Wider markets beckon for fibre-optic sensors

A new design of external cavity laser allows sensors to penetrate applications where reliability and lower cost are essential. **Tim Hayes** speaks to Radu Barsan to learn more.

The advantages of fibre-optic sensors are said to include their potential to be lightweight, small in size and offer high sensitivity. In practice, however, limitations in performance and usability have prevented them from becoming widespread in demanding sectors such as the oil and gas industry, and their cost has been a barrier in markets where affordability is critical.

The laser source is a key part of the fibre-optic system and often determines the performance and cost of the sensing system. Redfern Integrated Optics (RIO) has developed a new laser source technology called PLANEX, which could allow optical sensors to break into these sectors as well as a range of other new markets.

"Both of the two existing commercially viable designs of lasers for fibre-optic sensors have their limitations," commented Radu Barsan, CEO of RIO. "Semiconductor distributed feedback lasers (DFB) do not satisfy the requirements of linewidth, phase noise and wavelength stability needed for efficient sensing," he said. "At the other end of the scale, fibre lasers are very sensitive to environmental conditions, like vibration and temperature, as well as being extremely expensive, high maintenance and power hungry. And there's nothing available in between these two extremes. What PLANEX does is bridge the gap."

Both images: RIO

Top: Radu Barsan of Redfern Integrated Optics expects PLANEX sensors to be used in areas where fibre-optic sensing was previously not practiced. Bottom: PLANEX consists of a gain chip and a planar lightwave circuit with Bragg grating.

Planar lightwave circuit

PLANEX employs an external cavity laser (ECL), in which the cavity includes a semiconductor gain chip and a Bragg grating inscribed in a planar lightwave circuit (PLC) waveguide. The Bragg grating on the silica-on-silicon PLC determines the wavelength of the ECL, which in the first PLANEX devices is 1550 nm. RIO claims a linewidth of less than 5 kHz for the laser.

"The hybrid integration of the indium phosphide gain chip with a planar Bragg grating is the key," said Barsan. "We have developed the specifications and designs for these sub-components, as well as the manufacturing technology employed to make them and to carry out the hybrid assembly. Our approach uses semiconductor process technology to build the planar gratings on PLCs rather than in fibre, along with a carefully designed integration technology, an area in which we are experts."

According to RIO, etching the Bragg gratings into silica allows good process control, repeatability of parameters, immunity to vibrations and low sensitivity to temperature. Grating fabrication can be achieved with direct etching or UV writing in germanium-doped silica, employing RIO's proprietary processes.

Long cavity

ECLs are attractive for interferometric sensing applications because the long cavity means that they can demonstrate significantly narrower linewidth and lower frequency noise than semiconductor DFB lasers. Hybrid ECLs based on fibre Bragg gratings have been studied for interferometric applications before, but their phase noise was too high and they suffered from sensitivity to vibration.

"The general architecture of an ECL is not new," said Barsan. "They have been around for 15 years or more, and are widely used in tunable lasers and other sources. But what we have accomplished is a very low noise, stable, robust and vibration-insensitive ECL, through the use of the planar Bragg grating."

Combining the simplicity and low cost of semiconductor lasers with the performance of fibre lasers allows the PLANEX sensors to penetrate into both commercial and military fibre-optic sensor applications, including those using interferometric sensor arrays with high sensor counts.

Cost of ownership

"PLANEX provides the fibre-laser performance along with the size, power dissipation, stability, robustness and environmental insensitivity of butterfly-packaged semiconductor lasers at a very competitive price," said Barsan. "This obviously means that the device can be used in applications that previously had to use either semiconductor DFB lasers or fibre lasers, but it also enables a host of new applications that were previously held back because of the absence of this solution in the narrow-linewidth laser space."

The palette of these potential market

applications is diverse, including oil and gas exploration and production, structural health monitoring, microwave photonics, LIDAR, terrestrial perimeter intrusion detection and harbour security, pipeline and power-line monitoring, coherent communications, and test and measurement.

RIO is also targeting PLANEX at telecom and datacom markets, where its output power and spectral properties can be exploited in transmitter optical subassemblies. The original development was carried out with the datacom sector in mind.

"The form factor and the lower cost of this component make it possible to apply the benefits of this technology in areas that were prohibitive in the past," commented Barsan. "Either the desired performance was not available in a suitable form factor, or the laser was in an impractical package that was expensive or vibration sensitive."

In developing PLANEX, one aim of RIO was to produce a sensor with a lower purchase price than existing devices, but

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One of the potential applications for RIO's PLANEX sources is in monitoring oil and gas pipelines.

Barsan believes that the true economic significance of the laser becomes apparent when the product's lifetime is considered.

"When you look at the reduced cost of ownership that comes about because of the stability and reliability of our laser compared with alternatives, then the savings are even more significant," he said. "It is not just a matter of cost-effectiveness; it's the combination of the cost-effectiveness, smaller size, high reliability and stability, low power consumption, and low maintenance that enables the new applications."

Morphing the technology

According to Barsan, the development cycle of PLANEX sensors is a good example of laser technology being successfully applied to applications other than those for which it was first conceived. "Looking back, we went through two phases," he commented. "The first phase was the morphing of the qualified telecom technology into fibre-optic sensing applications. We had sufficient positive field trials and customer traction to give us the confidence to actually productize the technology specifically for these applications."

With this positive response in mind, RIO went back to its design for a second phase of product development and redesigned the laser to optimize all of the facets of performance that are critical to the specific sensor applications. "As a result, our laser is probably the only semiconductor laser available commercially that has been specifically designed for these sensor markets," commented Barsan.

Similar application-focused developments are planned for the PLANEX concept. "There are always opportunities to serve more diverse higher-end markets that have extreme needs not covered by the current specs of our first product line, and we plan to address those," Barsan said. "We also plan to address different applications that need different laser parameters, by customizing our designs. New applications will require different embodiments of the product, although using the same technology platform. We will build on our planar lightwave circuit technology." □