Photonics Research | December 2006

Grating Restricts Fiber Laser to Four Closely Spaced Lines

Output is switchable from one line to another, or two can lase simultaneously.

by Breck Hitz

Email Article
Printer Friendly
Save Article

Wavelength-switchable fiber lasers are required for flexible dense-wavelength-division-multiplexing (DWDM) networks, as well as for many fiber optic sensing systems and for spectroscopic studies. Although researchers at several laboratories have used fiber Bragg gratings (FBGs) to tune a laser from one line to another, the spacing between the lines has been relatively large (i.e., several nanometers). In many cases, especially DWDM, tuning among closely spaced lines is highly desirable.

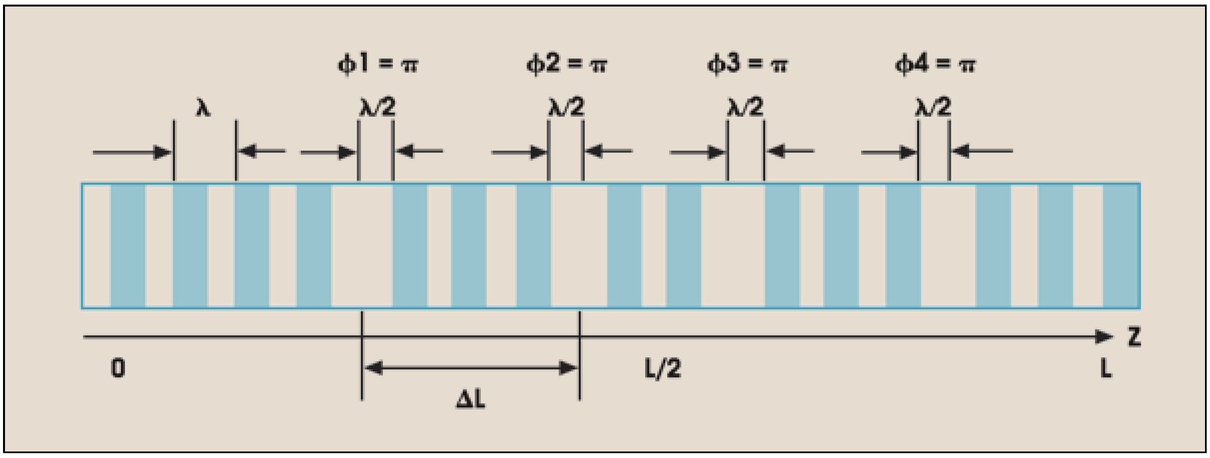

Figure 1. *Designed with four π-phase shifts, the FBG had a broad reflectance band that included four narrow transmission peaks, as indicated in Figure 2. Reprinted with permission of IEEE Photonics Technology Letters.*

Recently, researchers at Nanyang Technology University and at the Institute for Infocomm Research, both in Singapore, designed and demonstrated a fiber laser that is switchable among four lines, separated by only 40 pm.

A specially designed FBG is the key to the switchable laser’s operation. A conventional outputcoupling FBG has a single π-phase shift at its center and transmits a single narrow band in the middle of its reflectance spectrum. Extrapolating from this principle, the researchers designed a grating with four π-phase shifts with an equal spatial separation from each other (Figure 1). They calculated that its transmission spectrum would have four peaks whose separation in wavelength, determined by the spatial separation of the π-phase shifts in the grating, would be ~40 pm.

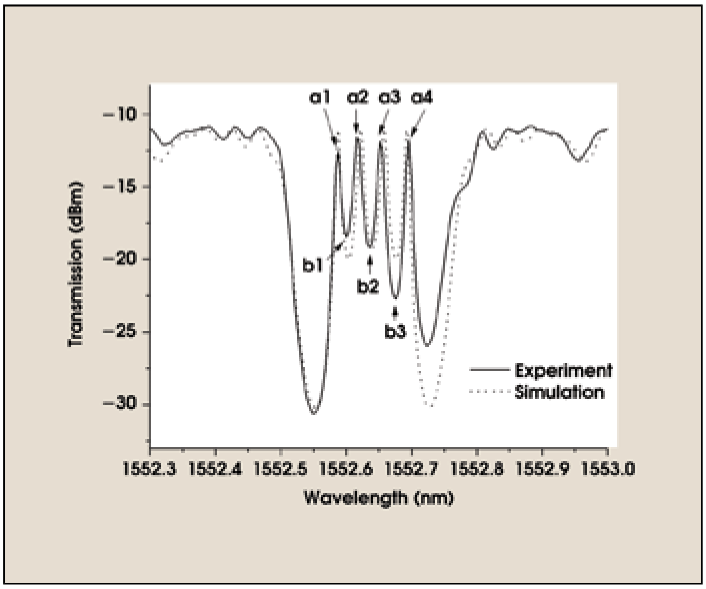

***Figure 2.** The researchers' calculation of the transmission spectrum of the grating in Figure 1 agreed closely with its measured spectrum.*

When they fabricated the grating and measured its transmission, they observed good agreement between their calculation and their experimental measurement (Figure 2). The slight disagreement could have been caused by mismeasurement of the amount and/or position of the phase shifts in the FBG or to nonuniformity introduced during its fabrication. At any rate, there was no significant discrepancy in the location or magnitude of the transmission peaks.

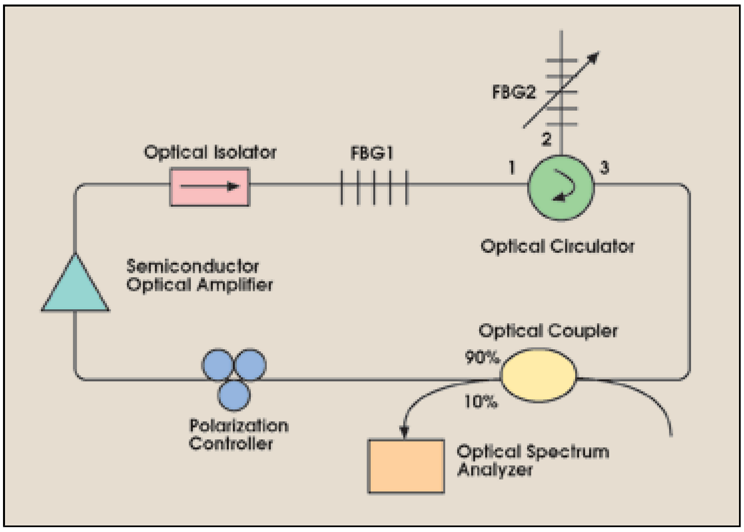

***Figure 3.** The spectra of both FBGs (FBG1, FBG2) influenced the spectrum of the laser's emission. The optical isolator prevented the reflection of FBG1 from contributing to the laser's feedback.*

The researchers constructed their laser in a ring configuration, using a semiconductor optical amplifier to avoid the homogeneous broadening of an erbium fiber amplifier (Figure 3). The specially designed grating, with four transmission bands, was part of the ring (i.e., FBG1 in Figure 3), and a second grating (FBG2) with no phase shifts was coupled to the ring through an optical circulator.

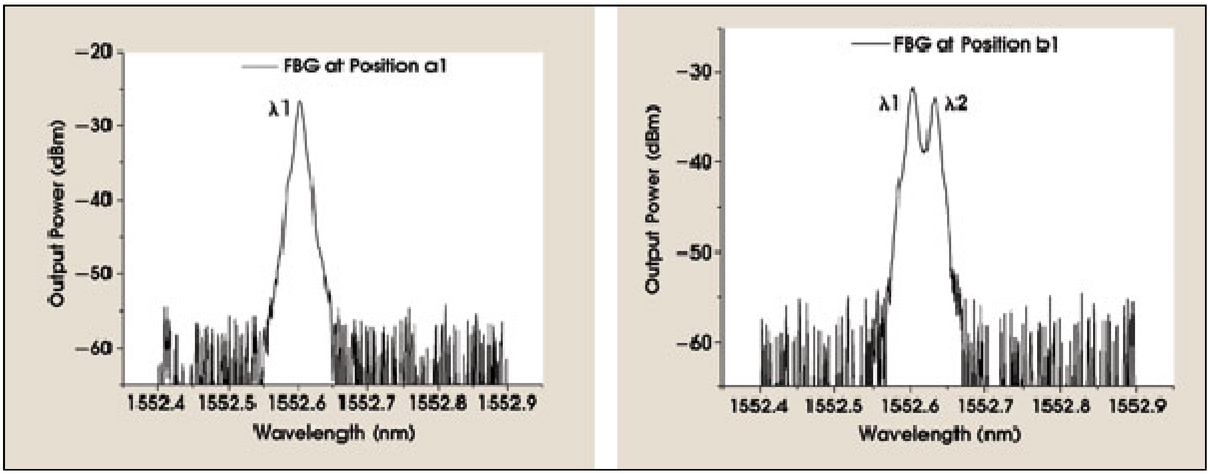

Figure 4. *When the reflectivity of FBG2 was set to the wavelength indicated at a1 in Figure 2, a single laser line at 1552.60 nm oscillated (left). When FBG2 was set to wavelength b1, lines at 1552.60 and 1552.63 oscillated simultaneously (right).*

The reflectance of the second grating could be tuned by mechanical strain, and it was broad enough to include two of the transmission peaks of the first grating. Thus, the researchers could stretch FBG2 so its reflectance was centered on one, or between two, of the transmission peaks of the first. In the first case, the laser emitted a single wavelength (Figure 4, left), and in the latter, two simultaneous wavelengths (Figure 4, right).

The researchers observed single-line lasing at each of the four transmission peaks of FBG1: 1552.60, 1552.63, 1552.67 and 1552.71 nm. They also observed dual-line lasing at each of the three pairs of adjacent lines. In all cases, the bandwidths of the individual lines were less than 10 pm.

IEEE Photonics Technology Letters, Oct. 1, 2006, pp. 2038-2040.

multiplexing (DWDM) networks