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Control of the long period grating spectrum through low frequency flexural acoustic waves

Roberson A Oliveira[1,2], Gustavo R C Possetti[1], Carlos A F Marques[3], Paulo T Neves Jr[4], Kevin Cook[2], Ricardo C Kamikawachi[1], C Bavastri[5], José L Fabris[1], Marcia Muller[1], Rogério N Nogueira[3,6], John Canning[2] and Alexandre A P Pohl[1]

[1] Federal University of Technology, Paraná, Curitiba, Paraná, Brazil
[2] Interdisciplinary Photonics Laboratory, University of Sydney, Sydney, NSW, Australia
[3] Instituto de Telecomunicações, Polo de Aveiro, Aveiro, Portugal
[4] Federal University of Technology, Paraná, Campus Toledo, Toledo, Paraná, Brazil
[5] Federal University of Paraná, Centro Politécnico, Curitiba, Paraná, Brazil
[6] Nokia Siemens Network Portugal S.A., Lisboa e redondezas, Portugal

E-mail: roberson.assis@gmail.com

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Abstract
We have shown experimental results of the excitation of long period fiber gratings by means of flexural acoustic waves with a wavelength larger than the grating period, validated by numerical simulations. The effect of the acoustic wave on the grating is modeled with the method of assumed modes, which delivers the strain field inside the grating, then used as the input to the transfer matrix method, needed for calculating the grating spectrum. The experimental and numerical results are found to be in good agreement, even though only the strain-optic effects are taken into account.

Keywords: long period grating, acousto-optic effect, assumed modes method, transfer matrix method

(Some figures in this article are in colour only in the electronic version)

1. Introduction

A long period grating (LPG) is a special optical fiber grating first reported in 1995 [1, 2], whose refractive index modulation period is chosen in order to couple light from the guided fundamental mode of the fiber and the forward propagating cladding modes. The high sensitivity of LPGs to the refractive index of the surrounding material shows great potential in applications such as hydrophone sensors and chemical detectors [3, 4]. The wavelength-dependent phase-matching condition in LPGs is governed by the relationship

$$\lambda_m = \left(n_{\mathrm{co}} - n_{\mathrm{cl}}^m\right) \Lambda, \qquad (1)$$

where λ_m is the dip wavelength of the mth attenuation band, n_{co} and n_{cl}^m represent the effective indices of the fundamental guided mode and the mth LP_{0m} cladding mode, respectively, and Λ is the grating period. At λ_m, the energy of the propagating cladding modes is lost due to absorption and scattering in the surrounding environment, thereby creating a rejection band in the transmission spectrum, strongly dependent on the external medium (temperature, refractive index, pressure and so on). The minimum transmission at this particular wavelength is given by the expression

$$T^m = 1 - \sin^2(\kappa_m l_g), \qquad (2)$$

where l_g is the length of the LPG and κ_m is the coupling coefficient for the mth cladding mode, which is determined by the overlap integral of the core and cladding modes and by the amplitude of the periodic modulation of the mode propagation constants [3].

The most used inscription techniques of LPGs are based on induced changes in the refractive index of the fiber core

