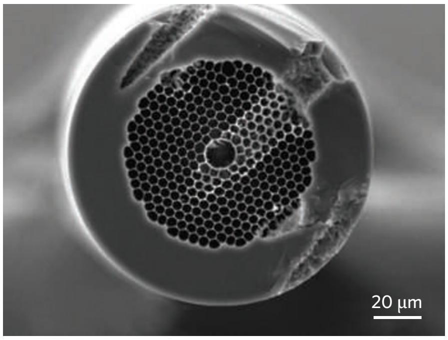
Fast-response fibre

IEEE Photon. Tech. Lett. **22,** 296–298 (2010)



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Researchers at the Hong Kong Polytechnic University have developed a rapid-response methane sensor that may be suited to harsh industrial environments. The Kowloon-based team, led by Wei Jin, previously demonstrated the practicality of using a photonic bandgap (PBG) fibre for gas sensing. Now, Jin and colleagues have improved response times by fabricating seven microchannels in a 7-cm-long PBG fibre using a Ti:Sapphire femtosecond laser.

After filling the microstructured fibre with a mixture of methane gas and nitrogen, the team measured its transmission spectrum using a superluminescent LED, and then probed the mixture using a distributed feedback laser of wavelength 1.67 μm. The system took three seconds to detect methane gas and had a detection sensitivity of 647 ppm. Significantly, this work shows that the sensor works well without the need to pressurize the gas being detected.

According to Jin, the sensitivity of the system could be improved dramatically simply by using a longer fibre: "The absorption signal strength scales up with the length of sensing fibre, but noise is almost independent of fibre length." Jin's analysis suggests that a 50-m-long PBG fibre containing 700 microchannels could offer a sensitivity close to 1 ppm, although the response time would increase to around one minute in this scenario.

Unstrained detection

Opt. Lett. **35,** 1034–1036 (2010)

A fibre-optic sensor developed by researchers at Carleton University in Canada does away with the usual requirement of transferring strain directly to a grating when measuring structural deformities. Li-yang Shao, one of the researchers involved in the study, says that this is the first fibre sensor to directly measure both the degree and orientation of bending using a single grating: "We are directly measuring bending, instead of inferring it from strains." As a result, their fibre sensor can be embedded in a soft-strain relief medium, protecting it from the surrounding hard structure of a building and thus improving its reliability. A further advantage is that the device is much less sensitive to temperature changes than a regular fibre sensor. "This is because we are measuring power levels, and not wavelength shifts," explains Shao.

Any stable light source with a bandwidth of a few nanometres can be used to illuminate the sensor. The researchers used an erbium-doped, fibre-amplified spontaneous emission source, but say that a superluminescent LED would work equally well. A crucial challenge of their work was to find the best taper shape for optimizing of the amount of grating-coupled, cladding-mode light that is directed back into the fibre core. The team also gained a clearer understanding of how the grating response is dependent on its relative tilt plane and the direction of bending.

Liquid food monitor

Meas. Sci. Technol. **21,** 035204 (2010)

The food industry would benefit from a sensor that combines optical, electrical and ultrasonic techniques to measure ingredients in liquids. A. Kimoto and T. Kitajima at Saga University in Japan are now developing such a sensor, and claim that their multipurpose, non-invasive device should be able to estimate the concentrations of three different ingredients within the same liquid.

The sensor uses optical measurements to determine the concentration of yellow food colourant, while salt levels and ethanol concentration are estimated simultaneously by electrical and ultrasonic methods. The device comprises a blue LED and a photodetector, combined with a polyvinylidene fluoride film featuring an indium tin oxide transparent electrode.

Although the researchers admit that their system does not give particularly precise measurements of yellow food colouring (±6 p.p.m. at a known concentration of 50 p.p.m.), the results show that this new approach will allow up to three liquid concentrations to be monitored separately.

Leafy photonics

Appl. Opt. **49,** 1687–1697 (2010)

A research team in France has developed an analytical tool that uses five LEDs to remotely measure the constituents of plant leaves. Jean-Pierre Frangi and colleagues at the Institute de Physique du Globe de Paris say that, unlike existing leaf analysis tools, their 'radiometric measurements *in situ*' (RAMIS) technique can analyse leaf water content both *in situ* and non-destructively.

"RAMIS is intelligent," explains Frangi. "It combines optical measurements with calculations from the radiative model." The key constituents in plants and leaves can be measured in a number of ways, for example using transmittance, reflectance, fluorescence or dielectric effects. However, these techniques usually require calibration for each different plant type, and are only effective for measuring chlorophyll content.

The RAMIS system uses LEDs operating at 656, 721, 843, 937 and 1,550 nm. Using several light sources improves the sensitivity of the system for detecting signature absorption wavelengths of water and dry matter in the near-infrared spectral region.

The current prototype yields accurate water content measurements, but is limited when estimating levels of other important leaf constituents such as dry matter and chlorophyll. Frangi says that the system could be improved by adding a sixth LED emitting in the 500–700 nm range to evaluate chlorophyll content, giving potential applications in forest management and precision agriculture.

Magnetic terbium

Opt. Express **18,** 5407–5412 (2010)

Researchers at the University of Rochester and Advalue Photonics in the USA have developed an all-fibre magnetic field detector that they claim would be suitable for use in harsh environments such as nuclear facilities and maglev railways. The sensor is based on a terbium-doped fibre, a fibre polarizer and a fibre Faraday rotator. Lei Sun and colleagues say that the sensor measures a magnetic field of up to 3 T, making it suitable for magnetic resonance imaging.

"There were two main challenges," explains Sun. "One was to increase the terbium doping concentration, and the other was to cleave and splice terbium fibre with silica fibre." Because the terbium fibre is ~50% doped by weight, its properties are significantly different from normal silica fibre. One of the effects of the doping is to increase the fibre's Verdet constant, which is a measure of the strength of the Faraday effect for a particular material.

By increasing the Verdet constant, the material becomes more sensitive to magnetic fields. Although conventional magnetic field sensors, search coils and Hall effect sensors are good at detecting very small fields, this all-fibre sensor has a wide dynamic range that can be varied by changing the length of the fibre or the level of doping.

One disadvantage of the fibre sensor, however, is that its Verdet effect is also sensitive to changes in temperature, meaning that an additional temperature sensor would be needed for any commercial applications.