SecureFLIM—Fluorescence Lifetime Imaging for Product and Brand Protection

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Fluorescent security inks are well known features used to protect banknotes, documents and high-value products from counterfeiting. Currently these features are verified simply by inspecting their appearance (color and position) under a specific illumination. Fluorescence lifetime is an attractive parameter, which can drastically increase the security of current fluorescent tags and allows distinguishing tags that appears identical under a conventional fluorescent camera. Measuring fluorescence lifetime is however not straightforward and has traditionally required bulky, complex and expensive equipment. Here, we present a novel system based on a portable, cost-effective fluorescence lifetime imager and specially developed for lifetime-encoded tags, which has the potential to accelerate the uptake of fluorescence lifetime for anti-counterfeiting.

Counterfeiting is a globally increasing problem impacting companies, governments and consumers, causing every year estimated losses of more than $ 200b worldwide. Of particular interest to counterfeiters are high-value products, such as pharmaceuticals, software, watches, and fashion goods. The problem is therefore particularly acute in Switzerland, with yearly losses estimated around CHF 2b. In response to this problem, anti-counterfeiting companies are constantly developing new and improved security features, in order to make valuable items harder to copy.

Fluorescent tags are well-known security elements, often encountered in banknotes, documents and luxury goods. Currently, fluorescent tags are checked simply by verifying their appearance (color, pattern) under a specific illumination (typically UV light), either by eye or with a fluorescence camera. Fluorescence Lifetime Imaging (FLIM) has recently attracted interest as an additional, hardly replicable covert feature. The adoption of the technology, however, has been severely hampered by the size, the high cost (60-100 kCHF), and the complexity of current FLIM systems, as well as by the lack of suitable materials for lifetime-encoded tags.

As reported previously, CSEM recently developed a compact, cost-effective reader for wide-field frequency-domain FLIM, including a MHz-modulated LED (460 nm), a CMOS-TOF imager (256×256 pixels), and dedicated FPGA electronics (Figure 1, left). The reader, originally developed for medical applications, yields a 2D map of fluorescent lifetimes with nanosecond resolution in a single shot.

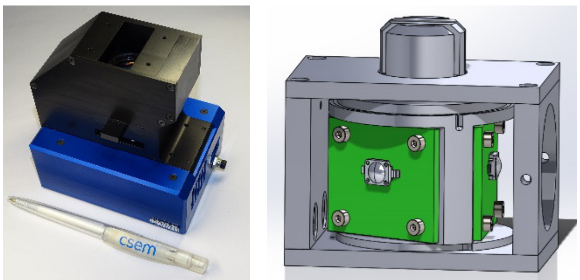

Figure 1: (Left) FLIM prototype with 465 nm excitation; (Right) Multi-wavelength illumination module with 3 LEDs (365 nm, 465 nm, 520 nm).

In collaboration with the Swiss company U-NICA, the FLIM reader was adapted for the specific needs of the anti-counterfeiting application. In particular, a multi-wavelength illumination module incorporating three LEDs (365 nm, 465 nm, and 520 nm) was developed (Figure 1, right), allowing the user to select the optimum illumination wavelength for various security tags. The new module will allow measuring security tags based on UV inks, which represent the majority of the fluorescent tags currently used. The imaging optics of the reader was also redesigned, reducing the field of view from 6×6 mm to 4.8×4.8 mm, in favor of an improved spatial resolution.

For developing the fluorescent lifetime tags, a wide range of commercially available and proprietary fluorescent materials were tested. FLIM-encoded tags were produced by patterning fluorophores with specific lifetimes, or by mixing fluorophores in different ratios. Several suitable candidates for both short (<20 ns) and long (>50 ns) lifetimes were identified and thoroughly characterized. Figure 2 shows for example a compound sample with three different compounds (two short-lived, one longed-lived), imaged with the SecureFLIM prototype. As can be seen, very different lifetimes can be determined in a single image, enabling a completely new class of security features.

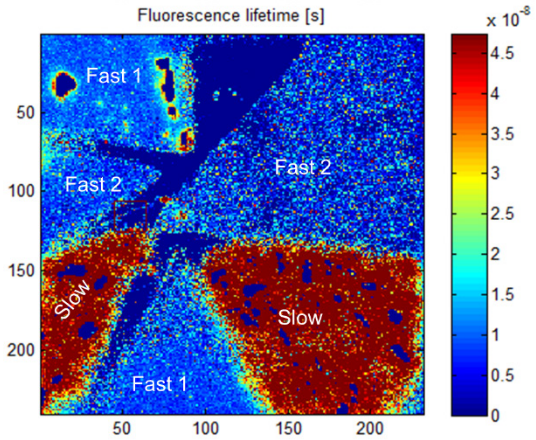

Figure 2: FLIM image of a compound sample, combining one slow (~45 ns) and two fast (<10 ns) fluorescent additives.

Next, the FLIM samples will be further refined to print patterns that can only be read in lifetime-mode. In parallel, polymer microparticles incorporating a lifetime-encoded barcode will be produced by UV polymerization in microfluidic channels. These advances will pave the way for a widespread application of FLIM in the domain of anti-counterfeiting.

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• U-NICA Micronics AG, Malans