WI5 Distributed temperature sensor using holmium-doped optical fiber

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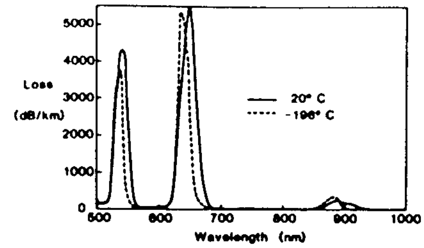
Preliminary results of an optical-fiber distributed temperature sensor using neodymium as the active fiber dopant have been reported.[1] An investigation has been made of fibers doped with the rare earths neodymium, erbium, praseodymium, and holmium which were fabricated using the method previously reported.[2] Silica fiber doped with holmium has an order of magnitude greater temperature sensitivity than the other rare earths. The sensitivity of the absorption to temperature is thought to be due to a satellite band on the long-wavelength side of the main absorption bands, as shown in the attenuation plots in Fig. 1. Thermal population at this energy level causes the attenuation to increase rapidly with temperature.

There are large changes in the fiber attenuations with temperatures at wavelengths of 555, 670, and 910 nm. In the 665-685-nm wavelength range the attenuation change is >2%/°C. Distributed measurements have been made with a tunable dye laser and optical time domain reflectometer (OTDR). The dopant concentration in the fiber is optimized to provide a long sensitive fiber length and high-temperature sensitivity.

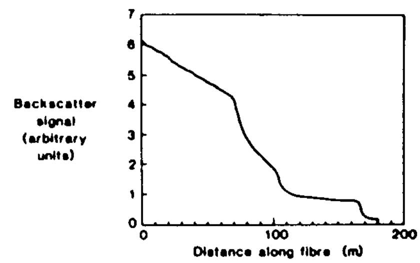
The backscatter trace signal of a fiber passing through regions of different temperatures is shown in Fig. 2. Variations in attenuation due to hot and cold fiber sections are clearly identifiable. The distributed attenuation obtained from the backscatter signal is shown in Fig. 3. A low loss of 10 dB/km is measured at −196°C, which enables a long fiber length to be used. A 5-m section of fiber at 20°C produces a significant attenuation of 100 dB/km. The large change may be easily detected with a simple OTDR. A further section of fiber in a variable temperature environment shows the resolution of the sensor to small temperature changes far down the fiber.

The temperature resolution is of the order of 1°C, and the spatial resolution is 3.5 m. This sensor is particularly sensitive at low temperatures, which are beyond the range of other distributed temperature sensors. A particularly useful sensitive wavelength is 904 nm at which suitable semiconductor lasers are available. By tuning the laser wavelength it has been shown possible to vary the range and sensitivity of the sensor. **(12 min)**

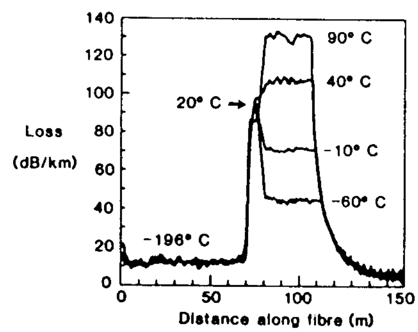
1. M. C. Farries, M. E. Fermann, R. I. Laming, S. R. Poole, D. N. Payne, and A. P. Leach, "Distributed Temperature Sensor Using Nd^{3+}-Doped Optical Fiber," Electron. Lett. **22**, 418 (1986).
2. S. B. Poole, D. N. Payne, R. J. Mears, M. E. Fermann, and R. I. Laming, "Fabrication and Characterization of Low-Loss Optical Fibers Containing Rare-Earth Ions," IEEE/OSA J. Lightwave Technol. **LT-4**, 870 (1986).



WI5 Fig. 1. Attenuation spectra of holmium-doped fiber at −196 and 20°C.



WI5 Fig. 2. OTDR trace of a distributed temperature sensor.



WI5 Fig. 3. Attenuation distribution along the fiber in regions of different temperatures.

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