Scorpio Fiber Lasers - The Ideal Solution for Fiber-Optic Acoustic Sensing

NP Photonic is the leading manufacturer of high power single frequency fiber lasers that operate at 1550 nm with output powers in excess of 100 mW and a spectral heterodyne linewidth of 1-3 kHz. These lasers have a coherence length of more than 100 km and are uniquely suited for long-range coherent acoustic detection via optical fiber.

Underwater Acoustic Sensing

While microwave radiation (RADAR) as well as laser light (LIDAR) are heavily attenuated and scattered underwater it is well known that water is an ideal medium for the transmission of sound. Underwater sound travels quickly and efficiently over long distances and many marine animals have adapted to use sound as a tool. The word SONAR is an acronym for Sound Navigation And Ranging. Active sonar is able to both send out and receive signals. Transducers convert electric signals to acoustics. After the transducer gives off sound waves, the waves travel until they strike an object and the waves are reflected in various directions. Some of the reflected waves return to the sonar where they reach its receiver. The receiver, being essentially an underwater microphone, is called a hydrophone. Typical sonar systems used throughout the world today rely on piezo-ceramic hydrophones and DC-powered signal conditioning and data telemetry. Passive sonar only receives underwater sounds and does not produce its own acoustics. For long-range detection, low frequency Sonar is used. While best suited for any threat detection system, passive Sonar has the most stringent requirements on the hydrophone sensitivity, and overall system noise.

Compared to piezo-ceramic and other electromechanical sensors, fiber optic sensors present major advantages like higher sensitivity, larger dynamic range, improved reliability (no underwater electronics, immunity to EMI), improved physical characteristics (100-fold weight reduction and thinner cables), and lower cost. Fiber-optic sensor multiplexing topologies have been developed for applications such as towed arrays, hull arrays, and bottom-mounted arrays.

Fiber Optic Hydrophones

Fiber optic hydrophones have been researched for decades and are now well developed. A common type of hydrophone consists of a length of fiber (10—200 m) wrapped under tension in multiple turns around a compliant mandrel. The pressure exerted by an acoustic wave causes a dimensional change in the mandrel, which modulates the length of the fiber and thus the phase of the optical signal traveling through it. This phase modulation can be detected by placing the hydrophone in an interferometer and measuring the resulting amplitude modulation. Over the past several years, the U.S. Navy has worked to develop fiber-optic hydrophones for electrically passive underwater acoustic sensing. Fiber optic hydrophones can have extremely low noise, (high sensitivity), a wide bandwidth, and a large dynamic range and are already used in active

and passive Sonar applications. Their sensitivity can approach the noise floor of a quiet ocean environment. When installed at the bottom of the San Diego Bay harbor, the mandrel- type of fiber optic hydrophone was able to detect divers that used an open circuit breathing system.
Another, even simpler approach to fiber optic hydrophones has recently experienced a new revival. Coated fiber transducers use compliant coatings directly applied to the fiber to increase responsivity. This presents the simplest and potentially lowest cost, transducer design as no additional components are needed and the coating can be extruded onto the fiber. Coated fiber transducers have been periodically investigated over the last 25 years, with little improvement, until recently. Air-included polymer coatings have recently shown to increase the responsivity by as much as 40 dB over previous coated fiber transducers. These fiber sensors are ideal candidates for distributed sensing approaches, a technique that is unique to optical fiber sensing technology.

Advantages of NP Photonic's Low Noise Fiber Laser

While the hydrophone sensitivity can, in general, be tailored and systems can be designed that are only limited by shot-noise, the laser phase noise is known to be the fundamental noise source in all-interferometric systems. It arises from frequency noise in the optical source (laser), which is converted to phase noise in the sensing or detecting interferometer. The sensitivity to laser induced phase noise makes laser selection crucial. One of the lowest noise lasers is the Nd:YAG ring laser produced by Lightwave Electronics and many of the first demonstrations of interferometric fiber sensing have used this laser. It operates at 1319 nm and can provide several hundred milliwatts of optical power. While it offers very good performance in terms of phase noise, this wavelength is not compatible with EDFAs and WDM technology in the telecommunications band. As a result these lasers are not applicable to the newer system architectures. Finding a suitable replacement in the 1550 nm band has proved to be difficult.
In the last few years single frequency Er doped fiber lasers having a spectral heterodyne linewidth of only a few kHz have emerged and will most likely boost, and even revolutionize the field of high sensitivity fiber optic sensing. The frequency noise of these lasers is 10-20 dB lower than that of the best available semiconductor DFB lasers and compares favorably with the Nd:YAG NPRO laser. It is possible to decrease the frequency noise of these lasers even further through phase locking to a reference interferometer and as part of our product development we have developed robust locking electronics.

Such a laser source is an extremely valuable tool when acoustic signals at low frequencies have to be detected, as for instance in the case of active SONAR geophysical oil and gas explorations

NP Photonics, Inc.

Founded in 1998, NP Photonics is the originator of Erbium Micro Fiber (EMF) technology and is dedicated to the design, manufacture and marketing of compact, low-cost, intelligent fiber-based products for the sensing and telecommunications industries.
NP Photonics is the leading supplier of a very competitive fiber laser product. Within 5 years from the first demonstration of single frequency lasing with 30 μW output power in our lab we have developed a fiber laser product with up to 150 mW power and have sold hundreds of these lasers to the most prominent customers in the world. In addition to an OEM version for systems applications we have also introduced a CDRH compliant bench top version of the laser that is sold to universities and research laboratories.
NP Photonics newest product is a multi-laser line card system with up to 10 lasers per card. The FLS10 fiber laser line card system has been designed as a building block for densely spaced DWDM fiber sensing applications. A single shelf of a standard 19" rack can hold a maximum of 80 ultra-low-noise single frequency fiber lasers. 10 vibration insensitive (!) lasers per card are spectrally multiplexed into one polarized fiber output and can be frequency modulated independently through a simple computer interface. The basic FLS10 Multi-laser system consists of a 10 laser line card, a communication card, power supply and software. The system is available either air- or water cooled
NP Photonics' mission is to be our customers' number one supplier of advanced optical components and subsystems.