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See-Through Science

Allowing non-destructive chemical identification through opaque materials, the TASIA-winning STRam(an) represents an evolution in Raman technology.

By Katherine A. Bakeev

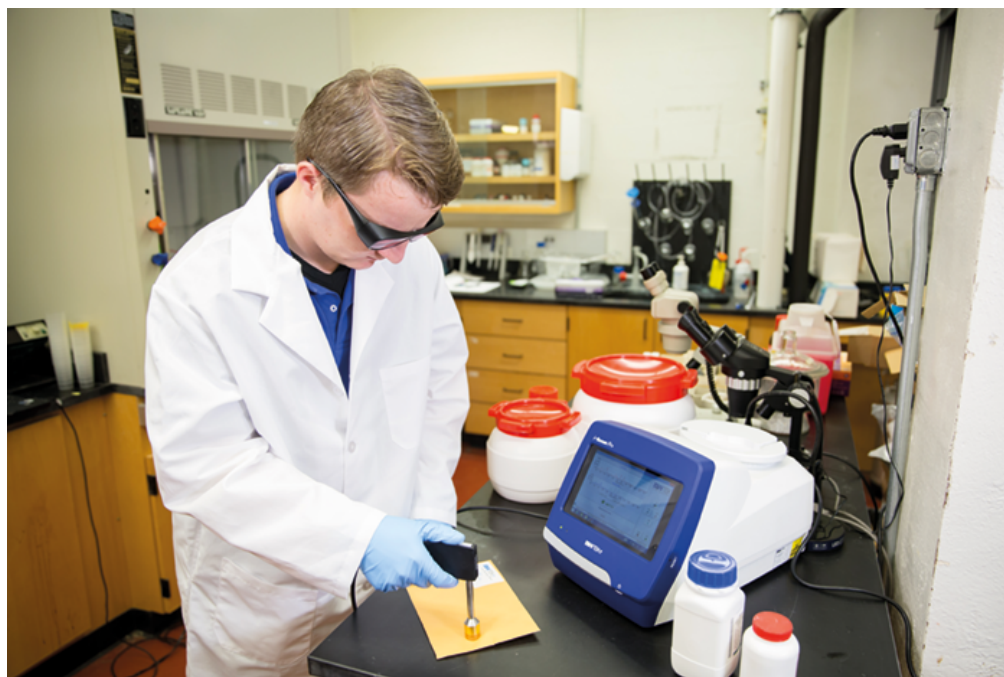
May 2018

The problem

Raman spectroscopy, now widely available in handheld and portable formats, is used for measuring the molecular fingerprint of a sample, and is particularly useful for rapid, nondestructive material identification. The specific molecular information supplied by a Raman spectrum has proved invaluable in chemical, material, pharmaceutical and biomedical research, and in medical diagnostics. But the technique has limitations – samples can only be measured directly, or through transparent containers. Raman identification through opaque packaging would make the technology easier to use for incoming raw

materials in warehouses and for first-responders, customs agents and others who need to rapidly identify materials without touching them. In addition, conventional Raman typically has a very small sampling area with a high power density at the laser focal point on the sample, which means that only a limited portion of a sample is measured, and samples may heat or burn. We reasoned that if we could design a system that overcomes these issues, Raman could be used more widely and give more repeatable results for heterogeneous samples, such as mixed powders or natural products.





Background

The STRaman technology, invented by Jun Zhao and Jack Zhou of B&W Tek, expands the capability of Raman spectroscopy to measure samples beneath diffusely scattering packaging material. Jun also developed the identification algorithm and led the product development, and I helped get the workflow in place and design the user interface.

We set out to design a system with a much larger sampling area than the conventional Raman spectroscopy confocal approach, to enhance the relative intensity of the signal from the deeper layers, thereby increasing the effective sampling depth and allowing the measurement of materials inside visually opaque containers. Raman spectroscopy is often used for material identification in pharmaceutical manufacturing, as well as by law enforcement for testing unknown materials, so we knew that sample measurement and identification through different packaging materials (without having to open containers) would give much more flexibility, reduce exposure to the samples and avoid sample contamination – ultimately making it quicker to get an actionable result.

The larger sampling area of STRaman technology has the added advantage of preventing sample damage by reducing the power density at the point of measurement, as well as improving measurement accuracy by eliminating the variability detected when measuring with a small spot size on a heterogeneous sample. The combined benefits of lower power density and greater penetration depth make the STRam system a suitable analysis tool for biomedical samples such as living tissue (such as under the skin's surface).

“To make measurements beyond the surface layer we knew that we needed to get more power to the sampling point.”

The solution

To make measurements beyond the surface layer we knew that we needed to get more power to the sampling point. We began by increasing the throughput of our portable Raman system to provide greater sensitivity and decreased measurement times, while still giving predominantly a surface measurement. The result is the STRam, a portable Raman instrument that has see-through capability.

The system is comprised of: the patent-pending probe, a high-throughput spectrometer, and specialized algorithms for the identification of the samples from the spectrum, which has contributions from the surface layers and underlying sample. Our design uses a coaxial excitation and collection path of the signal that is utilized in conventional Raman to measure beyond the diffusely scattering layers that cover a sample.

The STRam probe is designed to cover a larger surface area and increase the sampling depth compared with conventional Raman, so that the Raman spectrum beneath diffusely scattering opaque layers can be measured without being overwhelmed by the Raman signal of the surface layer.

The STRam is operated through an embedded touchscreen computer with software that walks users through the measurement steps and gives a match result in seconds. Our customers – who work in forensics, customs, border agencies, and pharmaceutical companies – wanted the ability to use commercial spectral libraries, as well as the ability to develop custom libraries. So we developed libraries and software to fulfill this demand, including a full narcotics library and 21CFR part 11 compliant ID software.

Many pharmaceutical companies already rely on handheld Raman for raw material testing through bottles and plastic drum liners. Chemical suppliers are able to verify the contents of their containers without breaking the seal, and because measurements can be done in seconds, can test a large number of packages in short time. Customs agents and

postal inspectors who encounter suspicious envelopes can use the STRam to determine if they pose a threat without exposing anyone in the process.

“We would like to see the STRam adopted widely for nondestructive, noninvasive inspections across the transportation industry.”

Beyond the solution

Customers are already asking for the technology to be extended to a handheld instrument, so that is one of our next challenges.

Another challenge for us is to expand the capability of the instrument to work at different laser excitations. Currently, the instrument comes with a 785 nm laser excitation; we want to offer 532 nm (carbon material analysis) and 1064 nm (fluorescence avoidance).

We would like to see the STRam adopted widely for nondestructive, noninvasive inspections across the transportation industry – including logistics and shipping companies and customs and border agencies. This has the potential to help verify that materials are what they should be and to identify unknowns, increasing everyone’s safety.

The laser power can be adjusted to as low as one percent, meaning it can be used in biomedical research and tissue analysis to increase understanding and early diagnosis of disease, with less chance of sample damage. The STRam’s more widely dispersed power could also prove useful in archaeology and conservation to contribute to the understanding of provenance, authenticity, and degradation – samples and artwork are less likely to be damaged and more representative measurements can be made of the samples.

The ability to measure samples inside packages, eliminating the need for sample preparation, is one of the major advantages of Raman. Going that step further and measuring through opaque packages – from white plastic bottles to fiber sacks, envelopes and even skin – allows easy adoption of this fundamental spectroscopic tool in many working environments, in the laboratory or in the field. This could open Raman to many new potential users, for whom it has not previously been a viable tool.

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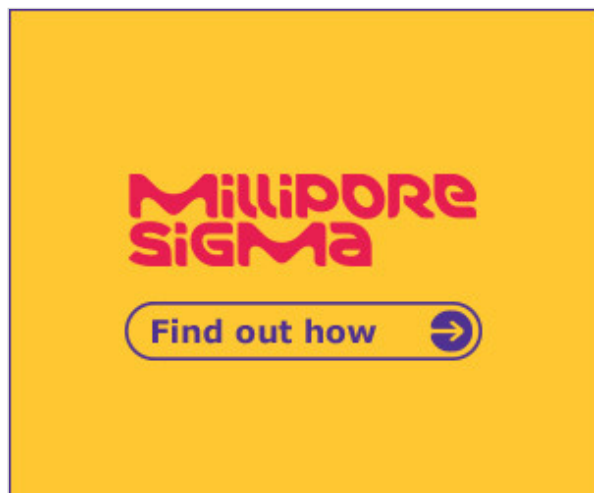
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Published in Issue #0518

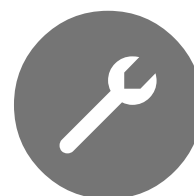
Welcome to our May issue! In Upfront, we hunt for hazards in cosmetics, have a pint with some scientists, and discover whether breast milk can help diagnose cancer. Personalized medicine is the focus of our features, including a behind-the-scenes look at the Maastricht MultiModal Molecular Imaging Institute and a plea for more chemistry in the clinic. Finally, we Sit Down With Genentech's Kelly Zhang to discuss the need for more collaboration in pushing pharma forward.



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