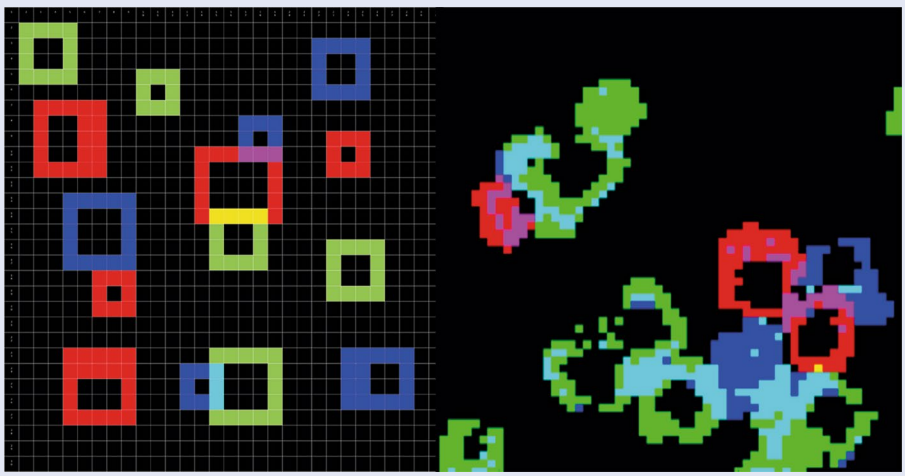
IMAGING AND SENSING

The genuine article

The fabrication of semiconductor devices inadvertently leaves behind additional microscopic structural variations that serve as so-called physical unclonable functions or PUFs. When probed, for example with appropriate light, the unpredictable but repeatable response from PUFs can be used to differentiate between otherwise similar microprocessors. PUFs can be difficult to reproduce and are thus used in cryptography and anti-counterfeiting.

Now, Miguel Carro-Temboury, Riikka Arppe, Tom Vosch and Thomas Sørensen have demonstrated an optical authentication system using luminescence from PUF patterns of lanthanide-doped materials (*Sci. Adv.* **4**, e1701384; 2018). An anti-counterfeiting system is shown and may not be far from commercialization.

The team's physical keys are PUFs made from random patterns of the taggants in polymer films (left image shows a representation of a pattern; right image shows an actual digital key read from a physical key). Specifically, the keys are made from zeolite (a robust mineral) doped with europium(III), terbium(III), or dysprosium(III) ions (using three lanthanide ions increases encoding capacities). Employing zeolite as the host material ensures that the PUFs are stable over time. Imaging the response requires excitation of the particular lanthanide(III) ions used, and by using at least two lanthanide(III) ion dopants the patterns can't be copied according to the authors. By using the custom hardware reader and software the authors designed, the random patterns are stored digitally and can later be used to authenticate a physical key in anti-counterfeiting or encrypting applications.



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Sørensen told *Nature Photonics* that they realized that the luminescent random patterns they were preparing as phantoms for optical microscopy were in fact PUFs. They wanted to make the first robust optical authentication system based on PUFs. He explained that most work went into building competency across the required broad range of fields and then bringing the parts together. He noted that there is no difficult fabrication required.

"It is worth mentioning that we resolve different patterns using different blue laser lines," said Sørensen. "Usually, different laser colours and differences in emission colour are used to resolve differences."

According to Sørensen, the next step is validation of the technology using 10,000 physical keys before commercialization. They want to "test the technology with a customer, and finally implement the technology with the customer in their specific application." The commercial activities will take place via the spin-out company Tukan ID (https://www.tukan.io/).

The technology, using excitation-selected imaging of lanthanide-doped zeolites, may yield tamper-proof tagging and provide economic and humanitarian benefits such as upholding trademark and intellectual property rights and confirming authenticity of medicine. ❐

David Pile

Published online: 29 March 2018
https://doi.org/10.1038/s41566-018-0151-2