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Chen Improves Sulfur Detection Technology, Gets Beckman Award

"Initially, we measured diesel. Now, (the X-ray fluorescent analyzer technology) also works for gasoline." —Chen

By Jim Strothman

Facing a U.S. Environmental Protection Agency mandate for a nationwide transition in 2006 from low-sulfur to ultra-low sulfur diesel (ULSD) fuel, refineries needed a measurement tool to assure they could produce a product that could meet ULSD's 15-parts-per-million (ppm) sulfur standard.

Adding pressure, diesel engine makers—already hard at work building ULSD diesel engines for vehicles introduced in 2007—needed assurance from petroleum makers that ULSD-compliant fuel would be universally available next year.

An answer to fuel makers' challenge came with a significant advance in X-ray instrumentation technology that enables petroleum companies to accurately measure sulfur level in fuels. That's a big reason why the technology's inventor, Dr. Zewu Chen, has won ISA's 2006 Arnold O. Beckman Founder Award.

Chen, a senior research scientist at X-Ray Optical Systems, Inc. (XOS), East Greenbush, N.Y., has become internationally recognized for inventing a novel doubly curved crystal, focusing monochromatic optics technology and many of its applications.

"It is an honor to receive the award," Chen said. "When I look at the list of those who received it before, I am very honored. I know I did something very useful, but I still was very surprised to receive it," he said. Chen's achievement will be recognized at the ISA's annual Honors and Awards (H&A) Banquet on 16 October at the Hyatt RegencyHouston.

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The Arnold O. Beckman Founder Award has had 35 winners since it was first awarded in 1960. However, while it may be conferred annually, it has not been presented to anyone since

1999. Winners receive a $3,000 honorarium and plaque. Chen was nominated for the award by Gary Brewer, of ABB Process Analytics, Lewisburgh, W.Va.

"This award is to recognize an outstanding development in instrumentation that has a significant contribution to the advancement of a technology," said Gerald Wilbanks, ISA Beckman Award subcommittee chair.

"Chen's work on the sulfur-in-diesel (SINDIE) analyzer resulted in the patent of a novel doubly curved, focusing monochromatic optics with a new configuration X-ray fluorescence system. This innovation has progressed into an advanced product being adopted by many major petroleum companies as a standardized measurement tool to address an important environmental concern of lowering the level of sulfur in fuels. The performance offered by the technology enables easy and precise measurement of sulfur levels in fuels and is under international demand in the petroleum industry. The Beckman Award Committee agreed this new advancement should be recognized, and Chen honored for his achievement."

The award is given in honor of Dr. Arnold O. Beckman, an internationally recognized scientist, educator, executive, humanitarian, and civic leader. Beckman served as President of ISA in 1952 and was elected an Honorary Member in 1959.

Founder and chairman emeritus of Beckman Instruments, Inc. (now known as Beckman Coulter, Inc., Fullerton, Calif.), Beckman died in 2004 at the age of 104. While still alive, he received the 1989 National Medal of Science from President George H.W. Bush for his leadership in the development of analytical instrumentation. He was presented by President Reagan with the 1989 Presidential Citizens Medal and the 1988 National Medal of Technology for outstanding contributions to the U.S. through technology. In 1999, he received the Public Welfare Medal from the National Academy of Sciences, Washington, D.C.

While doubly curved crystal optic technology has been around since the 1950s, "it was very difficult to make it work," Chen said. Chen's inventions and developments in X-ray instrumentation—notably novel doubly curved, focusing monochromatic optics, along with novel configurations of the optics in a new type of X-ray fluorescent (XRF) system—dramatically increases the performance and utility of XRF techniques.

The technology is at the heart of XOS' SINDIE analyzer product line. Hundreds of the units have been installed, primarily at U.S.-based pipeline terminals, where the technology is used to sample fuel flowing in and out of the terminals, Chen said.

"Initially, we measured diesel," he said. "Now it also works for gasoline," he said.

Doubly curved crystal (DCC) optics produce a highly monochromatic, focused x-ray beam by Bragg reflection (diffraction). DCC optics capture a large solid-angle of X-rays from micron-sized as well as large point sources. These X-rays are reflected and redirected by the DCC to form a focal spot equivalent to the source size.

XOS has refined the focusing modality by precisely and accurately bending and aligning crystals in two directions to direct only the source X-rays with a single wavelength into a focal spot. XOS said its DCC optics can be tailored to generate a range of monochromatic beams from 1.5 to 40 keV. Very high sensitivity is created by the exceptionally high signal to background ratio of the focused monochromatic beam, making the DCC optic ideally suited for micro-XRF and micro-TXRF analysis.

The SINDIE line, which received an R&D 100 award in 2005 from *R&D Magazine*, includes a compact bench-top sulfur analyzer designed for petroleum fuels from ultra-low sulfur diesel and gasoline to heavy fuel oil. Its monochromatic wavelength dispersive X-ray fluorescence (MWDXRF) technology offers a limit of detection (LOD) of 0.4 ppm with a dynamic range of 3,000 ppm, the company said.

A second product, the SINDIE On-Line Analyzer, is an industrial grade process sulfur analyzer with detection capability for monitoring fuels streams as exacting as ultra low sulfur diesel and gasoline. Pipeline terminals have been snapping it up because they require measurement speed and reliability. The on-line product offers a LOD of 0.6 ppm, and a dynamic range of 3000 ppm.

MWDXRF technology has four unique elements, which complement each other to achieve high-performance trace element analysis, compared to other XRF techniques, Chen said.

First, monochromatic excitation leads to a greatly reduced background X-ray signal from scattered photons.

Second, focusing the incident beam to, and collecting from, a small sample spot enables the use of small, thin windows. This avoids losing characteristic line X-rays from low-Z elements such as sulfur that are easily absorbed by thicker windows.

Third, the use of a monochromating optic before the detector allows the use of a single channel detector, without the need for a multi-channel analyzer.

Fourth, by using an incident beam optic to focus to a small spot on the sample, the collection optic can have a very large effective collection solid angle. This enables the use of a low power tube.

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