Sensor Networks

Fiberoptic Sensors Come of Age

By Winn Hardin
Although the rise and subsequent consolidation of the optical telecommunications industry left its mark on many global markets and regional economies, component development funded by telecom companies has benefited many optoelectronic applications, from diode lasers for material processing to fiberoptic sensing.

Although fiberoptic sensors were “oversold” in the late 1980s and early ’90s, promising to revolutionize all sorts of smart structures, many applications remain in R&D today, although commercial demand is increasing. “Fiberoptic sensors have advanced to an extent that they can readily find many applications in manufacturing and detection segments,” explains Peter Adrian, technology analyst for Frost & Sullivan’s Technical Insights (San Antonio, TX). “Recent innovations in fiberoptic instruments and their cost advantages have boosted their utility and demand in several sectors. Environmental and atmospheric monitoring, industrial chemical processing, utilities, and biotechnology, as well as defense and security, are some of the areas that find use for optic sensors,” Adrian says.

According to Peter Fuhr, chief technology officer at Apprion Inc. (Moffett Field, CA) and previously the director of the Institute for Sensors and Wireless Networking at San Jose State University (San Jose, CA), fiberoptic sensors come in two types: intrinsic, where the light signal is modulated inside the fiber, and extrinsic, where the signal is modulated outside the fiber.

More than 60 fiberoptic sensor types exist today—including Raman scattering fiber sensors for continuous temperature monitoring; Brillouin scattering sensors for temperature and strain sensing; fluorescence sensors for chemical sensing and microbending; and microresonating sensors for temperature and strain sensing—but intrinsic Bragg gratings for point-source temperature, strain, and pressure sensing, and Sagnac interferometric sensors for gyroscope navigation are today’s most commonly used fiberoptic sensors.

The unique characteristics of fiber sensors make them particularly useful in network configurations, including structural, industrial, and process-control applications. “The multiplexing capability of optical sensors makes them an excellent candidate for structural health monitoring in aerospace applications where weight is a major consideration,” notes Frost & Sullivan’s Adrian. Compared to electron-based sensors, fiberoptic photon-based sensors have other inherent strengths, such as ruggedness to high temperatures, harsh environments, and electromagnetic interference; electrically passive operation for explosive environments; and the ability to be multiplexed. Fiberoptic sensors are also long-lived, compact, and flexible, characteristics that make them attractive for embedding into organic (the human body) and inorganic structures (bridges, buildings, and vehicles).

Speaking at the recent Photonics Applications Systems Technologies meeting of the Optoelectronics Industry Development Association, Arpad Bergh identified five key application areas for fiberoptic sensor applications: structural health, security-protection, traffic monitoring, positioning and controlling, and acoustic sensors.

According to Bergh, the global optical sensor market, excluding the medical and automotive markets, should grow from approximately $200 million in 2005 to more than $1.2 billion by 2008. Bergh cited several key markets, including security, smart structures, seismic, aerospace, shipboard, process, wells, pipelines, and power lines. Of these markets, Bergh estimated that shipboard sensing for naval vessels will be the largest segment in 2008, claiming close to $400 million in total revenues, followed by security at approximately $200 million, and pipeline monitoring at $150 million.

“The optical sensing area is a field in which new technologies are being developed and tested continuously,” says Frost & Sullivan’s Adrian. “Companies such as Airak [Ashburn, VA] have developed fiberoptic electric field sensors for monitoring utilities, such as rectangular bus bars and electrical distribution lines. Fiber Optic Systems Technology Inc. [Toronto, Canada] has developed interferometric sensors targeting aerospace and defense that can measure temperatures greater than 450°C. With increasing emphasis on safeguarding the environment, fiberoptic sensors are being employed to measure pollutant levels and contamination in the environment in real time. Scientists are also working to apply the technology in microbial ecology, as well as in veterinary and human clinical diagnostics,” Adrian concludes.