GOOD VIBRATIONS

Microsensor arrays offer chemical monitoring solutions for public spaces

On March 20, 1995, five men boarded the Tokyo subway on separate lines, all headed toward Tsukiji Station in Central Tokyo. It was Monday morning rush hour, a time when it would have been easy to blend into the bustling crowds at one of the world's busiest commuter centers. The men carried bags with containers that would later be described as resembling lunch boxes or thermoses. Inside the containers was a colorless, odorless liquid that, when activated, would release a nerve gas called Sarin. At a coordinated moment, not long after stationing themselves in their selected cars, the five men dropped their bags and exited the subway while the fumes from the liquid began to leak out. In a panic, sick passengers exited at various stations, carrying traces of the fumes with them. When bystanders tried to help the victims, they were also exposed. In all, 13 people died and more than 5,500 people were injured by the attack, which was later connected to a doomsday cult called Aum Shinrikyo. The incident sparked renewed recognition that transportation infrastructures, especially where there are people in confined spaces, were particularly vulnerable to assault. And it also raised the question of how to handle the immediate aftermath of a chemical attack.

"The desire to monitor these locations for any trace releases was already a high priority," said Hank Wohltjen, founder of the Bowling Green, Kentucky-based Microsensor Systems, Inc. "But even in the Tokyo subway incident, the people who were injured were immediately transported to the hospital, and, at that point, no one knew what they were dealing with. Of course their clothes were contaminated, so lots of people associated with the incident were inadvertently exposed to low levels of these toxic chemicals."

For four decades, Wohltjen has been exploring the question of how technology can monitor low-level traces of toxic chemicals. In the late 1970s, as a graduate student at Virginia Tech, he invented the Surface Acoustic Wave (SAW) microsensor—a small chip of quartz with a microelectrode patterned onto the surface. He continued to develop the technology in the early 1980s as a researcher at the U.S. Naval Research Laboratory (NRL) in Washington D.C.

The SBIR program, through its support for growing businesses and nascent technologies, provides a launchpad for passionate innovators looking to develop their ideas.

"The quartz device mechanically resonates—like the string on a guitar—at very high frequencies," Wohltjen says. "We apply extremely thin coatings of a polymer to the devices to make the vibrations sensitive to chemical vapors. The coating acts as a 'sponge' for certain types of vapor. When the 'sponge' absorbs a particular vapor molecule, it gets heavier and causes the resonant frequency of the chip to decrease. Using this technique we can measure mass changes as small as a few picograms."

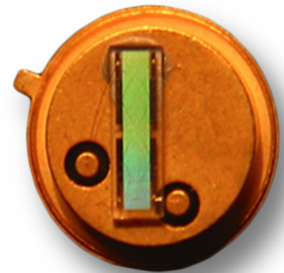

Hank Wohltjen

In 1985, Wohltjen and some of his colleagues left the NRL and formed Microsensor Systems, Inc. where they worked on the commercial development of SAW microsensors. They created a pocket-sized chemical warfare detection system using the technology, and they also began manufacturing gas chromatographs for agencies such as the Occupational Safety and Health Administration (OSHA) who used the chromatographs for industrial safety and hygiene purposes.

Then, in 1995, the Tokyo subway was attacked, and the desire for Microsensor Systems' technology spiked. Through the Small Business Innovation Research (SBIR) program, the U.S. Department of Defense (DoD) called upon Wohltjen's company to create a detection system that would help protect U.S. troops and American citizens from similar chemical attacks and their consequences. The company contracted with the Defense Advanced Research Projects Agency (DARPA) to develop a fully-automated, high-performance SAW microsensor array for mobile air sampling and chemical monitoring. The first phase of the technology was completed in 1998 and combined the SAW technology with the miniature gas chromatographs and pattern detection software. It's since been developed into a highly reliable, portable monitor that can be deployed anywhere in the world with the unique ability to detect low levels of chemical agents. The project, as it was originally developed with DARPA, has been focused on intelligence gathering. Those programs are classified but, according to Wohltjen, the technology has been used to help protect key facilities across the country, including major metropolitan mass transit systems.

"I can say that it was successfully deployed in the field and that it was in operation for several years monitoring for unexpected releases of toxic chemicals." Wohltjen said. "It has turned out to be a useful device in monitoring the presence of toxic materials in scenarios where it was necessary to protect people from potential exposure."

The detection system continues to be developed for commercial use. For instance, the company has built systems to



A surface acoustic wave chemical microsensor "chip" from Microsensor Systems is only 5 mm in diameter.

measure emissions so that refineries can meet environmental standards. Other commercial applications overlap with the goals of DoD and public health agencies. Monitors have been deployed at chemical weapons handling depots to detect leaks. And hospitals can use the monitors in the event of a chemical weapons attack, if something like that were to happen in the U.S. Wohltjen says the machine could be positioned in the emergency room where it would continuously analyze the air.

"As people came in, it would be able to detect toxic materials present and sound an alarm," he said. "Then people would know to take more careful action in handling these people who are coming in for triage."

Wohltjen has come a long way from when he first founded Microsensor Systems, Inc. In the early days, he said, he was simply fueled by the belief that the detection technology he and his colleagues were developing had the potential to make a contribution to society. Now Wohltjen serves on several boards for tech start-ups and has worked as the principal investigator on more than $10 million of U.S. government funded R&D projects.

As for Microsensor Systems, Inc., it no longer exists by that name, having gone through several acquisitions, most recently by ENMET, LLC, in Ann Arbor, Michigan (for whom Wohltjen serves as the CTO). Still, Wohltjen says, a lot of the people who started with the SBIR contract in 1996 continue to work at their same desks in the Bowling Green office. And the detection technology? It has relied on niche applications in which it continues to be highly relevant and effective. For example, Wohltjen's company builds and maintains critical infrastructure detectors in Washington, D.C., New York, Boston, Los Angeles, and Chicago.

The SBIR program, through its support for growing businesses and nascent technologies, provides a launchpad for passionate innovators looking to develop their ideas. "You have some technical people who have an idea and want to commercialize it, but who know nothing about business or production—I'm speaking mainly about myself," he said. "But we believed the technology had utility. There's a relentless effort required to adapt technology as required to solve a specific problem for a specific customer. It's something that takes many, many years. But that has been our passion. And we've stayed with it."

Photos courtesy Hank Wohltjen

Microsensor Systems (ENMET, LLC)

Modernization Priority: Microelectronics

Bowling Green, KY (Ann Arbor, MI) • SBIR contract: DAAH01-96-C-R115 • Agency: DARPA • Topic: SB941-067, Fully Automated, High Performance SAW Microsensor Array for Mobile Air Sampling and Chemical Monitoring