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WDM GRID TUNABLE FILTER BASED ON A SAMPLED FIBRE GRATING AND A FFP

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Abstract: We propose and report on a novel device based on the cascade of a sampled fibre grating and a fibre Fabry-Perot. The operation and experimental demonstration of the combined structure are presented showing stability and tunability advantages for filtering and channel routing applications in WDM telecommunication systems using normalised frequency grids, such as that proposed by the ITU.

Introduction

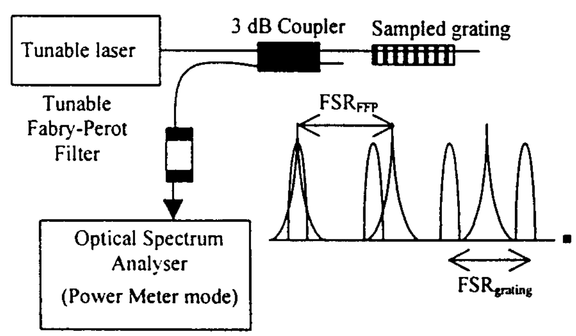
Fiber optic devices for WDM applications are attracting great interest since they are key components in the implementation of networks with increasing number of channels and bandwith per users. In this context, devices based on the combination of fibre Bragg gratings and fibre Fabry-Perot filters (FFP) have been proposed to obtain high finesse and non-periodical optical filters with unique features [1]. Recently it has been demonstrated the possibility of accurate fabrication of multiband filters based on sampled Bragg gratings [2] opening new possibilities to filtering applications. In this work we present for the first time to our knowledge, a demonstration of a combined device, using a sampled Bragg grating and a fibre Fabry-Perot filter that exploit the Vernier effect between them to provide high finesse non-periodical response, and fast tunability. These devices have potential applications in WDM systems based on normalised frequency plans.

Device Operation

The device consists of the cascade of a sampled fibre grating and a fibre Fabry-Perot (see figure 1). Sampled gratings are generated by a periodically varying envelope of index modulation [3]. The sampled grating has been designed to provide an equally spaced multiband response of N passbands of the same amplitude. These passband frequency positions can be easily designed to comply with the international standard (ITU-standard) frequency values for a WDM system. The FFP presents a periodical response with resonances spaced by its free spectral range (FSR), allowing the selection of these normalised bands through a voltage signal. The cascade of these two filters can exploit the Vernier effect by the proper design of the FSR and the channel separation of the sampled grating (see figure 1). To achieve the Vernier effect the FSR and the sampled grating channel spacing must be of similar magnitude but different enough to assure that only one of the channels is selected at a given time and that the adjacent channels (worst case) are sufficiently rejected. In the structure design, parameters such as the FFP resonance bandwidth and finesse, and the channel bandwidth of the sampled grating are strongly related to the maximum number of possible channels N.

This combined structure benefits form the advantages provided by the sampled gratings, i.e. temperature stability, easy and precise fabrication of normalised multiband responses, rejection of non-desired signal between channels, produced by channel deviations from the ITU-standard or ASE noise accumulation in multistage amplified systems. The exploitation of the Vernier effect in the combined structure makes it possible to use an FFP with low FSR, to tune any resonance of the sampled grating rather than requiring an FFP with an FSR well over the spectral region covered by the sampled grating band. This feature can be also of great interest not only for data but signalling channels. Faster tunability than in the common approach presented in [1] is provided, since lower values of FFP tuning voltage change are required in order to select a different channel using another FFP resonance. Tuning stability is assured by the sampled grating and no typical stability problems associated to Vernier structures based on two FFP have been observed.

Figure 1: Experimental setup



Experiment

The experimental setup is shown in Fig. 1. The optical source is a tunable laser capable of providing continuous wavelength scanning from 1500 to 1560 nm in steps of 1 pm and an output power of 1 mW. The output signal from the laser is launched into the sampled fibre grating through a fused 3 dB coupler and the reflected signal is directed towards the optical input of the tunable FFP (see Fig. 1). The measurement of the output signal from the FFP is provided by an optical spectrum analyser configured in a power meter mode.

The experimental demonstration of the device is performed with two different sinc-sampled gratings. Each grating is 10 cm long and written in Deuterium-loaded germanosilicate fibre by a novel continuous grating writing technique [4]. The Bragg wavelengths are around 1560.2

and 1551, comprising 4 and 8 channels of 14 pm and 30 pm bandwidth, respectively, and the channel separation is about 37.5 GHz. All channels exhibit similar characteristics, being uniform with a 94% reflectivity (see insets in Fig. 2 and Fig. 4, solid line). The fibre Fabry-Perot tunable filter shows an FSR of 35.0 GHz, bandwidth of 170 MHz and tuning voltage/FSR of 12 V (see dashed line in same insets).

Fig. 2 shows the total response of the device comprising a 4-channel sampled grating and a non-biased FFP. All the FFP resonances, except the one which is located in a grating bandpass channel (λ_1=1549.83 nm) are nearly supressed. The presence of the other resonances is due to some reflection happening either in the coupler or at the end of the fibre which can be easily eliminated if required. By tuning the FFP [1], other grating channels can be selected.

Figure 2: Filter response. Inset: 4-channel grating and FFP characterisation

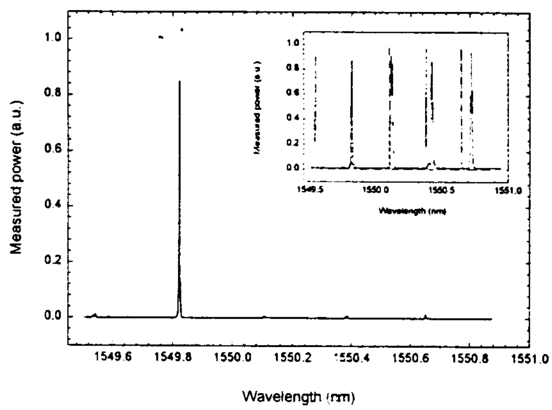
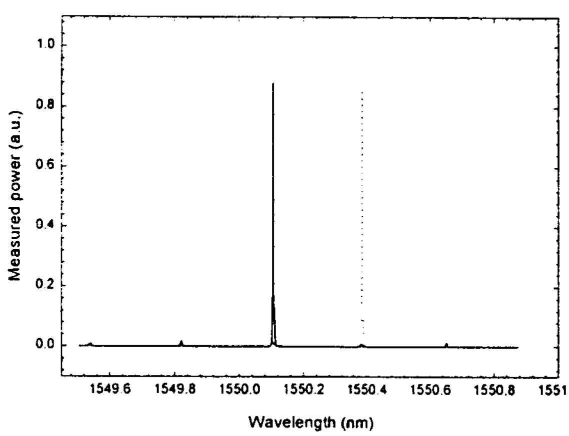


Fig. 3 shows the second and third channel of this sampled grating (λ_2=1550.13 nm, λ_3=1550.40 nm), which have been selected by applying 0.8 V and 1.6 V, respectively.

Figure 3: Tuned filter response in a 4-channel system.



The response of a second device based on cascading the 8-channel grating and the FFP is measured. Fig.4 shows the spectrum when a FFP resonance is tuned to be located in the first channel of the sampled grating (λ'_1=1549.90 nm) by applying a voltage of 3.4 V and Fig. 5 shows the ability of tuning two different channels (λ'_4=1550.72 nm, λ'_7=1551.57 nm) by applying 7.7 V and 8.5 V, respectively.

Figure 4: 8-Channel grating and a FFP based filter response. Inset: Individual characteristics.

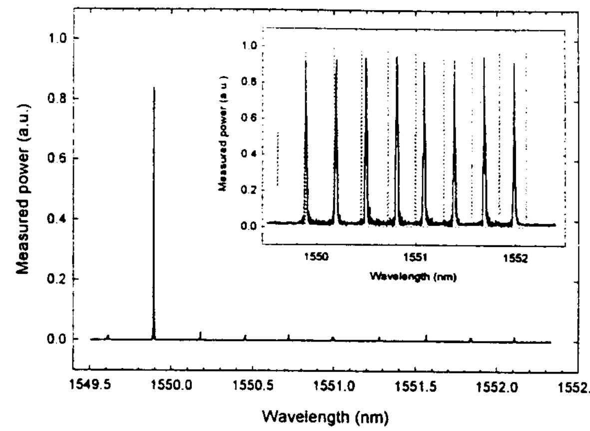
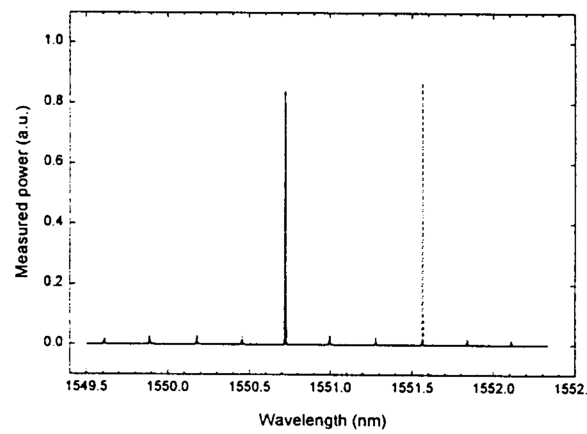


Figure 5: Tuned filter response in an 8-channel system.



Conclusions

We have presented a novel all-fibre device which consists of cascading a sampled fibre grating and a fibre Fabry-Perot. It shows a fast and stable tunability as a result of the combination of the properties of fibre gratings and fibre Fabry-Perot's. The interest of such a device is due to its many potential applications in WDM telecommunication systems which use normalised grid frequency plans. Examples of them are ASE filtering in multistage amplified systems and selective channel routing in WDM systems by designing the appropiate ratio between the FSR of both components.

References

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