Institution: Imperial College London

Unit of Assessment: 9 Physics

Title of case study: P12 - Anticounterfeiting: Ingenia Technology Ltd and Laser Surface Authentication

1. Summary of the impact (indicative maximum 100 words)

A spin-out company, Ingenia Technology Ltd, was launched in 2005, to bring the technique now known as Laser Surface Authentication (LSA) to market. LSA is used to detect and prevent forgeries by allowing a unique, naturally occurring and uncopyable identity code to be read from material surfaces. It is particularly useful for fighting counterfeiting and smuggling of high-value documents and products and as such makes an important contribution to (i) industrial and consumer safety, (ii) commercial revenues and (iii) countering criminal activity. Organisations and companies contracted to use Ingenia's LSA technology include the pharmaceutical firm Bayer, carton manufacturers CARTONDRUCK and Grafiche Bramucci, Swiss precious metal refiner PAMP and the International Atomic Energy Agency.

2. Underpinning research (indicative maximum 500 words)

Prior to moving to Imperial in January 2005, Professor Cowburn developed a nanometrology instrumentation to allow reflected laser light to be used as a probe of the magnetic state of nanostructures fabricated on a silicon surface. In August 2005, after moving to Imperial, Cowburn published a paper in Nature [1] showing how the same optical geometry could be reconfigured to allow non-magnetic information with nanometre sensitivity to be extracted and how this could be used to probe the "natural nanostructure" (surface morphology) present in paper and other surfaces. With LSA, a surface is illuminated with normally incident laser light that scans across the surface. Photodetectors then capture photons that have been diffusely scattered while not seeing those that are specularly scattered. It is the fluctuations in this diffusely scattered intensity as the laser probe is scanned across the surface that is related to the underlying physical structure. Ingenia Technology was born out of this finding.

The initial observation and realisation of its potential use, was made prior to Professor Cowburn moving to Imperial, but the physical origin of the effect was incorrectly interpreted in [1]. It was only after further research entirely carried out at Imperial College after August 2005 by Professor Cowburn and his team (equivalent to 16 research years of basic physics research), that the phenomena was understood properly, and only on this basis was it possible to develop the instrumentation used today within Ingenia that is responsible for the impact reported here.

Research performed for paper [2] and PR Seem's PhD thesis (2009) proved key in helping to understand the physical mechanism that links surface morphology to the random optical intensity variations which are actually recorded. In paper [1] that mechanism was described as laser speckle; paper [2] disproved that and showed it to be an incoherent scattering similar to that known as 'clutter' in radar signals over sea water. This information radically changed the design of the laser heads – specifically, the team learned that it was necessary to maximise the numerical aperture of the receiving optics in order to minimise speckle. This was the very opposite of what had been initially thought of as the best way to design sensor heads because the effect was originally interpreted as due to laser speckle. In this way, the work at Imperial College represents a fundamental contribution to the technology.

Patent [3] describes a complete system for protecting the identity of goods and documents, involving an enrolment stage in which laser scattering is used to capture a (i) unique signature, (ii) all of the digital signal processing that has to be applied to the signal to make it useful and robust, (iii) the required database architecture and (iv) a validation stage in which a second laser scan is taken and the database searched for the matching algorithm (based around cross-correlation). In summary, this makes the observed signature as robust as possible for use in real-world environments. Further patents (e.g. [4, 5]) describe improvements such as breaking the signature into small blocks that are allowed to move freely to account for stretch in the object or errors in the time-base of the recording instrument, as well as specific embodiments in which the laser head is

integrated into, for example, a printer.

Key researchers:
Prof Cowburn, Chair in Nanotechnology, Imperial College London, 2005-2010
Dr P Seem, PhD student, Imperial College London, 2005-2009
Dr JDR Buchanan, Senior Application Engineer, Imperial College London, 2005-2010
Dr S Buehlmann, Senior Application Engineer, Imperial College London, 2008-2010

3. References to the research (* References that best indicate quality of underpinning research)

[1] *Buchanan JDR, Cowburn RP, Jausovec A, Petit D, Seem P, Xiong G, et al. "Forgery: 'Fingerprinting' documents and packaging", Nature, 436, 475 (2005). DOI. **30 citations as at 21/11/13**

[2] *Seem PR, Buchanan JDR, Cowburn RP, "Impact of surface roughness on laser surface authentication signatures under linear and rotational displacements", Optics Letters, 34, 3175 (2009). DOI. **4 citations as at 21/11/13**

[3] *Patent WO2007012816 A1, "Verification of authenticity", Inventors: Cowburn RP, Buchanan JDR, Applicants: Ingenia Technology Ltd, Publication date: 1/1/07

[4] Patent US2010316251 (A1), "Optical Authentication", Inventors: Cowburn RP, Buchanan JDR, Seem PR, Applicant: Ingenia Holdings Ltd, Publication date: 28/6/07

[5] Patent WO2007132174 (A1), "Data storage device and method", Cowburn RP, Petit D, Read D, Petracic D, Applicant: Ingenia Holdings Ltd, Publication date: 22/11/07

4. Details of the impact (indicative maximum 750 words)

The research in [1-3] provided both the original observation that "natural nanostructure" could be probed with enough repeatability using a relatively simple and inexpensive laser geometry as well as the physical understanding of the scattering mechanism required to translate this laboratory observation into a proper technology that could be deployed into real-world settings.

The impact was secured by Imperial forming a partnership with the investment company Ingenia Holding Ltd (formed in 2003) which provided both the research funding required and the technology transfer know-how to fully launch the company, to engineer products and to form business partnerships. Buehlmann and Buchanan's positions at Imperial were both funded via a £1M per year research contract between Ingenia and Imperial. Imperial also allowed Professor Cowburn's teaching duties to be bought-out in 2005-2010, thus freeing his time to serve as Chief Technology Officer to Ingenia Technology from 2005-2010 [A], ensuring that the research and the impact were closely aligned. The company started trading in 2005, following the publication of [1], and was incorporated in England and Wales in 2006.

The physics of the optical light scattering that underpins LSA is more complex than it first appeared. This has important consequences for the optimum way to engineer products based on LSA. Without the close relationship between the physics research within Imperial and those trying to commercialise the technology at Ingenia Technology, success would not have been possible. Dr P Seem joined the Ingenia team after graduating in 2009 and Drs S Buehlmann and JDR Buchanan joined after leaving Imperial in 2010 [A].

Ingenia Technology now employs seven people in total [A]. Its headquarters are in the City of London and it also has offices in Vienna and Zurich. It is part of the NewScope Group, a Swiss-based, privately funded business, comprising a number of specialist high-end technology companies. The Ingenia team consists of a mix of business and security experts and of specialist engineers and physicists with many years of experience in electronic and product engineering and includes three members of the original research team from Imperial College [B].

Ingenia currently offers several main products including line and field scanners, and LSAControl and LSANet software [A, C]. The research at Imperial contributed, either directly or indirectly, to the development of these products [A]. Ingenia supplies these solutions to luxury product manufacturers, carton producers (e.g. CARTONDRUCK, Grafiche Bramucci), precious metal refiners (PAMP), one of the world's largest perfume manufacturers, pharmaceutical firms (e.g. Bayer [D]), government agencies (e.g. International Atomic Energy Agency, IAEA) and national laboratories, as detailed below. These projects have ranged in value from £20,000 to £200,000

each [A].

With the IAEA Ingenia developed the LSA system to "extract an intrinsic material signature from both the copper and brass parts of the IAEA CAPS metal seal" [E]. The LSA system "has been delivered and tested to meet IAEA specification for usability and accuracy" [E]. The technique will augment and potentially replace the subjective imagery analysis method of comparing metal seal optical images that are currently used, thereby providing strong protection against counterfeiting.

In 2010, Ingenia signed a partnership agreement with IDT, a leading 2D and 3D in-surface decoration systems provider, allowing IDT to offer Ingenia's LSA technology to its customers. "Working with Ingenia Technology will allow us to offer a much more comprehensive authentication and identification package for our customers," commented Peter Woodd, CEO of IDT Systems. "Ingenia's LSA technology is the most robust and sophisticated solution for product tracing and anti-counterfeiting that we have seen in the marketplace, making it a perfect complement to our existing D Series system technology" [F].

In 2010 a partnership with CARTONDRUCK, a leading worldwide manufacturer of high-quality cartons, was announced, "supporting movement into the luxury goods market" [G]. This agreement allows "Germany-based CARTONDRUCK, a manufacturer of high quality boxes for the cosmetic and fragrance industry…to offer Ingenia Technology's Laser Surface Authentication (LSA) anti-counterfeiting technology as a service to its customers" [D]. The cartons are used by CARTONDRUCK's customers to authenticate and track their products. The most important function in this market is to combat diversion of products from one country to another and sale of products by unauthorised retailers. The "agreement will also see both companies partnering to promote LSA technology more broadly to empower owners of high value brands with an effective tool for fighting counterfeiting and smuggling" [H].

In 2013 a similar deal was announced with luxury carton manufacturer Grafiche Bramucci, enabling Grafiche Bramucci to provide clients in cosmetics, fragrance and luxury products customers with access to Ingenia's LSA technology. Grafiche Bramucci has installed Ingenia's scanning and coding system as part of what it describes as a "comprehensive anti-counterfeiting and anti-diversion initiative" [I]. Commenting on the deal, Francesca Bramucci, director and owner of Grafiche Bramucci, said "With the rise of illicit trade within the luxury sector and given our prestigious customer portfolio, it is vital that Grafiche Bramucci is able to offer the very best solutions for anti-counterfeiting and anti-diversion" [I]. The Italian firm counts a number of luxury goods companies among its clients, including Garnier, Giorgio Armani, Lancome, Moschino and Versace, as well as other premium brands such as Campari [I].

Ingenia has developed a complete authentication system for precious metals with leading Swiss refiner PAMP, the world's leading bullion brand. This Veriscan™ system uses Ingenia's LSA system to scan and code every gold and silver bar produced by PAMP and then enables authentication by multiple users across the world. According to the PAMP press release, "PAMP, the renowned industry innovator, once again transforms the world of precious metals by introducing the latest in Laser Surface Authentication technology: VeriScan™. With a uniquely individual and imperceptibly present 'surface signature' that is up to four-times more distinctive than a human fingerprint, each PAMP bar is designed to enhance authenticity while offering you a world of possibilities to identify and manage your transactions of PAMP bullion. Progressive worldwide rollout begins early 2013" [J]. Ingenia hosts the secure database for PAMP and has developed a customised version of their hardware and software for them.

The practical value and novel benefit of Ingenia's LSA technology was nicely described in an Economist article in 2011. The article describes the novel "tamper-proof method of "laser surface authentication"….developed initially at Imperial College, London" [K]. The "fast, low-cost" method is praised and described [K]:

- "Nor is the system easy to fool. A piece of paper such as a banknote can be crumpled, soaked in water, scorched and scribbled on but still have its surface clearly readable. Even torn, scratched and partially missing surfaces can be read."

- "With scan times of less than a second, the system is fast enough to be used on a production line."
- "Ingenia has tested the system on the packaging used for various high-value goods, like perfume, along with the security seals used on dangerous or valuable substances, and on passports, postage stamps and documents such as financial instruments. As the system provides each item with an identity, it can be used to track genuine goods and documents. Should a bank want to, it would be able to match every note it issued with the serial number printed on it. However clever a counterfeiter is, forging that is likely to prove impossible."

The LSA system is very versatile and "can be used to validate the authenticity of official documents, passports, visas, evidence certificates, ID cards, packaging and products…LSA™ can be also used: (i) in the protection of national borders through the authentication of documents and personal identities, (ii) to identify counterfeiting of pharmaceuticals, tobacco products, alcohol and other vulnerable goods, (iii) to ensure secure supply chain management, (iv) to help detect currency counterfeiting, (v) for authentication of critical parts for the aerospace and automotive industries, (vi) to reduce 'grey market' issues, (vii) to prevent revenue fraud, (viii) forensic analysis, (ix) art and collectable item authentication, (x) document security" [L].

Since its inception LSA has been internationally recognised via the award of numerous prizes:

- Winner of Global Security Challenge (2006)
- Winner of Hermes International Technology Award with Bayer Technology Services – a €100,000 prize awarded at the Hanover Fair for the best new technology exhibited (2007) [J]
- Red Herring Global 100 award (2007) – the naming of Ingenia by the investment magazine Red Herring as one of the best 100 companies in the world for investment
- EU Descartes Prize Nominee for excellence in trans-national collaborative research (2008)

5. Sources to corroborate the impact (indicative maximum of 10 references)

[A] Business Development Director, Ingenia Technology (UK) Limited

[B] Ingenia Technology Ltd 'About us' webpage, http://www.ingeniatechnology.com/about-us/ (archived at https://www.imperial.ac.uk/ref/webarchive/2qf on 3/9/13)

[C] Ingenia Product webpage, http://www.ingeniatechnology.com/product/ (archived at https://www.imperial.ac.uk/ref/webarchive/3tf on 11/10/13)

[D] http://www.bayertechnology.com/en/press/hermesaward.html?sdl=1&cHash=630ed69e55a790128453cba6b0bd88fd (archived at https://www.imperial.ac.uk/ref/webarchive/ysf on 27/9/13)

[E] International Atomic Energy Agency, STR-371 document, 'Development and Implementation Support Programme for Nuclear Verification, 2012–2013', page 124 (archived here)

[F] Business Wire article on bloomberg.com, 29/10/10, 'Ingenia Technology and IDT Systems Ltd Sign Partnership Agreement', http://www.bloomberg.com/apps/news?pid=newsarchive&sid=agwJplFj4vdM (Archived at https://www.imperial.ac.uk/ref/webarchive/wqf on 30/8/13)

[G] Business Wire article on Reuters.com, 11/1/11, 'Ingenia Technology Reflect on a Successful 2010 as Key Markets Are Identified for 2011', http://www.reuters.com/article/2011/01/11/idUS124988+11-Jan-2011+BW20110111 (Archived at https://www.imperial.ac.uk/ref/webarchive/xqf on 30/8/13)

[H] Packaging Business Review article, 14/10/10, 'Ingenia, CARTONDRUCK sign agreement on LSA technology', http://automationandtechnology.packaging-business-review.com/news/ingenia-cartondruck-sign-agreement-on-lsa-technology (Archived at https://www.imperial.ac.uk/ref/webarchive/yqf on 30/8/13)

[I] SecuringIndustry.com article, 15/7/13, 'Ingenia forms alliance with Grafiche Bramucci', http://www.securingindustry.com/cosmetics-and-personal-care/ingenia-forms-alliance-with-grafiche-bramucci/s106/a1780/ (archived at https://www.imperial.ac.uk/ref/webarchive/1qf on 3/9/13)

[J] PAMP Press release about Veriscan™, 10/12, 'The Fingerprint of the Future' (available here)

[K] Economist article, 12/7/11, 'Zapping fakes with lasers', http://www.economist.com/blogs/babbage/2011/07/anti-counterfeiting-measures (Archived here)

[L] Laser Surface Authentication LSA™ Security Solution Presentation, Ingenia Technology (UK) Ltd 2010, page 9 (available here)