Integrated Bragg Grating Structures

M. Jalal Khan, Michael Lim, Charles Joyner, Tom Murphy, H.A. Haus, H.I. Smith.
jalal@mit.edu, mikel@mit.edu, chj@lucent.com, tem@ll.mit.edu, haus@mit.edu, hismith@mit.edu

Introduction

Bragg gratings are useful components with numerous applications, including use as optical add/drop filters. Integrated gratings offer the advantages of smaller size and large-scale manufacturability over commercially available Fiber Bragg gratings. Integrated Bragg grating structures were fabricated in an InGaAsP/InP material system. This paper describes their measurement and characterization

Measurements and Characterization.

Three different classes of devices, shown in Fig 1, were measured: (1) Straight Bragg Gratings, (2) λ/4 phase-shifted Bragg Grating Resonator Cavity and (3) Coupled Bragg Resonator Cavities.

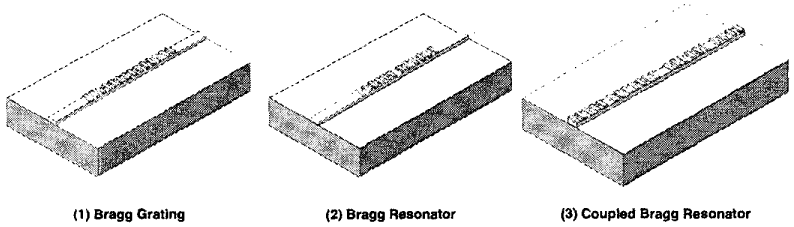

Fig 1. Classes of devices measured.

Measurement setup is shown in Fig. 2. A tunable laser source, connected to a polarization controller, was fed into a lensed fiber via a 10/90 power splitter. The splitter was used to account for any power drifts of the tunable laser source as the wavelength was scanned. The lensed fiber enabled better coupling to the smaller waveguide modes. At the output facet the light was collected using another lensed fiber and fed into a power meter. The polarization state was experimentally ascertained to remain stable over a period of many hours. Following alignment of the input and output lensed fibers numerous wavelengths scans were performed.

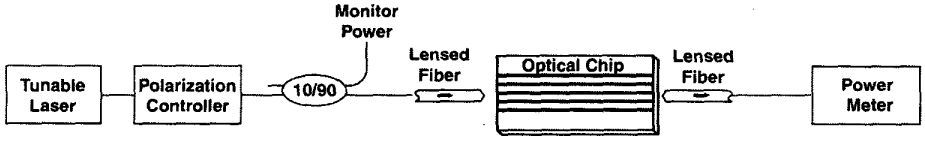

Fig 2. Measurement Setup.

Bragg Gratings

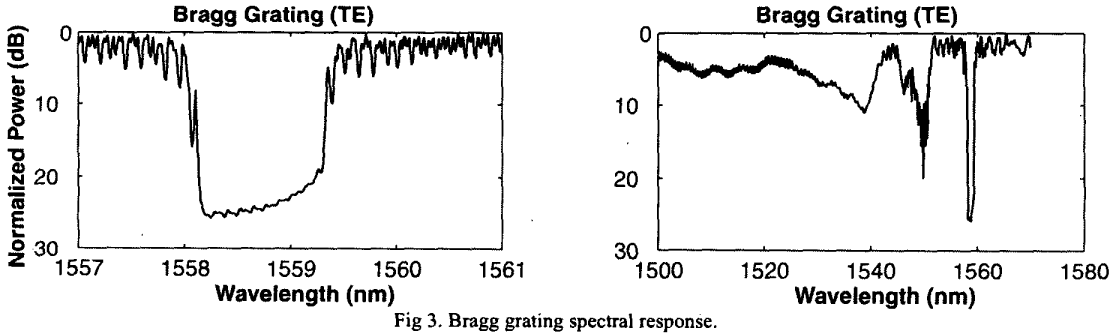

Fig 3. Bragg grating spectral response.

Fig. 3 shows two wavelength scans over a narrow and wide wavelength range performed on the same Bragg grating device using a TE polarized input. The scans reveal a clear stopband with a suppression in excess of 25 dB. The

suppression was noise-limited due to the chip layout and measurement setup. Radiation losses on the low wavelength side were observed. The decreased transmission near 1554 nm is thought to be due to phase-matched coupling by the grating between the first-order forward traveling guided mode to the second-order backward traveling guided mode. Since the waveguides were designed near cut-off we expect a second order mode to be excited at low wavelengths. The oscillations observed within the stopband and outside of it are due to Fabry-Perot modes caused by reflection from the uncoated chip facets.

Bragg Grating Resonator (λ/4 phase-shifted Grating)

Fig. 4 shows the transmission measurement on a λ/4 phase-shifted Bragg grating. As expected a resonant transmission state exactly in the center of the grating stopband is observed. The resonant transmission nearly returns to the 0 dB level, indicating an extremely low-loss resonator. The linewidth of the response was about 5 GHz which yields a measured Q in excess of 35,000. Radiation losses on the low wavelength side were also low as can be seen on the wide wavelength scan.

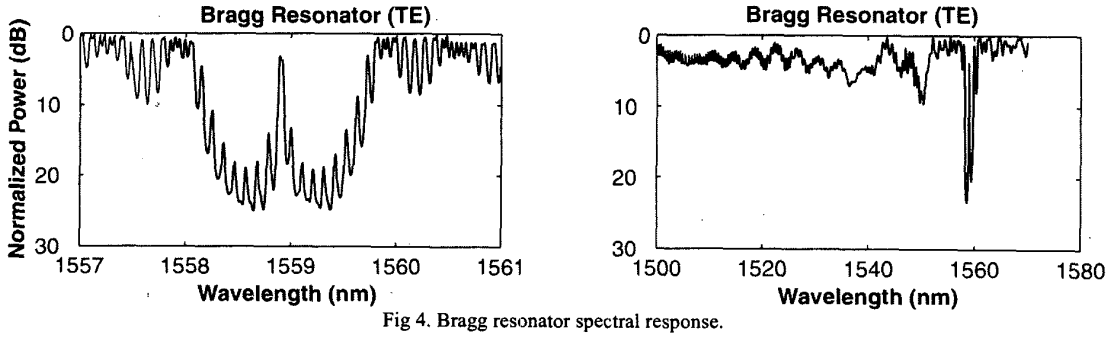

Fig 4. Bragg resonator spectral response.

Coupled Bragg Resonator Cavities.

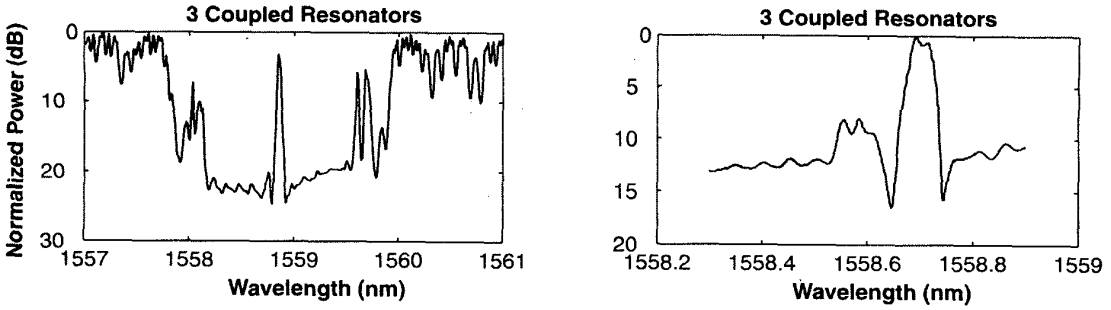

Fig 5. Three Coupled Bragg Resonators' spectral response.

Fig. 5. shows the response of 3 coupled Bragg resonators. The higher-order resonant transmission state is observed in the center of the stopband. The additional structure at the edges of the stopband and the flat-top response, with faster roll-off, is characteristic of the coupled resonators. Comparison with Coupled- Mode theory (not shown here) for all the devices showed excellent agreement.

Conclusions

Integrated Bragg grating structures with extremely low-loss and high Qs were successfully fabricated. The Bragg gratings showed a noise-limited transmission suppression within the stopband in excess of 25 dB. The measured Q of the Bragg resonators was over 35,000. Coupled Bragg resonators with flat-top responses and faster roll-offs with wavelength were demonstrated. These successfully demonstrated devices form the basic building blocks of integrated add/drop filters using Bragg gratings.