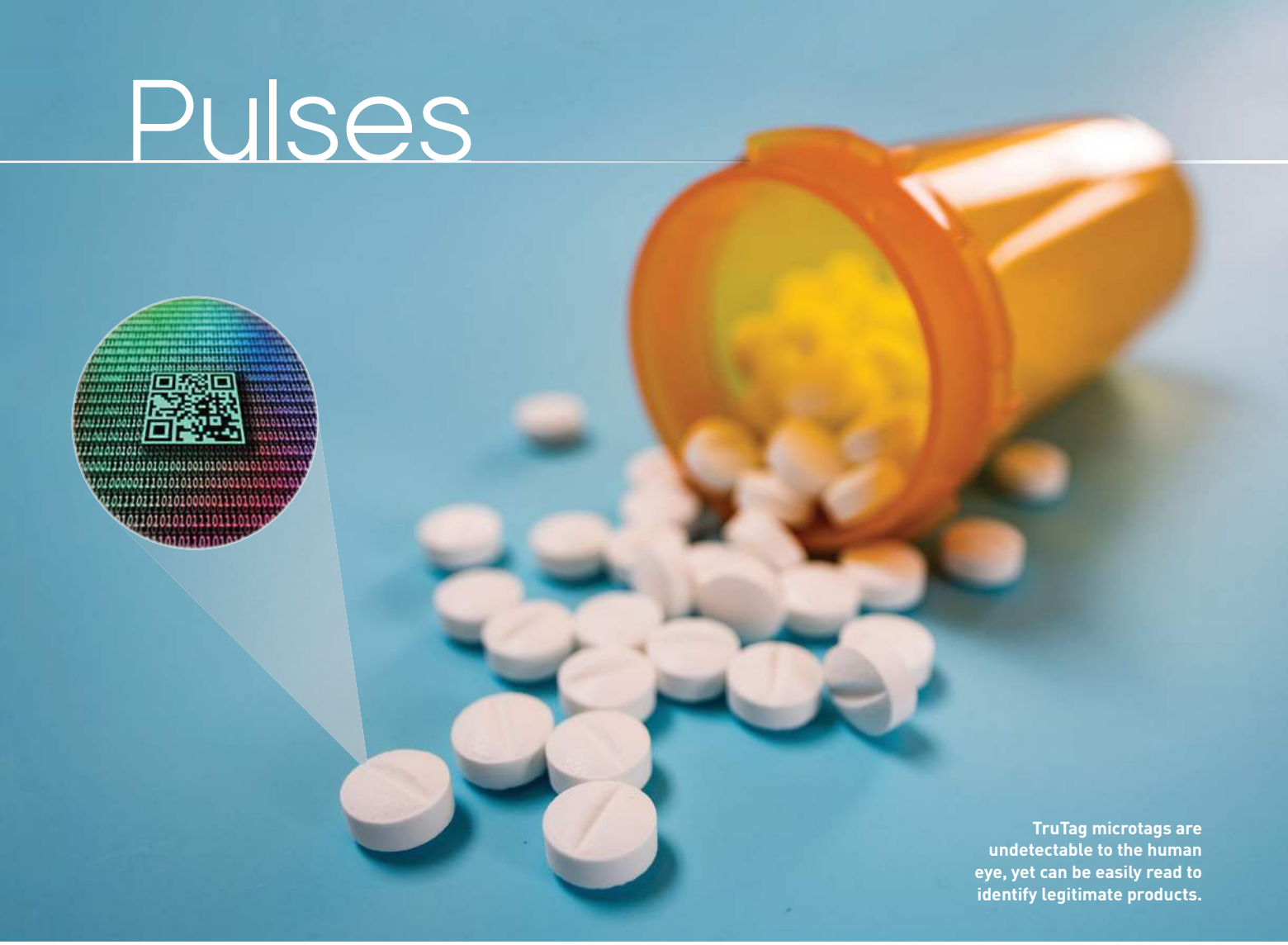


TruTag microtags are undetectable to the human eye, yet can be easily read to identify legitimate products.

Inset: TruTag/Background: Getty Images

OPTICS INNOVATIONS

# Seeing Beyond with TruTag

An incubator spin-out has found a home for its products beyond its initial markets to unleash the full capabilities of hyperspectral imaging.

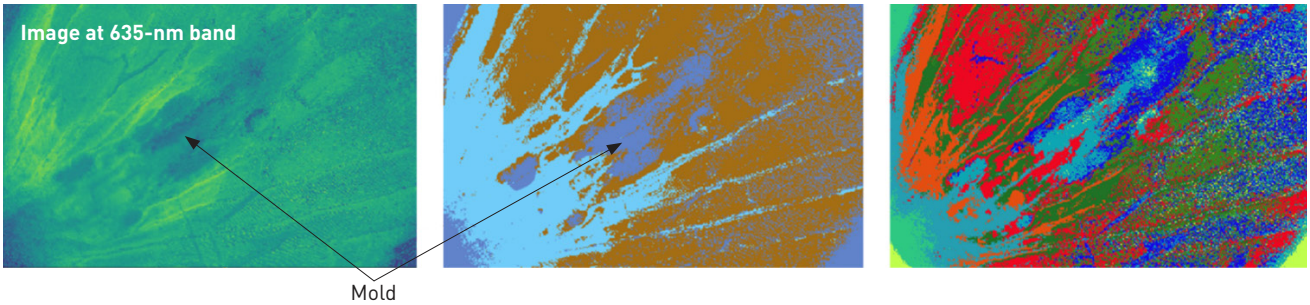
Alexandre Fong

TruTag Technologies began with the goal of solving a growing problem: counterfeit pharmaceuticals and their risk to patient safety. As a physician, Hank C.K. Wuh, CEO of SKAI Ventures—a technology accelerator with projects covering development of artificial corneas, specialized polymers for remediation and decontamination, bio-sensors for threat detection and beyond—was acutely aware of the problem and had a vision: an edible bar code that could be used to mark not only medicine but many other high-value products as well.

This bar code would need to be small enough to be present on a variety of tablet sizes and undetectable to the human eye, impossible to reproduce or copy, yet quickly and unambiguously detected and read so that legitimate products could be conveniently identified. With that goal in mind, Wuh asked his technical advisor, Mike O'Neill, to scout and develop technologies that could satisfy these requirements.

After working with numerous partners, O'Neill, now chief science officer of TruTag Technologies, found the solution by combining nanoporous silicon dioxide particles, or tags, which act as a spectral lock, with hyperspectral-imaging cameras, which act as the key in the closed-loop system. It was soon realized that this new tool could be

TruTag




Above: Classified images of a shallot generated using machine learning algorithms. Pixel groupings are similar spectra profiles, and cluster centers can be considered the end-members or representative spectra.

used beyond identification of pharmaceuticals in the field to protect IP and ensure supply-chain security for other products. Thus TruTag Technologies was spun out from SKAI ventures and incorporated in 2011, with a focus on providing supply-chain security and product identity solutions.

## A problem looking for a solution

Unlike most technology-driven startups, TruTag's core philosophy was to find the right solution to the problem rather than finding problems to solve with a technological development. That approach provided the flexibility not only to find the optimal solution, but also to adapt the initial solution should something more appropriate become available.

To read the tags, a conventional diffraction-grating-based "whisk-broom" hyperspectral imager was utilized in early tabletop implementations. However, as the range of applications expanded into new industries, the reader needed to adapt to the various operating environments, ranging from laboratories to warehouses and factory floors. The search for a more flexible technique led the team to utilize an approach based on a Fabry-Pérot interferometer (FPI). Such a technology could be packaged into a very compact, battery-operated, one-handed platform that could yield immediate results.

### TruTag Technologies

**www.trutags.com**

**HEADQUARTERS**: Emeryville, Calif., USA

**PRODUCTS**: Hyperspectral-imaging cameras

**CEO**: Michael Bartholomeusz

**PARTNERS**: Sumitomo Corp., Acer, Arocrest, WuXi AppTec, SKAI Ventures, DiNova Venture Partners

**NUMBER OF EMPLOYEES**: 35

FPIs operate by placing two mirrors parallel to each other. By controlling the reflectivity of the mirrors and their spacing, high-finesse spectral filtering can be achieved. TruTag Technologies developed the world's first battery-operated hand-held staring hyperspectral camera based on an FPI—TruTag model 4100H.

The camera captures multi-megapixel images in 600 spectral bands in as little as two seconds. The camera's embedded hardware enables real-time processing so that the user does not need to handle the large data sets typically generated by hyperspectral systems. Rather, the camera can identify features of interest, both in the spectral and spatial domains, and identify these features in the image. Moreover, the capacity to provide the critical components in high volumes means that hyperspectral-imaging technology can be made affordable and thus accessible to a wider audience.

## Building on big data

Following the introduction of the 4100H, there was significant interest in expanding its role in applications that didn't involve the tags; from that, a new business unit, Hinalea Imaging, was born. Hinalea's focus is on answering the demand from industries and markets that can benefit from TruTag's innovative hyperspectral-imaging tools. This includes further developing platforms based on modular elements of the current hand-held hyperspectral-imaging system to accommodate these new applications, as well as adopting new technologies on the horizon as they mature.

One area of interest is the incorporation of big-data algorithms. The 4100H's ability to capture 600 channels of data per pixel over 2.3 million pixels means that 1.5 billion data points are collected in mere seconds. The raw data are complex waveforms that cannot be interpreted intuitively without expert knowledge.

Hence, there is a need to reduce data into meaningful information with machine-learning and AI tools (that is, algorithm development, embedded software, cloud storage and reference libraries). These tools are used to classify the images

and make the immense amount of data contained within more easily interpretable by users. Michael Bartholomeusz, CEO of TruTag Technologies, notes, "Cost and a means to interpret the information have been the major barriers to adoption of hyperspectral imaging; our goal is remove such obstacles and finally unleash the full value of that technology."

## The cloud is the limit

Making the technology accessible in terms of cost and usability means that all the promise of decades of research in hyperspectral imaging will finally be made practical. This has enormous implications for the use of hyperspectral imaging in a variety of fields in which decisions are currently made based on incomplete information. For example, using a hyperspectral-imaging camera, the mapping of blood oxygen content in limbs can be an indicator of peripheral arterial disease or diabetic ulcerations. The unique spectral signatures of contaminants can be used by hyperspectral-imaging cameras to detect potential crop and food safety threats. TruTag's technology combines affordable and portable solutions that deliver results that experts and non-experts alike can easily interpret and act on.

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The opportunity in hyperspectral imaging is sufficiently vast that IBM recently deemed it one of the top five technologies to shape the world in the next five years. TruTag's Hinalea Imaging unit is well positioned to seize that opportunity to solve problems in fields as diverse as medical diagnostics, precision agriculture, environmental monitoring, mining and mineralogy and beyond—taking hyperspectral imaging out of the lab and into the cloud. OPN

Alexandre Fong (afong@trutags.com) is Director, Hyperspectral Imaging, at TruTag Technologies.