Programmable fiber Bragg gratings for spectral CDMA

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Abstract: Spectral encoder/decoder for CDMA application is implemented and experimented by using fiber Bragg grating arrays and broadband incoherent source. High encoding flexibility is obtained by tuning independently each grating with piezo-electric elements.

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The employment of optical code-division multiple-access (OCDMA) offers high advantages in allocating bandwidth for bursty access networks, where wide bandwidth services are required [1]. Many different optical CDMA implementations have been proposed [2,3]. Spectral slicing [4] appears an attractive technique because spectral data encoding provides a large number of simultaneous users and transparency to data format and bit-rate. CDMA realized by using a cascade of fiber Bragg gratings (FBG’s) allows to combine all the advantages of spectral encoding [5,6] with the compactness and robustness of a totally guiding structure without free-space architectures losses [4].

In this paper we experiment FBG technology in order to realize spectral CDMA with programmable encoding. The cascade of 8 FBG’s is used in encoding/decoding operation: each grating can be tuned independently by means of piezo-electric elements in order to program the desired user code. A broadband incoherent light providing a very low-cost and easy optical set up powers the device. The employed array consists of 8 fiber gratings (L=5mm in length, spaced 5mm apart, written on SM fiber) having Bragg wavelengths corresponding to standard WDM-ITU channels. They increase by steps of 1.6nm (200 GHz) from 1543.73nm to 1554.94nm, (Fig. 1.a) with a bandwidth of 0.3nm and reflectivity over 99%.

The decoding device consists of a reverse connected gratings arrangement. The gratings are stuck to piezo-electric elements, 5mm long, useful for stretching. For a better stretching response of the fiber, a special coating (90% polyimide, 2.5µm thick) and epoxy paste are utilized. To achieve a Bragg peak shift of 0.8nm, corresponding to a zero-reflection position for two neighboring no-stretched gratings, a fiber stretching of 2.6µm (obtained by applying about 50V) is necessary. Mechanic and thermal isolation is guaranteed by a suitable insulating structure (Fig. 1.b). A PC controls independently all the 16 voltages applied to the FBG arrays in order to suitably program the user code. An EDFA 12nm equalized amplified spontaneous emission (ASE) is employed (14dBm in power) and intensity modulated by an electro-optic modulator up to 2.5 Gbit/s. In Fig. 2 the detected signal is shown after transmission. When the decoder is spectrally matched to the input encoder, the detected signal has maximum intensity; on the other hand in case of complete mismatching no signal is detected by the receiver.
We show the results of system operation in case of two simultaneously transmitting users orthogonally encoded and broadcast by means of a star coupler. In the shared common transport fiber the superimposition of the two asynchronous IM signals is visible (Fig. 3a). By tuning the FBG array the code of the receiving user is programmed and only the due signal is selected (Fig. 3b).

In conclusion we have experimented a programmable FBG encoding/decoding device for optical CDMA applications. The use of piezo-electric elements useful for tuning the fiber grating response allows very high flexibility in spectral encoding/decoding. By choosing suitable code families [4] or frequency/time hop techniques [7], a large number of simultaneous users can be supported with limited crosstalk.

References