

Hyperspectral imaging: seeing the big picture

Hyperspectral imaging is one of the fastest-growing segments of the analytical instrumentation market. David Bannon, chief executive officer of Headwall Photonics, tells **Marie Freebody** about the commercial potential of this next-generation technology.

David Bannon co-founded Headwall Photonics (Fitchburg, MA) in 2003, through a divestiture from Agilent Technologies. Bannon has since transformed the company from a components business into a thriving instrumentation vendor that is focused on product innovation in hyperspectral and Raman imaging.

What is hyperspectral imaging?

Hyperspectral imaging is a technique that allows users to simultaneously measure and rapidly analyse the spectral composition of all objects within the field of view of the instrument. These imagers are now being deployed in a broad range of commercial and industrial applications where high speed, in-line inspection and enhanced quality control are essential.

Traditionally, capturing precise spectral information for process-manufacturing applications has involved either simple machine vision or single-point spectral instruments deployed in-line or at-line. These systems are a costly option as they are only capable of sampling a very small area of the overall product, resulting in poor sampling rates.

Hyperspectral imagers, on the other hand, allow a much greater percentage of the object to be analysed. They can also generate the chemical composition or spectral signature for any object or any point within their field of view. What's more, the image scene can be colour-rendered for the presence or absence of materials based on established spectral libraries.

What are the main applications?

There are three distinct waves of technology adoption, each focusing on a different set of applications. In the late 1980s and early 1990s, hyperspectral technology was deployed primarily as an airborne technique for environmental remote sensing, as well as for military applications such as reconnaissance and surveillance.

Over the past 10 years, hyperspectral



The next wave: David Bannon predicts the growth of hyperspectral imaging into new markets.

technology has been adopted for many commercial applications such as food inspection and safety, quality control of flat-panel screens and increasing pharmaceutical production yields.

The next wave of adoption is currently under way in biotechnology, life sciences and medicine. In this context, Headwall's Hyperspec instruments are being used in laboratories to detect skin cancer and being attached to microscopes to aid with drug discovery and cellular spectroscopy.

What is the most important recent advance in this field?

Without doubt it's the use of aberration-corrected optics to achieve the imaging performance necessary to support mission-critical applications. Hyperspectral instruments are deployed in applications where there is either a lot of money at stake and downtime costs are high – as with production lines – or where lives are at risk – as with military and defence.

For such applications, the quality of imaging is paramount. Spectral and spatial resolution are key differentiators and image distortions cannot be accommodated. As a result, the most advanced instruments make use of all-reflective designs and avoid transmissive optics or prisms that greatly contribute to image distortion and inconsistent spectral measurement.

Has commercialization been a success and how will it progress?

Commercialization has been successful as manufacturers follow a path to more integrated, easy-to-use hyperspectral instruments. For example, off-the-shelf hyperspectral solutions now include application software that allows customers to quickly ramp the instruments into production environments. Of course, commercialization requires hyperspectral instruments that are stable, durable and capable of producing consistent measurements over the range of harsh conditions that is typically found in factory environments.

What key challenges remain?

There are two technological challenges being addressed. The first involves reducing the volume of data collected by hyperspectral imagers. At present, these instruments capture and create a hyperspectral cube of data that contains the entire spectral and spatial information within its field of view. This data creates a processing burden that results in the need to bin pixel data on the detector chip or focus on regions of interest for fast, real-time processing.

Another key challenge is to reduce commercial instruments from the size of a grapefruit to the size of an orange. Optical science currently drives device size and requires an optimization trade-off between imaging performance, resolution, f/number and field of view.

What's next in product innovation?

The next big breakthrough lies in the important long-wave infrared (LWIR) spectral region, which lies between 8 and 14 μm . So far, deployable hyperspectral instruments operating in the LWIR range require expensive detector technology and large, cooled systems. New instrument designs make use of cost-effective, uncooled microbolometers that approach the noise-equivalent spectral radiance and performance of high-end detector chips. □