Submitted OFC '94 (San Jose) 772

# Novel Channel-Dropping Filter by Grating-Frustrated Coupling in Single-Mode Optical Fibre

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## Abstract

A novel all-fibre channel-dropping filter based on a new physical principle, *grating-frustrated coupling*, is demonstrated. A prototype device with 0.7 nm bandwidth, 13 dB isolation and 0.2 dB excess loss is reported.

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Owing to their excellent properties and increasing availability, photorefractive Bragg gratings[1] have become ideal as building-blocks for creating new types of wavelength-selective optical components.[2,3] In this paper, we introduce one such component: the *grating-frustrated coupler*, a novel all-fiber and very low loss channel-dropping filter (Fig. 1). It consists of two single-mode fibers, *1* and *2*, forming a 2×2 directional coupler. The two fibers are identical, except that the core of fiber *2* contains an index grating with Bragg wavelength $\lambda_B$. At wavelengths far from $\lambda_B$, the device operates as a conventional coupler. Near $\lambda_B$, however, within a narrow spectral region known as the stop-band, the strong grating operates in two ways to *frustrate* the transfer of optical power from fiber *1* to fiber *2*: first, it introduces a strong dispersion, making the coupler *asynchronous*; second, it creates a barrier (photonic band gap) that rejects photons attempting to tunnel through. The grating-frustrated coupler can therefore be designed to transmit wavelengths within the grating stop-band through fiber *1* while other wavelengths are coupled to fiber *2*.

A coupled-wave theory model was developed to analyze the grating-frustrated coupler and to optimize the design parameters in a prototype device. Two single-mode fibers, one of them containing a photorefractive Bragg grating with $\lambda_B$=1535 nm, were mounted into glass blocks, side-polished and assembled as in Fig. 1.[4] Light from a 1540 nm LED was launched into fiber *1* through a 50:50 coupler. The polished coupler was tuned until a maximum coupling of 97%

was obtained. The calibrated spectra measured at the four output ports of the device are shown in Fig. 2. As expected, most of the light at $\lambda_B$ is transmitted through fiber *1* while up to 97% of the input light is transmitted through fiber *2* outside the grating bandwidth. Filtered signal $T_1$ has a maximum of ~70%, a bandwidth of 0.7 nm and 13 dB isolation. The other transmission spectrum, $T_2$, has a 1.0 nm bandwidth and 18 dB extinction at $\lambda_B$. The reflected signal $R_1$ is larger than expected, while $R_2$ remains small at all wavelengths. The coupler response was also characterized using a white light source; the coupling was seen to decrease by 1% over a 100 nm range. A cutback measurement indicated an excess loss of 0.22 dB. In Fig. 3, a good theoretical fit of the measured spectra was obtained using the coupled-wave model. The discrepancies that are observed can be attributed to the non-uniformity of the photorefractive grating.

In conclusion, a novel all-fiber channel-dropping filter based on a new physical principle - grating-frustrated coupling - has been designed and demonstrated. Our first prototype, operating at 1535 nm, has already produced excellent results - 0.7 nm bandwidth, 13 dB isolation, 70% peak transmission and 0.22 dB excess loss - and theory shows that significantly improved performance is to be expected in a better optimised device.

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**Figure captions**

Fig. 1

Schematic diagram of a grating-frustrated coupler, used as a channel-dropping filter It consists of a polished fiber coupler (effective coupler length $L_C$) with a photorefractive Bragg grating (Bragg wavelength $\lambda_B$, length $L_G$) inscribed in fiber *2*. A signal at $\lambda_B$ can be extracted from broadband input light.

Fig. 2

Measured reflection and transmission spectra of all-fibre grating-frustrated coupler.

Fig. 3

Calculated reflection and transmission spectra for $L_C$=2.5 mm and $L_G$=4.5 mm.