Sensor system monitors corrosion damage

■ Corrosion, one of the main culprits responsible for the costly failure of oil and gas pipelines, is being tackled by a Canadian company with a patented, fiber optic corrosion-monitoring system. Fiber Optic Systems Technology, known as FOX-TEK (Toronto, Ontario), provides nonintrusive sensors that monitor corrosion damage in real-time to prevent leaks, spills, and unplanned downtime.

Fiber optic sensors rest on the exterior of the elbow section of an Alberta refinery pipeline to monitor telltale signs of corrosion. Courtesy of FOX-TEK.

The fiber optic sensor systems can be applied to monitor corrosion of buried pipelines, refinery pipelines, bridges, and a host of other applications, says Gary Jolly, president and CEO of FOX-TEK. The sensors, made of coil and grid mesh and weighing as little as 2 oz (28.4 g), are designed to precisely measure temperature, pressure, and the subtle, localized swelling of pipeline walls that signals the presence of corrosion. While early detection and constant monitoring are key to leak prevention, say company officials, current corrosion-monitoring methods are often unreliable, invasive, or prohibitively expensive.

The sensor system has a variety of advantages, Jolly explains. In measuring subtle changes in the pipeline wall, the fiber optic sensors proactively monitor the progress of corrosion, giving operators necessary data to prevent costly leaks and spills. The nonintrusive sensors also offer advantages over smart pigs, which are costly and require that operations be interrupted. "The pig is very good in what it's designed to do," Jolly explains, "but it costs too much in many instances. What it's not good at is measuring the rate of corrosion change, so you need another tool to do that. What companies use today is ultrasound, but every time you need to ultrasound an underground pipe, you have to dig it up. That's very expensive."

Operators can bond the sensors to the outside of the pipe, even in hard-to-reach areas, without penetrating any part of the pipe wall. "Pipelines, elbows, reactor vessels, steam pipes, or boiler walls can all lose wall material from a combination of corrosion, erosion, or cavitation," say company officials. Perhaps the sensor technology's greatest advantage is its ability to provide continuous, real-time monitoring, complemented by a proprietary software system that relays data from potential danger zones before accidents occur. "We tailor our solutions to what the client wants to do," Jolly says.

Here, a fiber optic sensor is bonded to a tailings pipe in a serpentine configuration. Courtesy of FOX-TEK.

"I think most of our oil and gas companies want to do a good job in their corrosion capabilities, and what we're doing is giving them a new tool set that provides capabilities they've never had before," says Jolly. "The problem of corrosion is not new, but, unfortunately, neither are the technologies used to monitor it," he says.

Pipeline operators can use the technology to monitor a range of potential problems, including strain brought about by pressure surges, bending, loading, currents, fatigue, or a change in process conditions. Users can place the sensors over pipe areas that might experience stress corrosion cracking or structural damage caused by weather and other external factors. The sensors also can be permanently installed over areas of concern or embedded in the structure, company officials explain.

A close-up view of a fiber optic sensor designed to monitor local wall thinning, a technology patented by a Toronto-based, fiber optic technology company. Courtesy of FOX-TEK.

Besides monitoring corrosion on buried pipe, the fiber optic sensor system has proven useful on refinery pipelines. "These sensors are uniquely suited to monitor corrosion within every refinery operation, worldwide," says Jon Hykawy, a

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technology analyst at Research Capital Corp. (Toronto, Ontario). "The system's measurements are so precise that corrosion-induced pipe swelling can be detected early, even in locations traditionally difficult to monitor. Scientists at some of the world's largest oil exporters have deemed the sensor systems as the best solution they've found to monitor highly flammable overhead lines for corrosion."

In addition, bridges, dams, tunnels, irrigation canals, and water pipelines can be monitored effectively using the fiber optic sensors. They give civil authorities fair warning about structural health problems such as deformation, bending, foundation settling, and sagging from excessive loads. "We have had the sensors installed on bridges across Canada for 10 years," Jolly says.

Corrosion, one of the main reasons oil and natural gas pipelines fail, costs U.S. industries $276 billion per year, according to NACE International. "With oil and gas prices at an all-time high and demand steadily increasing, it's imperative that companies have an accurate system that not only monitors corrosion, but does so in a proactive manner," Jolly contends. "The problem goes beyond oil production, day-to-day operations, and revenue to the larger issue of meeting the world's energy needs."

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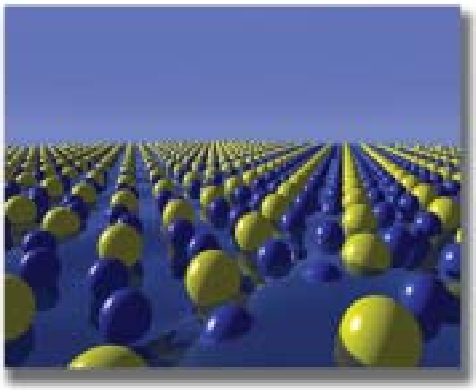
Liquid alloy reveals solid-like crystal structure

■ A liquid alloy used in nanotechnology, described as a silicon and gold molten alloy, has unusual structures at its surface, report researchers at the U.S. Department of Energy (DOE) Argonne National Laboratory (Argonne, Illinois). The study, led by Oleg Shpyrko, was finalized at Argonne's Center for Nanoscale Materials and published July 7 in the journal *Science*. Research on the liquid alloy was also conducted at the DOE's Brookhaven National Laboratory (Upton, New York).

While atoms are randomly configured within the bulk of a metal, they form into discreet layers at the surface. The phenomenon of surface layering was originally discovered in mercury and gallium at BNL in 1995, BNL officials report. In the current study, researchers investigated a gold-silicon eutectic alloy consisting of 82% gold and 18% silicon. ("Eutectic" means that the alloy melts at a temperature lower than the melting temperature of its individual components.) The gold-silicon eutectic alloy under study melts at about 1,000°C lower than either of its components, at 360°C.

Until now, scientists have known that atoms in a crystalline solid are configured in an "orderly, periodic fashion," and their arrangement is disordered in a liquid, Argonne officials explain. Since the BNL discovery, it has been understood that metallic liquids exhibit two or three distinct atomic layers near the surface without any crystalline-like order. Recently, though, Shpyrko and his team discovered seven or eight layers near the surface of the gold-silicon eutectic alloy. They also learned that the substance's highest surface layer contains a crystal-like structure usually found in solids.

These findings are important for the field of nanotechnology, in which the basic unit of measurement is a billionth of a meter, Argonne officials say. "By the time you reduce the size of an object or device down to one nanometer, practically everything is surfaces and interfaces," Shpyrko says. "We need to understand what the new laws of physics and chemistry that govern the surface structures are."



This image represents periodically ordered gold (yellow) and silicon (blue) atoms within the surface-frozen monolayer of liquid gold-silicon eutectic alloy. Courtesy of BNL.

Future research into the structure of liquid alloys will benefit the metals industry and has implications for new nanotechnologies. "The gold-silicon interconnect junction, for example, is one of the most common connections used in cell phones, computers, and other devices," BNL officials say. The new findings surrounding gold and silicon will enhance research into computer technology, because both substances are used in the field. Argonne officials explain that gold is an oxide-resistant, "noble" metal, easily shaped into tiny, computer chip interconnects, and silicon is the main component used in many semiconductor devices.

"If you think about it, you have gold and silicon in contact with each other in about every electronic device," Shpyrko says.

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—C. Greenwood