Fibre lasers stretch from cells to wind farms

Turning a laboratory laser into a real industrial application needs flexibility. Koheras tells **Tim Hayes** how it adapted its fibre laser technology to suit two different markets.

Natural Power

Natural Power

ZephIR is the only realistic alternative to masts for wind farms located in difficult terrain (left). The system consists of three portable pods weighing a total of 150 kg and standing 1.5 m tall (above).

Koheras has its origins in the Technical University of Denmark and the work done there on fibre lasers in the late 1990s. "At that time a group was spun out from the university, originally with the aim of developing a relatively immature distributed feedback (DFB) fibre laser technology," said sales manager Søren Løvgreen. "This was initially targeted at the telecoms sector, but we found the fibre laser to be 'overqualified' for that market, and to be a very good fit with a range of uses in sensing instead."

The company focused at first on single-frequency narrow linewidth lasers for sensing applications, originally employing 15 people. "Since then we have grown to around 65 people, and developed additional laser technologies for specific markets," said Løvgreen. "Along with the single frequency lasers, we have developed supercontinuum sources whose properties are well suited to particular confocal microscopy applications, and today our business is split roughly equally between the two product areas."

The single frequency laser is based on DFB fibre laser technology, said by Løvgreen to provide significant advantages for sensing applications compared with distributed Bragg reflector or semiconductor lasers. "The DFB structure means that there is a grating integrated into the gain medium of the laser and a very short cavity," he said. "This gives a very stable device that is less susceptible to acoustic noise and vibration noise. The laser packaging is also important in enhancing the laser's properties and protecting it against any environmental perturbations."

LIDAR sensing

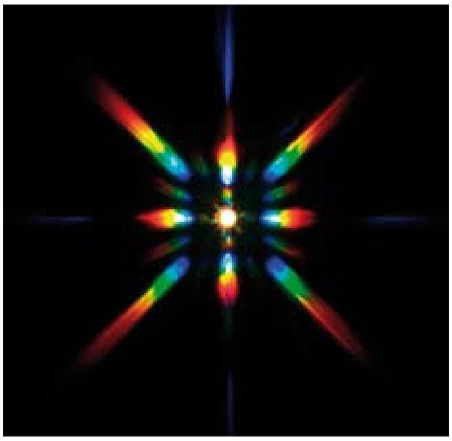
The most mature application for these sources is also the only one that employs free space sensing, rather than sensor interferometry. The ZephIR is a wind speed measurement system based on light detection and ranging (LIDAR) that is marketed to the wind energy industry by renewable energy consultancy Natural Power.

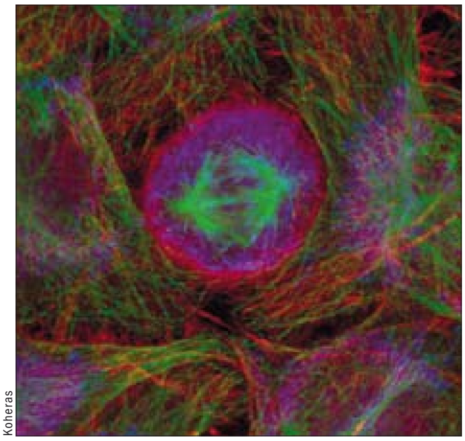
"To develop a wind farm you naturally need to have a good idea if the site is windy, and if it stays windy throughout a year," explained Natural Power's Alex Woodward. "Traditionally you would find out by erecting a mast, perhaps 70 or 80 m tall, with cup anemometers on it and leaving it in place for 12 months."

ZephIR does away with such masts and instead uses narrow linewidth lasers to measure wind speeds at altitudes of up to 200 m. "We use the laser to measure wind speeds at five different heights," said Woodward. "The beam is thrown out at a 30° angle and rotated to form a cone emerging from the top of the ZephIR pod. We can then focus at different heights in that cone and measure 50 points of data every second at each height. That gives us more data and much better accuracy than an anemometer cup, which can only give a single data point."

The key parameters for the laser in such an application are a combination of a narrow linewidth of less than 30 kHz, single frequency operation and low intensity noise. "In this system the amplified seed DFB fibre laser provides power of approximately 1 W," said Løvgreen. "The wavelength is in the 1.5 μm range, which means that all optical components are telecom-graded and highly reliable."

Locations for potential wind farm sites are becoming more demanding, with increasing numbers proposed for sites that are forested or feature large undulations in terrain. In these situations a grid of masts is not practical. The ZephIR system consists





A diffraction image of the SuperK through a 3D photonic bandgap crystal (left). A HeLa cancer cell illuminated by the Leica SP5x confocal microscope system with the SuperK source (right).

of three portable pods weighing a total of 150 kg and stands only 1.5 m tall. It provides the only realistic solution to masts in difficult terrain, according to Woodward. "This is a complete game change compared with the time and manpower needed to build a mast," he said.

Supercontinuum source

Koheras' supercontinuum sources were originally earmarked for LIDAR applications but have proven their worth in the very different area of confocal microscopy.

"We first started working with supercontinuum sources in 2003," said Husain Imam, sales manager for supercontinuum products. "At that time Koheras saw supercontinuum technology as another platform to augment our existing core competencies in providing light sources for LIDAR."

A source developed specifically for that purpose happened to catch the eye of Leica Microsystems CMS GmbH, which had previously investigated the use of supercontinuum sources in confocal microscopy, but had been unable to find sources of suitable power and reliability. The Koheras SuperK source appeared to be a perfect match.

"The key advantages of supercontinuums are the ultra-wide spectral range and availability of a continuum of wavelengths at high brightness," noted Imam. "In practice, confocal applications only require 400–750 nm, although supercontinuum sources are a lot broader than that, typically 400–2400 nm. High power in the visible part of the spectrum is essential. Our sources for this application emit the most visible light available, at over 1.2 W in the visible spectrum. This high-power visible light is fibre-delivered as single-mode light, further simplifying the architecture of a confocal setup."

Although the technical advantages were clear, product development still took time. "We spent more than two years on intensive product development alongside Leica to commercialize the product, even though we already had a working source," commented Imam. "We had to optimize the usability, safety, serviceability, the user interface and numerous other aspects that are critical to developing a plug-and-play system that can be used by non-specialist operators."

One advantage in this development was access to Koheras' sister company, Crystal Fibre. Both companies operate under the umbrella of their parent, NKT Photonics. "The key element in a supercontinuum light source is the photonic crystal fibre (PCF), and Crystal Fibre has been selling those to industrial companies and research institutions for longer than the supercontinuum sources have been available on the commercial market," said Imam.

Simple set-up

A particular challenge that needed to be addressed was the reliability of supercontinuum systems. "To generate a high-power visible supercontinuum, a lot of optical energy needs to be pumped into the crystal fibre," said Imam. "This affected the optical properties of the crystal fibre negatively in the early days of product development. However, a combination of optimal crystal fibre design and manufacture has now solved this issue."

The modular laser architecture based on commercially available fibre optical components from demanding industries such as telecommunications also helps to boost reliability.

A second key advantage is that the broad supercontinuum avoids the need for a separate bank of lasers to cover the same wavelength range. This turns out to be particularly important to confocal microscopy applications that employ multiple dyes on a single sample. Tuning the wavelength enables the operator to maximize one dye over another and avoid cross-excitation, allowing for better contrast and more precise identification of early-stage cancers, for example. Alternatively, multiple wavelengths can be tuned and emitted at the same time to allow the fluorescence of multiple dyes in a sample in the same fashion.

"Previously you might have needed perhaps four to six lasers, and used a complicated optical set-up to make the beams collinear and channel them to a sample," said Imam. "The optics involved were complicated and tricky to adjust, so the user needed some knowledge of optics to obtain maximum performance. With supercontinuum sources you don't need to do that. It's just a white light visible beam that comes out through a fibre and needs no adjustment to optimize the power."

Rapid analysis

"We have heard that the speed of preparing samples and carrying out an analysis can be significantly reduced," Imam noted. "You can prepare samples according to the chemistry and biology of the cells rather than be constrained by the wavelengths that you had available in your confocal microscope."

The optical properties of the sample can be affected by changes in the local environment, but being able to tune the excitation wavelength continuously allows the user to optimize the fluorescence emission and obtain new information about cell behaviour, which can be exploited in drug development and discovery. As a result the whole process can be speeded up and what previously took two months can now be done in two weeks, according to Imam.

Other markets for supercontinuum sources are still emerging. Koheras says that a number of industrial players are interested in integrating them into their own systems. "There are some cost implications in moving from a conventional laser or a lamp source to a supercontinuum, but the advantages of having a much more powerful and ultra-broadband fibre-coupled source allows new and valuable features to be incorporated into a product," said Imam. "Furthermore, integrating SuperK systems rather than conventional lasers or lamps has a cost-of-ownership benefit in some cases. We are seeing interest from many sectors including the biomedical, semiconductor and food industries, which are actively evaluating SuperK systems for their applications. We expect that it will take 1–2 years before supercontinuum will be firmly established as a laser source technology in these new areas." □