Acousto-optic control of the LPG spectrum for sensing applications

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ABSTRACT

Experimental and numerical demonstration of the acousto-optic effect applied in long period grating by means of flexural waves is presented. The interaction between acoustic and optical waves is modeled with help of the method of assumed modes, which delivers the strain field inside the grating and the transfer matrix method, which, given the strain field as input, calculate the resultant grating spectrum. The experimental and theoretical results are found to be in good agreement. The main effect of the bends in the grating is the break of degeneracy of the circular cladding modes, leading the attenuation band to be changed. Among all the applications of this methodology, it is important to mention the possibility of use as a tunable filter, laser cavity gain controller, switching device and transducer in sensing systems.
Keywords: Long period grating, acousto-optic effect, tunable gratings, optical filter.

1. THE GRATING TECHNOLOGY

When the refractive index of a fiber is modulated, with modulation period around hundreds of micrometers, a long period grating (LPG) is generated [1]. This period is chosen in order to make the grating able to couple light from the guided fundamental mode into the forward propagating cladding modes and irradiated modes. The high sensitivity of LPGs to the refractive index of the surrounding material shows great potential in sensors applications [2]. Moreover, such technology can be used in optical communications devices, for instance, as rejection filters [1].

The most used inscription techniques of LPGs are based on induced changes in the refractive index of the fiber core through electric discharge [3], exposure to 193 nm UV light [4] and 10.6 µm (CO_2) laser radiation [5]. Another very popular technique uses the formation of bends in the fiber through transversal pressure of the fiber axis [6]. Such bends can also be generated by the propagation of “high” frequency flexural acoustical waves in the fiber, which gives rise to several useful devices [7]. The interaction of a flexural acoustic wave, generated by longitudinal excitation with an LPG “already” existent in the fiber, however, has not been reported so far in the literature. In this work, we show experimentally the dynamic control of the LPG transmission spectrum, whose results are compared to numerical simulations, carried-out using the methods of assumed modes and transfer matrix [8].

2. METHODOLOGY

The acousto-optic effect [7-9] has been successfully used in the construction of a variety of all-fiber devices. In this work, the interaction of the acoustic wave with the LPG is simulated with the help of a numerical technique based on the methods of assumed modes (AM) [10, 11] and transfer matrix (TM) [12]. The numerical approach consists in calculating the time-space variation of the displacement field in a length of fiber through the method of AM, delivering the strain field in the LPG, which is further used as the input to the TM method. This allows the behavior of the transmitted spectrum of the grating to be calculated under the influence of the strain generated by the acoustic wave.

The AM approach is a method used in mechanical engineering, which is based on the discretization of a system consisting of *n* elements and *n* degrees of freedom in order to find approximated solutions through numerical series. For

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