine readable data, to name but a few. Many of those features are supposed to prevent or reveal any tampering and forgery attempts in modern passports. Although security features are generally difficult to counterfeit, it is clear that they are ineffective or even counter-productive if not properly integrated into the passport booklet. Therefore, sophisticated bonding solutions are required to ensure both secure integration of security features and high durability during the ten years of a passport's life.

Early predecessors of passports were signed letters or documents which allowed the holder of that document to travel to a defined place. The first booklet-type passports included a simple photograph to identify the holder. Over time, more and more security features were added: countries replaced the holder's glued-on photograph with a printed or laser engraved one, and started to incorporate an integrated circuit - thanks to the digital revolution.

From a technical point of view, the electronic passport is a complex combination of different materials bound together in a booklet-type document. The components used for passport production vary from country to country, resulting in many different national passport solutions (figure 1). Not only is the booklet and its content supposed to reliably withstand a time span of ten years in different climatic regions of our world, they need to withstand or reveal any illegal document manipulation and tampering attempts. In order to fulfil those demanding requirements and to produce a unique and tamper-resistant passport, secure bonding solutions are needed for the production of the passport cover, booklet and inlay, for protection of the personal data (both the readable data on the data page as well as the element containing the electronic data) and to grant additional rights to the owner of the document during the validity period of the passport (visa, permits).

ICAO e-Passport requirements

Now that air travel has become common place for long distance journeys, and due to the need for increased security after 9/11, the International Civil Aviation Organisation (ICAO) has laid down the basic functional specifications for machine readable travel documents (MRTDs)[1]. The organisation also provides test specifications for biometric or e-Passports, i.e. machine readable passports which incorporate contactless integrated circuits. For these, ICAO specifies the minimum requirements to which e-Passports have to comply with regard to durability and quality level. The e-Passport as a whole must meet the laid down specifications; the booklet must not delaminate upon any of the stress tests thereby ensuring document durability of ten years.

Passport booklets are subjected to a number of mechanical, chemical and environmental stress tests, to simulate normal booklet handling over a needed fsminimum tbiometri(onment)123(and)-23

Figure 1
Passport specifications and components vary from country to country, resulting in many different national passport solutions.

wet bonding process. During this process the cover material, endpaper and inlay are bonded together by a water-based adhesive (figure 2).

Other bonding technologies are:
- moisture-curable hot melt adhesives, which are utilised to form the assembly of inlay and cover materials;
- adhesive films (reactive and non-reactive) that are activated by heat and pressure.

Security thread
The end page, data page and visa pages are sewn together using a security thread to form the book block. In order to enhance the mechanical stability and tamper resistance of the sewn pages, before sewing the book block together, across its spine a reinforcement tape is attached to the endpaper (figure 3). Additionally, the security thread can be fixed with an adhesive, making it more difficult to remove it from the finished product.

Passport cover and booklet production

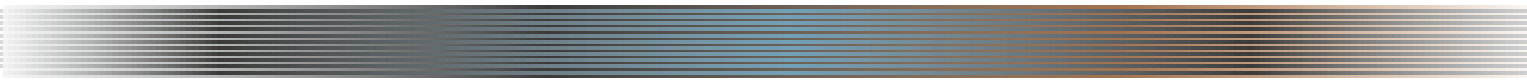
Until recently, the passport cover mainly had to protect the passport pages from damage during its usage of up to ten years. Manufacturing properties and good mechanical stability of the laminate were more or less the only requirements for the adhesive used. However, new bonding solutions are required since the introduction of the e-Passport, as the passport cover may be constructed in a number of ways, involving new materials (inlay, shield material, etc.). The cover itself has now become a security feature to be protected, as it contains the integrated circuit and electronic information about the passport holder. This should be considered when determining specifications and requirements for the electronic cover.

Box 1

Reactive and non-reactive adhesives

Today, both reactive and non-reactive adhesive systems are applied for the different bonding solutions in electronic passports. Reactive bonding solutions are considered to provide an improved resistance to tampering, but is this really true? What is true, is that cross-linking enhances cohesion in reactive adhesive systems accompanied by an improved heat and chemical resistance. However, the adhesive is only one component of the entire system and therefore it is imperative that the final system is always taken into consideration.

All the materials and techniques used (machine, substrates and adhesive) have to match in order to end up with a comprehensive solution which



document manipulation and tampering attempts. In order to fulfil those demanding requirements, secure bonding solutions are needed for the production of the passport cover and booklet, for protection of the personal data and to grant additional rights to the owner of the document during the validity period of the passport. While there are methods to test the durability of a laminate in different stress situations, specifying