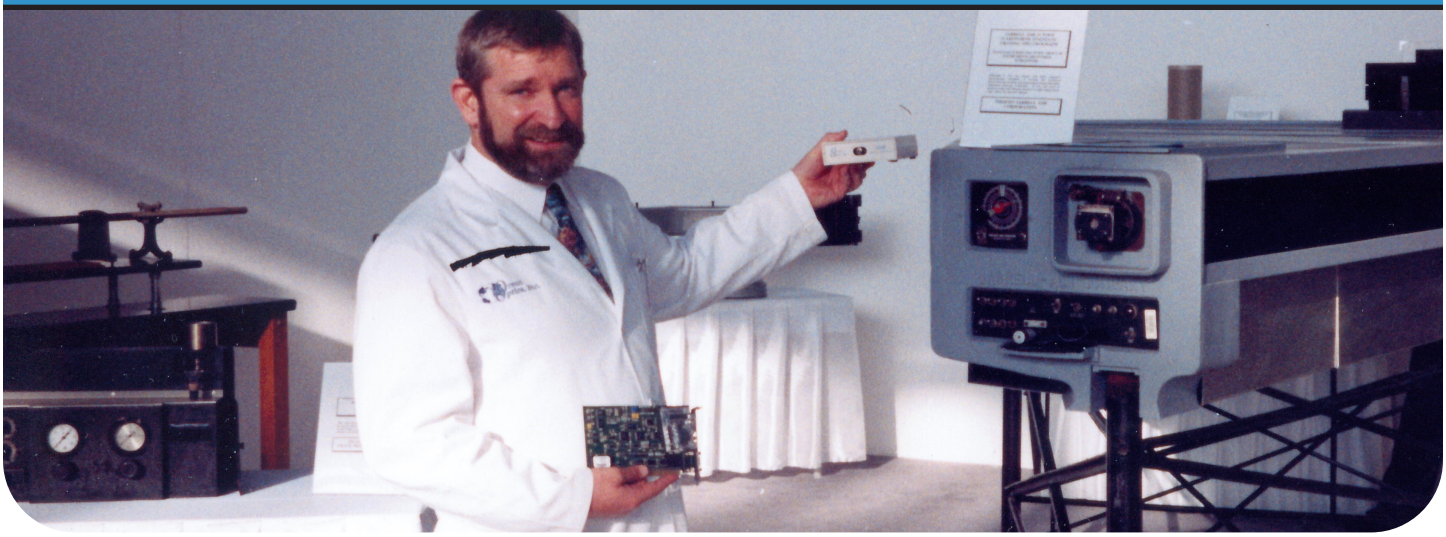
Miniature Spectrometers Come of Age

How Ocean Optics Helped to Revolutionize Commercial Spectroscopy



The story of Ocean Optics as a pioneer in miniature, or compact spectroscopy is equal parts inspiration and improvisation, culminating with the launch of the "world's first miniature spectrometer" and heralding a new way of thinking about and utilizing spectroscopy that endures to this day.

A Brief History of Ocean Optics

Several enterprising scientists from Florida started Ocean Optics in the late 1980s, seeded by a Small Business Innovation Grant from the U.S. Department of Energy for an oceanographic fiber optic pH sensor.

During the project, the Ocean Optics team discovered that a spectral component essential to the pH instrument wasn't readily available. The team needed a spectrometer both small and flexible enough to fit into an underwater housing but were surprised to discover that none meeting their requirements existed. So, like all resourceful inventors, they made their own.

By 1992, that spectrometer became the first commercial product released by Ocean Optics, making it possible for customers to take the spectrometer out of the lab and to the sample. That new-found measurement flexibility helped put Ocean Optics on the map, setting in motion a continuing partnership with customers across various industries and research sectors. The shared goal? To find new ways to solve problems using spectroscopy. Since then, Ocean Optics spectral technologies have evolved and our product offering has expanded, while customers continue to surprise us with applications once thought impractical using spectroscopy.

The Evolution of Miniature Spectrometers

Early miniature spectrometers benefited from a fortuitous combination of circumstances: the development of small-scale CCD-array detectors for mass-volume markets, which lowered system costs dramatically and allowed designers to make the instrument much smaller and more portable than traditional spectrometers; the evolution of computing technologies, which enabled spectrometers to process high-speed, high-resolution spectral data; and the growth of fiber optics, which made it much easier to bring the spectrometer to the sample.

Today's miniature spectrometers are more powerful and adaptable than ever, utilize a variety of detector types, and can be integrated into customer instrumentation as a component or subassembly or built into a turnkey solution addressing a specific application challenge. In addition, successive generations of compact

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spectrometers of all types have become faster, more accurate and more compatible with data transmission communication protocols including Ethernet, RS-232 and Wi-Fi. This has virtually eliminated performance trade-offs inherent to earlier compact spectrometers and makes them more scalable for industrial customers and other high-volume users.

As spectrometer hardware has advanced, so, too, have the analytical processing tools that derive meaning from the data collected. For customers dealing with massive or complex data sets, more robust software applications and tools including algorithm development, chemometrics and machine learning offer another layer of insight.

Compact Spectroscopy and Industry

In the decades since Ocean Optics kick-started the market for compact spectrometers, the ensuing technical innovations have benefited scientific, research and industrial sectors and spurred additional advances in spectrometer development. But perhaps the biggest impact of this evolution has been felt by industrial customers, who have benefitted from the path shaped by the earliest adopters of compact spectrometers and are now reaping the rewards.

Here are three industries where we've observed how compact spectrometers from Ocean Optics and other suppliers are making a difference:

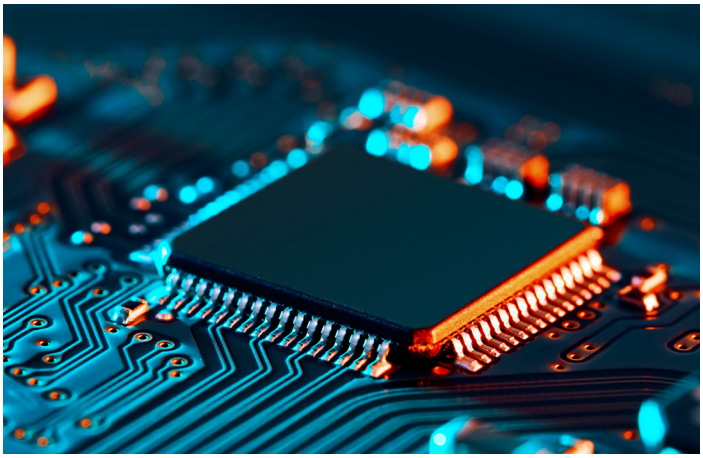
Medical Diagnostics and Life Sciences

In biomedical applications, compact spectrometers often are used as components or subassemblies for integration into point of care and laboratory diagnostic instruments, complementing the customer's technologies as part of fully realized instruments for applications ranging from biofluidics control to molecular diagnostics.

In fact, customers involved in point of care diagnostics were among the first industrial customers to take advantage of the inherent benefits of compact spectrometers, especially their utility for real-time, noninvasive and in situ measurements. Consider applications such as blood gas analysis and pathogen detection, where spectral technologies help users to quickly extract accurate, meaningful data from their measurements to drive productivity, reduce risk and improve outcomes.

Semiconductor Processing

Producing semiconductors is a complex undertaking, with precise monitoring of fabrication processes integral to successful yields. As a proven analytical technology, miniature spectroscopy is embraced by the semiconductor industry because of its versatility, simplicity and accessibility. Compact spectral systems are routinely used throughout semiconductor inspection, testing and manufacturing processes, where real-time, in situ analysis helps to ensure reliable results.



The semiconductor industry saw the potential for Ocean Optics spectrometers and its competitors early on, pressing suppliers to develop more robust, process-ready systems for its demanding production environments. In one case, Ocean Optics rapidly reengineered an existing high resolution spectrometer to meet a customer's thermal wavelength stability threshold, which meant the customer could run their process with fewer interruptions and more reliable results, thus saving time and money.

Pharmaceuticals Analysis

For the pharmaceuticals industry, the advantages of compact spectroscopy strike a familiar chord: the ability to deliver rapid, real-time, in situ measurements by integrating the instrument into the process, whether for materials analysis or cleaning validation.

Optical sensing technology is familiar to the pharma industry, which has long relied on high-sensitivity Raman analysis and powerful NIR spectroscopy as monitoring and analysis tools for complex pharma ingredients and formulations. Making these tools more compact, and adding UV-visible spectroscopy to the mix, have presented another set of options leading to higher yields, improved product quality and reduced contamination risk.

With compact spectroscopy, inline monitoring of pharma processes can be more easily incorporated into process streams from raw materials to finished products. Spectral measurements can be made at critical stages throughout the process, allowing for quick intervention when performance falls outside specified parameters. More tightly controlled processes lead to reduced waste and more consistent product quality.

Coming of Age on the Analytical Landscape

Where users once thought of miniature spectrometers as “toys” or gadgets fun to tinker with, today they accept them as the remarkably sophisticated analytical instruments these spectrometers have become. For example, late adopters and more recent generations of users simply expect that compact spectrometers will perform as well as standard spectrometers for most applications.

In the years after Ocean Optics came on to the scene, the earliest promoters of compact spectrometers encouraged suppliers to engineer instrument refinements and new applications. Each challenge yielded some new insight that could be built into future generations of products, with advances in areas such as optical coatings and components helping to elevate spectrometer system performance without significantly adding to the cost. Today, thanks in large part to improved detectors, optoelectronic designs and communications interfaces, miniature spectrometers can be used everywhere from patient bedsides in hospitals to process lines in factories.

What comes next? The advances being pushed by today’s mass markets will have a big impact. Today, manufacturers seek to capitalize on spectroscopy technologies to understand more about their processes – to find solutions allowing them to produce a better product, improve quality, or develop more streamlined or reliable processes. This could inspire developments such as higher-performance imaging sensors, continued migration of computing to smartphone-sized electronics packages, and the pairing of spectroscopy with tools like artificial intelligence and virtual reality.

Just as the miniature spectroscopy revolution that Ocean Optics helped launch made possible those applications previously not feasible with conventional spectrometers, so, too, will the spectral sensing breakthroughs of today have even greater impact on how we sense and control our world tomorrow.