Improvements in Document Security- The Next Generation

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Abstract

Typically the variable data on identification documents are secured with an over laminate which is a costly and slow process. The Currency and Security Document team at Note printing Australia (NPA) has focused on securing the variable data without the need for lamination. NPAs efforts have focused on developing a unique securitised polymer film carrier combined with tamper evident smart coatings. The smart coatings are translucent which enable two way image verification and demonstrate excellent receptivity to inkjet printing for high image quality. The coatings can be imaged using a mask based laser system which creates an optical switch effect with the micro elements of the base substrate. Substantial product testing has been undertaken which shows that the integrity of the document is maintained in normal use. The paper also highlights other security feature developments which create improved levels of document security.

Background

Criminals are constantly focusing their attention on simulating or altering security documents for fostering a range of criminal activities. These illegal documents are often used for obtaining genuine legal documents such as drivers licences and bank loans. An identification document which can be easily forged or counterfeited is a potentially embarrassing situation for government issuing agencies aiming to protect the personal and economic security of its citizens. Therefore a high value document must have exceptional security on a number of levels.

Firstly and most importantly, it must possess easily recognisable overt security features which must be examined and authenticated in a short time frame. It must be difficult and costly for the counterfeiter to simulate. If alteration is attempted it must be clear to the examiner that tampering of the document has occurred, in particular the photograph area, which is still the key biometric identifier on many identification documents such as a passport datapage which is commonly targeted by criminals for photo substitution. Key overt security features overlapping the photograph must be destroyed or partially destroyed when tampering is attempted. If only part of the security feature indelibly remains behind with tampering this makes it difficult for the forger to re-register a simulated feature with the previous genuine security feature. The first line of defence feature must be designed to overlap the photograph area but must also not dominate the photograph.

Secondly, the security should incorporate covert security features, which are often protected by secrecy and generally confirmed with the aid of special devices. These features afford various levels of protection depending on how easily they can be found, analysed and duplicated or simulated by the counterfeiter. The identification document usually has a range of these features, with the highest level feature reserved for the issuing authority and the low to medium level features primarily for third party verification.

This paper focuses on developments at Note Printing Australia (NPA) on both overt and covert levels of document security for identification documents such as passport datapages, drivers licences and ID cards.

Autostereoscopic Film

It is well known in prior art that microlenses can be used to develop visual autostereoscopic effects [1]. NPA has developed a security film with microlenses below the resolution of the human eye. Typically the stereoscopic imaging was limited by the print resolution. Recent advances in laser writable materials has enabled NPA to create high resolution autostereoscopic images which can be used as first line security features.

The microlens parameters were determined using paraxial approximation. In the paraxial approximation (small angles) the relationship between the radius of curvature, Rc, and the focal length, f, are given by:

$$R_c = \left(d + \frac{n_l}{n_s} t \right) \left(\frac{n_l - 1}{n_l} \right) \tag{1}$$

Where R_c is the radius of curvature, d is the thickness of the varnish and t is the thickness of the substrate and n_l is the refractive index of the varnish and n_s is the refractive index of the substrate.

Spherical aberrations and field of curvature are not taken into account using this approach, however, it is possible to reduce such aberrations by shifting the focal plane out of focus. The microlens parameters were also determined using ray tracing simulations. A comparison of the lens parameters determined from paraxial approximation and ray tracing methods are shown in Table 1. The results between paraxial approximation and ray tracing methods were found to be within 5%. The approximate depth of focus of the lenses was approximately 4 microns and therefore a tolerance of +/- 2mm is acceptable in the overall thickness variation.

Table 1: Calculated Lens Parameters

Method	t (μm)	R_c (μm)	d (μm)	Lens height,S, (μm)
Paraxial approx.	152	58.7	22.0	16.3
Ray Tracing	152	61.7	20.6	15.1

n_l =1.505 (clear uv varnish)
n_s=1.505 (Melinex 342 Polyester film)

A tool is micromachined using a diamond tipped tool with the profile determined from the lens calculations. The microlenses are then manufactured using UV forming process shown in Figure 1. The UV varnish is applied to the substrate using a reverse roll coating technique. The tool is contacted with the varnish to form the profile of the lenses whilst simultaneously cross linking the varnish with ultraviolet light.

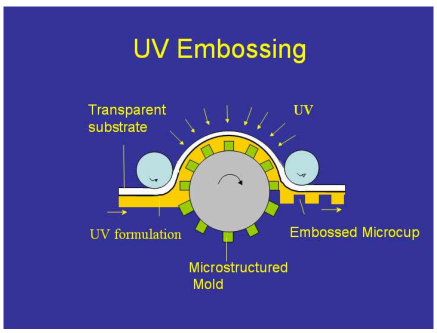

Figure 1: UV forming process for lens manufacture [2]

Intelligent Coating Developments

NPA has also developed novel translucent inkjet receptive coatings which form high contrast marking when irradiated with a UV laser light source [3]. A photochemical reaction takes place to form dark high resolution lines, typically below 40 microns as shown in Figure 2. A 248nm KrF Excimer laser with a mask based imaging system has been used for the laser marking process. Typically laser energy fluences of 100-200mJ/cm^2 per pulse have been used to create the images. The images create an optical effect when combined with the autostereoscopic film.

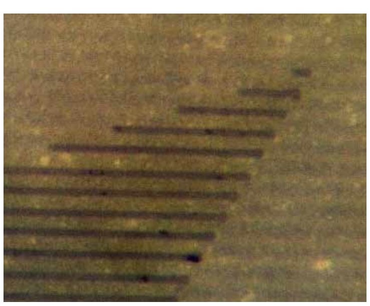

Figure 2: High resolution laser imaging (x40 Magnification)

Inkjet Print Personalisation

Inkjet printing is commonly used for personalisation of identity security documents. It is a relatively efficient and low cost approach for printing variable data. An example of the inkjet printed coating is shown in Figure 3 which is applied as a thin layer, typically in the range of 6-8 microns. The translucency of the coating enables two way image verification. This makes it more difficult for substitution of the photograph from the back of the substrate.

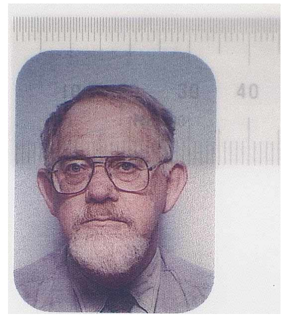

Figure 3: Two way inkjet printed image verification.

Figure 4 shows a comparison of the superior dot sharpness of the inkjet print in comparison to an existing cotton based document security paper. The paper printed image shows feathering, typical of inkjet printing on paper. This enables good variation in skin tones reducing the risk of imposters with lost or stolen ID documents.

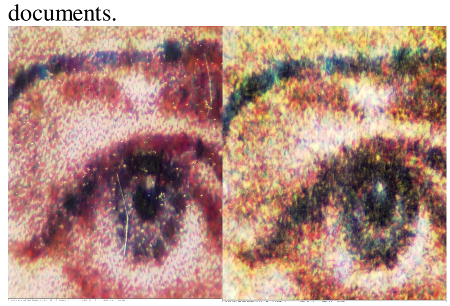

Figure 4: Inkjet print comparison between intelligent coating (left) and paper (right) – (x40 magnification)

The intelligent coating is receptive to dye and pigment based inks. The inkjet ink penetrates into the laser marked coating, such that if the variable data is removed the lasered autostereopscopic effect is destroyed. The security film is no longer inkjet receptive for overprinting with new variable data. A modified acrylic with cationic resin chemistry is used for dye fixation of the anionic inkjet dyes. This is particularly important to ensure that the inkjet dyes are indelible with different leaching agents.

Transitional Security

A security stripe pattern is printed beneath the translucent intelligent coating. Only part of the original variable data is printed in the stripe area of the document. This creates a weakness in the coating which is visible when leaching is attempted with domestic and industrial cleaning chemicals. The stripe resin chemistry was developed so that it was soluble with alkaline chemical solutions. Figure 5 shows an example of a photograph before leaching with a domestic cleaning agent and after tampering and overprinting with a new inkjet printed photograph.

Figure 5: Inkjet printed data before tampering (left) and after tampering and overprinting (right)

A range of domestic and industrial chemicals were used to test whether the inkjet printed data could be removed without destroying the autostereoscopic feature or security stripe pattern. The chemicals incorporated a range of acids, bases, organic solvents and cleaning agents. In some cases the data and coating removal was obvious clearly destroying the variable data and security features. In other cases there was no noticeable change in the coating or variable data. In a few cases partial removal of the data was possible, however, the stain from the original photograph was clearly visible when it was over printed with a new photograph and/or there was removal of the stripe pattern or the autostereoscopic effect.

Extensive laboratory tests were performed to ensure that the coating and printed variable data does not fail in normal use of the security document. The coatings were developed to obtain a correct balance between tamper evidence and normal wear of the exposed coating. If the coatings are designed to be very tough the inkjet printed data will be removed without disturbing the coatings and security features. If the coatings are inherently weak the coating and data will be destroyed with normal wear and tear. The print and coatings perform well in both tamper evidence and robustness tests. The coatings performed well against accidental spills with common liquids, exposure to heating, freezing, humidity and sunlight and against abrasion and scratching.

Multi-Level Structures

A multi-level complex embossed structure increases the complexity for the forger and counterfeiter. A scanning electron micrograph (SEM) of this feature patented by NPA is shown in Figure 6 [4]. It has been laser micromachined using a 248nm UV Excimer laser. A macro image is created and is represented by the vertical recessed areas in Figure 6. On each wall of the macrostructure there are microstructures created with two different images. The microstructured directional images on each wall are only visible at pre-determined viewing angles according to:

$$\alpha=\arctan(h/(a+s))\times(180/\pi) \qquad (2)$$

Where α is the viewing angle from the horizontal plane, h is the height of the macrostructure wall, a is half the horizantal base distance of the macrostructure and s is the horizontal distance at the bottom of the macrostructure.

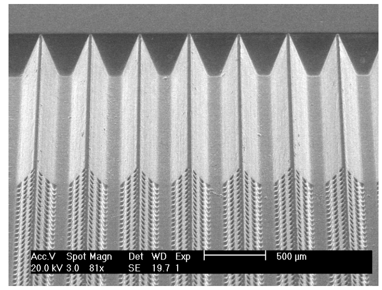

Figure 6: SEM of complex embossed patterns

Typically the recessed macrostructures are in the range of 20-100 µm in depth. The directional images are small semi-circular microstructures with typical diameter in the range of 10-30 µm.

Only one of the microstructure images is visible at the angle determined by Equation 2. As the document is tilted to the mirror image angle the second microstructure image is visible and the first microstructure image is no longer visible. An SEM of this effect at an angle of 45° is shown in Figure 7.

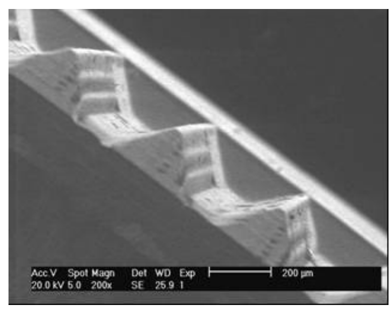

Figure 7: SEM of microstructure image at 45° viewing angle

High quality mass replication of these structures using UV embossing is being explored. Previous research into mass replication of three dimensional structures using the intaglio printing process, which is already well known for providing security documents with tactile feel was discussed previously by Muke [5]. The thermal embossing into polymer films such as polypropylene and polyester had limited success which was attributed to the high yield stress of the polymer and elastic recovery of the polymer upon releasing the stress.

Conclusions

New generation security features discussed in this paper make it more difficult for simulation and forgery of security documents. Successful developments in creating autostereoscopic effects using laser writable materials were presented. Inkjet receptive coatings which incorporate transitional security have been developed. The printed variable data is partially removed and security features are destroyed when alteration of data is attempted.

References

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Biography

Dr Sani Muke completed his PhD in polymer rheology at RMIT University. He has been working as a Senior Research Scientist with Note Printing Australia for 4 years. He leads key research and development projects in both currency and passports. He holds several patents in the field of document security and has authored many papers on the topic at internationally recognised conferences. He is a registered document examiner and an active member of the "Four Nations" counterfeit deterrence working group.