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Security Print Features based on Additive Manufacturing – threat or opportunity?

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Abstract

Additive Manufacturing technologies have the potential to be of significance in the field of secure documents. The aim of this paper is to show with examples areas where these could arise. It concentrates on the areas where Additive Manufacturing can add tactile features to a document as this could well be the area where the technology has earliest significance in security printing.

To a certain extent 2.5D printing already exists in the security sector, but not specifically from the digital domain. It may well be that Additive Manufacturing will initially be a threat to these established features, rather than a source of new ones. So the paper illustrates the potential for Additive Manufacturing systems to duplicate existing tactile security features and then shows where this knowledge could be the source of new features.

The work also considers the possibility for the fabrication of optical features for secure documents by Additive Manufacturing.

Introduction

Additive Manufacturing technologies have established themselves as a fabrication technique in a number of applications areas. Many of these implementations require the fabrication of rigid or semi-rigid features so techniques such as laser sintering of metals are important. However, some applications require the fabrication of more flexible structures and here polymer materials become significant. It is the aim of this paper to demonstrate that polymer fabricated structures could be of significance in the field of secure documents.

Tactile features are an important feature of many secure documents. Examples of these include banknotes, identity cards, passports and entry visas. They are important because they are used as an authentication test by touch alone, leaving the document inspector free to view and interact with the person presenting the document.

These features look likely to be the area where Additive Manufacturing will have the earliest significance in security printing and so this is the focus of this paper. These features are currently produced by both printing and embossing techniques and are essentially 2.5D features – the height will be shown to be much smaller than their horizontal dimensions.

So to a certain extent 2.5D printing already exists in the security sector, but not specifically from the digital domain. For example, intaglio printing is used in passports and banknotes to produce tactile features.[1] It may well be that Additive Manufacturing will initially be a threat to these established features, rather than a source of new ones. As a result this paper illustrates the potential for Additive Manufacturing systems to duplicate existing tactile security features and shows where this knowledge could be the source of new features.

The area of Printed Electronics is one that can be seen as Additive Manufacturing and has a potential place in Security Printing.[2] However, this is outside of the scope of this present paper and will not be considered here.

2.5D printing in secure documents

Most of the print in secure documents is produced by 2 dimensional manufacturing techniques.[3] Although multiple printing techniques are used and overlaid it produces output that is substantially flat over the scale of a printed sheet. This is 2D print in the lexicon of additive manufacture.

However, there are a number of features used in secure documents that intrude into the 3rd dimension with the aim of producing a tactile feature – an artefact that can be discerned by touch. It will be shown later in this work through a combination of photography (camera and microscope images) and white light interferometry that these height differences are of the order of 15-30μm so the vertical scale is much smaller than the print area. Hence the label "2.5D printing".

This work considers the physical characteristics of two tactile features used in secure documents – raised engraved features on identity cards and intaglio print on paper documents, including banknotes.

Polycarbonate identity cards

Tactile features can be produced on polycarbonate using a card press. Features engraved into the plates in the card press transfer the engraving into the surface of the card, producing a tactile feature. This type of feature is illustrated the microscope image shown in Figure 1, taken from the design illustrated in Figure 2

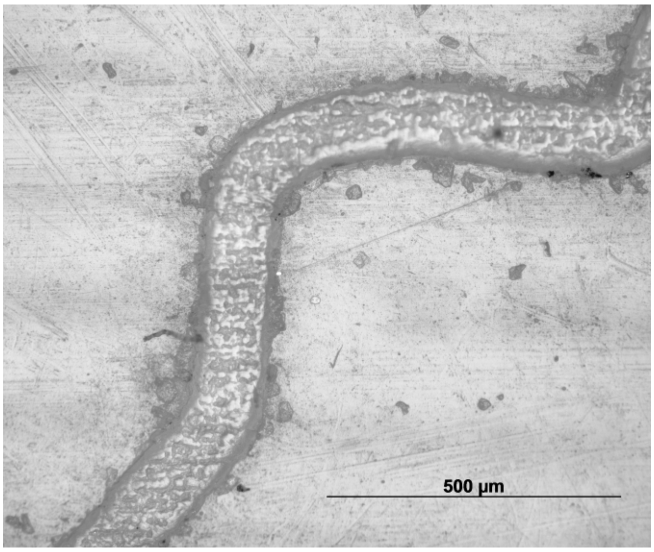

Figure 1 Tactile feature on the surface of a polycarbonate identity card

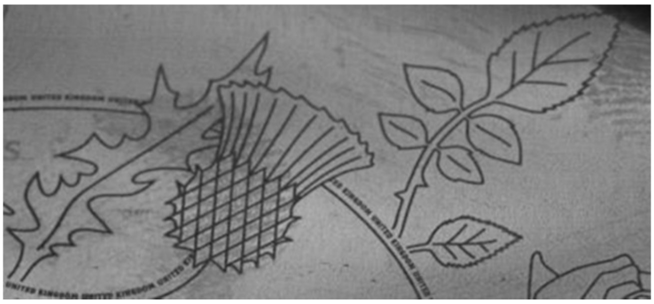

Figure 2 Glancing angle illumination on a polycarbonate card tactile feature

These 2.5D features that can be rendered visible by the unaided eye are highly sought for secure documents. The 2.5D detail within these features can be measured using white light interferometry, as illustrated in Figure 3.

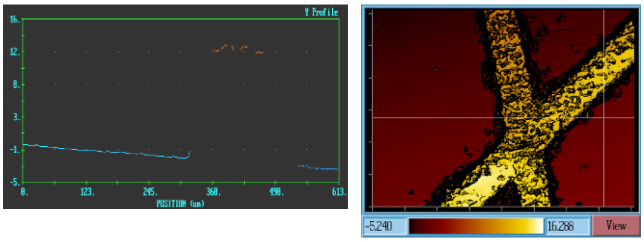

Figure 3 White light interferometer images from the polycarbonate tactile feature in Figure 2.

Figure 3 demonstrates that the tactile feature has a height of around 10 – 15 µm which is sufficient to provide tactile features that are easy to discern. It can also be seen from Figure 1 that the surface of the tactile line has greater surface roughness than the surrounding polycarbonate card, probably adding to the tactile differentiation.

Intaglio print on documents and currency

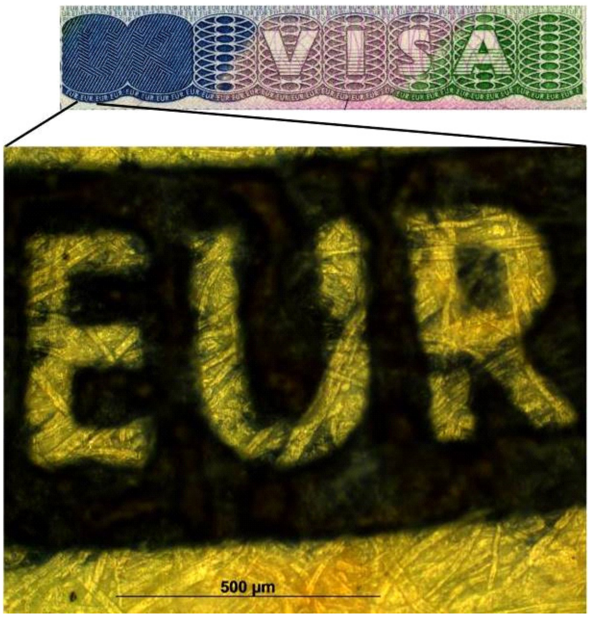

Figure 4 Intaglio print onto paper with microscope image

Intaglio printing features widely in both secure documents and currency production. In addition to fine detail and tight registration of printed features the process also produces a surface relief to the print, imparting a tactile feature.[4] This is an important and secure feature as the supply of intaglio presses is controlled.

Figure 4 shows an example of an intaglio print onto a paper visa. Again, the 2.5D detail within these features can be measured using white light interferometry, as illustrated in Figure 5. The area measured is the central limb of the letter “E” in Figure 4.

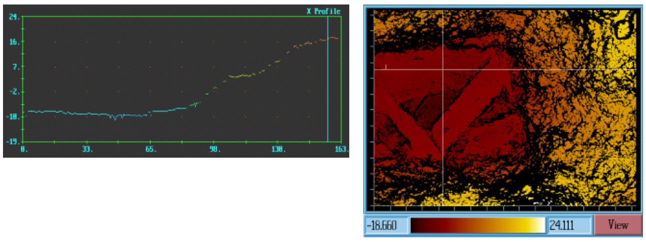

Figure 5 White light interferometer images from the visa tactile feature in Figure 4.

Figure 5 demonstrates that the tactile feature has a height of around 25 – 30 µm, again sufficient to provide tactile features that are easy to discern.

The potential for new print technologies

The manufacturers of secure documents need a continuing source of new features to keep ahead of the technologies deployed by the counterfeit and forgery “industry”.[5] Moving forward, Additive Manufacturing techniques could lead into new areas for variable tactile features for secure documents, in areas such as variable texture.[6]

There are several Additive Manufacturing platforms that can aid in the production of a tactile feature. Powder bed printing, inkjet printing, extrusion, stereolithography and selective laser sintering all offer different build mechanisms, product finishes, post processing requirements and accessibility. The most applicable for the fabrication of tactile features are currently those that focus on polymeric materials.

Inkjet printing and stereolithography both offer high resolution builds however the inkjet platforms allow the use of a wide range of substrates. Inkjet printing for Additive Manufacturing encompasses a variety of techniques. Printing binder onto polymeric particles can fabricate a textured three dimensional object. These printers are more suited to three dimensional prints and do not offer any control over the substrate or enabling the tracks to adhere to a surface. The use of UV curable polymer resins form the basis of the higher resolution printing models. These print the UV curable resin and support matrix which is then followed by a UV light source to cure the material before the next printing pass. In this manner it is possible to create three dimensional objects with fine detail. The typical resolution of printers using this technology can reach 16µm.

Extrusion based Additive Manufacturing is readily available and is not limited to those marketed at hobbyists. There is a large range of high precision extrusion printers available which can achieve layer thicknesses of 100-300µm (Fortus 250MC – Stratysys). Extrusion offers a more diverse material selection without any specialist formulations and yields a final print which is robust and easily handled, allowing for more post-processing techniques which may be required to incorporate it into a secure document.

The basic replication of a 2.5D tactile feature does not require a specialised three dimensional printer. The Dimatix DMP2800 printer is a widely used laboratory tool for inkjet deposition which is simple to use, requiring little specialist training, readily available and capable of overlaying ink to produce track widths of 100-200 µm with a controlled height. Commercially available inks range from silver nanoparticle ink used to create conductive features to polymeric formulations such as PriElex® which is aimed at challenging the lithography market. The use of an SU-8 material such as PriElex® can yield track heights of 12-15µm from one pass making the tactile feature height an easy target.[7] Printers, both home and specialist are becoming a readily available commodity with a user base that is not afraid to modify the materials, hardware or intended applications. Printers are already used to bypass fingerprint scans and are moving towards the generation of tactile features for the blind. It is therefore logical to assume that they will be used to add tactile features to security documentation.

An initial practical example

It was decided to conduct some initial tests to look at technologies to reproduce this type of 2.5D feature in order to both inform the authorities how this may be done illicitly and to generate novel features.

Thermographic printing is a known technique to reproduce such features but can often be differentiated from the original by the surface roughness. Using modern Additive Manufacturing technologies we should be able to improve on this.

In order to demonstrate the effectiveness of inkjet to generate these type of 2.5D features an initial experiment was conducted. A number of digital printing technologies were considered, such as clear toner.[8] However for various practical reasons an inkjet solution was preferred as this would appear to be more scalable.

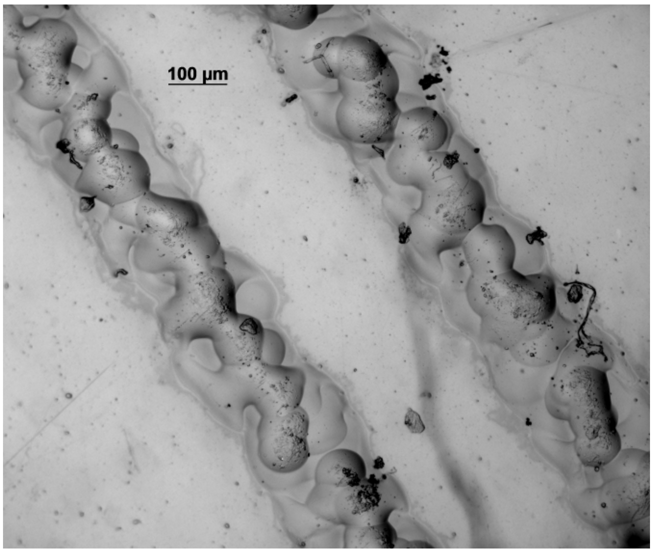

Figure 6 Tactile UV cure ink lines on an acetate sheet

The initial aim was to replicate the type of clear, raised feature illustrated in Figure 1. This first test was therefore made on an acetate sheet using an Apache flatbed UV cure inkjet printer fitted with Epson DX5 print heads using clear ink in collaboration with Axzyra in Cambridge UK. The feature was built up with 4 passes of 1440 x 1440 dpi with 3 of the 8 available channels using the printhead in a scanning mode with one led cold cure UV lamp. The aim was to begin to explore the range of tactile features that could be created with readily available UV cure systems.

The result from printing a set of nominally 100µ parallel lines is illustrated as a photomicrograph in Figure 6. Although comparison with Figure 1 shows the inkjet printed lines to be somewhat wider to the unaided eye they appear very similar, close enough to pass a front line visual and tactile inspection.

The 2.5D nature of these inkjet printed features is revealed in Figure 7. This first test was readily producing features in the 10 – 15 µm, illustrating that this space was relatively easy to explore by UV cure inkjet. This reinforces the findings of a previous study.[9]

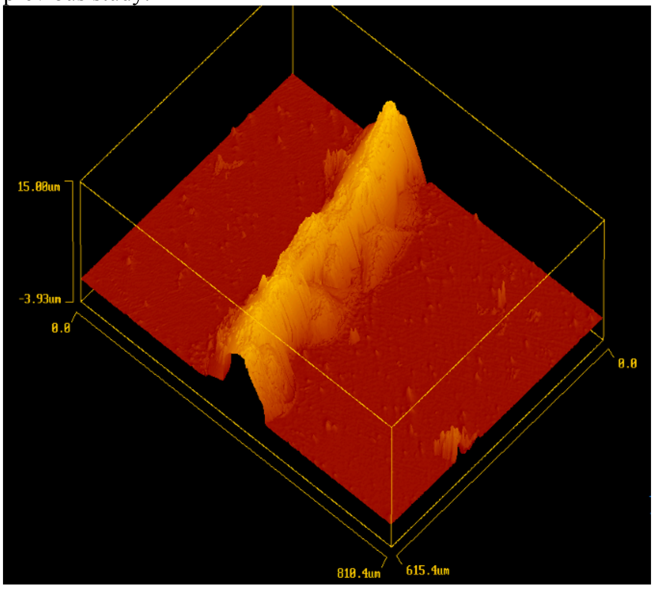

Figure 7 White light interferometer images from a UV cure inkjet line from the print illustrated in Figure 6.

Additive Manufacturing – the threat to existing features

As the images in the previous section illustrate, UV cure inkjet is capable of producing features that could be easily confused with tactile features on polycarbonate cards. As such they seem likely to pass level 1 inspection – an unaided visual and tactile inspection.

The situation with intaglio print is somewhat more complex. As illustrated in Figure 4 these features are printed in colour but with UV cure inkjet this can readily be achieved. It would then become an exercise in colour management to achieve the right visual appearance.

However, this threat is for the moment only at level 1. One specific area where secure document inspection differs from commercial print is in the use of 10x hand lenses. These are routinely deployed by document inspectors to look for the precise registration and fine features that should distinguish a good secure document from a counterfeit or fraudulent alteration. The use of a 10x lens does allow for useful features sizes below 100µ. An example of this is illustrated in Figure 8, a microscope image from the same intaglio print as Figure 4 but from an area directly above the “EUR” text. It can be seen that intaglio print is capable of producing some very sharp lines, distinguishing it from many other printing techniques. These would readily be distinguishable from the sort of features illustrated in Figure 6.

There are now also machine vision inspection systems in use where images are acquired using CCD cameras and a variety of optical configurations.[1] These tend to be limited to back office or forensic examination because of convenience and cost but are a machine vision application where considerable opportunity still exists. These too should readily differentiate these features.

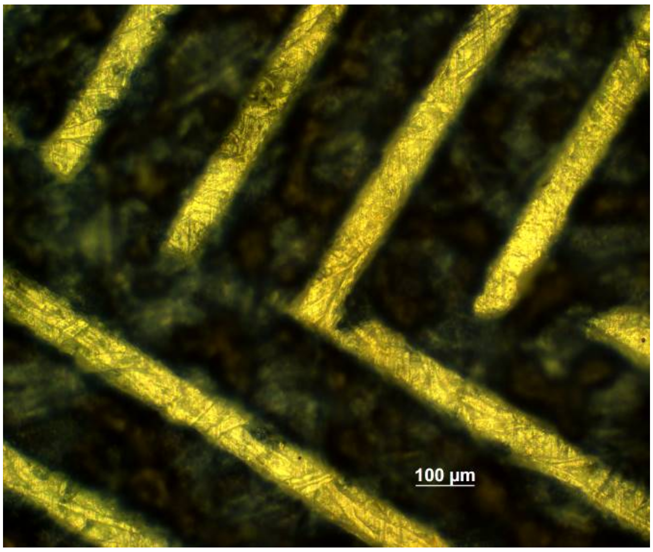

Figure 8 Intaglio print onto paper showing fine detail and sharp, straight edges

Additive Manufacturing – the opportunities for new features

Additive Manufacturing techniques open up a new area of potential for document security features. Here are 2 examples of these opportunity areas.

Digitally printed tactile features

The tactile features are detected by touch by the document inspector. In the simplest case this comes down to a simple question "is there any differentiation to feel?". At a deeper level the examiner may be considering the roughness of the surface, to differentiate a real feature from a counterfeit.

Features that have variable roughness would provide an attractive alternative in this application area. It has already been shown that Additive Manufacturing techniques can produce some interesting texture differences.[6] This is a field that could be fruitful to explore for secure documents

Printed optical features for secure documents

Optical features are often used as security features in identity documents, some of which use arrays of micro lenses.[10] These micro lenses themselves impart a tactile feel due to their surface relief.

It has been shown that Additive Manufacturing is a technology that could produce such micro lenses to produce interesting features.[11,12] This could be a source of future security features but Additive Manufacturing systems could provide us with much more.

Conclusions

In the short term Additive Manufacturing technologies pose a threat to established tactile features in secure documents. It is easily capable of duplicating the feel but not the look of established features.

However, the technology platform opens up exciting areas for new features. Novel tactile features will certainly be one but optical features are certainly an attraction. Whilst this is certainly an exciting option for security features the technologies described in the tactile features may provide a shorter route to early adoption.

Acknowledgement

The authors would like to thank Steve Woods of Axzyra, Cambridge UK for making the sample illustrated in Figure 6.

Biography

Alan has 30 years experience in printed hard copy and a background in photography and image science. After consultancy work in Printed Electronics and Security Printing he has also spent 7 years at 3M, specialising in print solutions for high security documents and the integration of Printed Electronics into 3M manufacturing. He has recently returned to his consultancy business, working on printing consultancy projects that include functional print.

Alan has a BSc in colorant chemistry and a PhD in instrumentation, both from the Department of Chemistry at the University of Manchester. After a 30 year gap he has returned to the University as a Visiting Academic to the Centre for Digital Fabrication. He is immediate past President of the IS&T.

Rachel is a Senior Experimental Officer for the Centre of Digital Fabrication at The University of Manchester. Rachel graduated from The University of Manchester with an MEng (Hons) in Biomedical Materials Science, incorporating an industrial placement at DePuy CMW formulating novel bioactive bone cements. She completed her PhD with Professor Brian Derby researching the effect of inkjet printing on cell survival. An EPSRC Life Sciences Interface Research Fellowship enabled Rachel to continue her research in inkjet printing for tissue engineering applications which has since expanded into printing functional materials, electronics and solar cells.

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