광섬유 클래딩 모드의 분산 특성 조절에 의한 장주기 격자 내에서의 공명 피크의 free spectral range 향상

Enhancement of free spectral range in the resonance peaks in a long period fiber grating by controlling clad mode material dispersion

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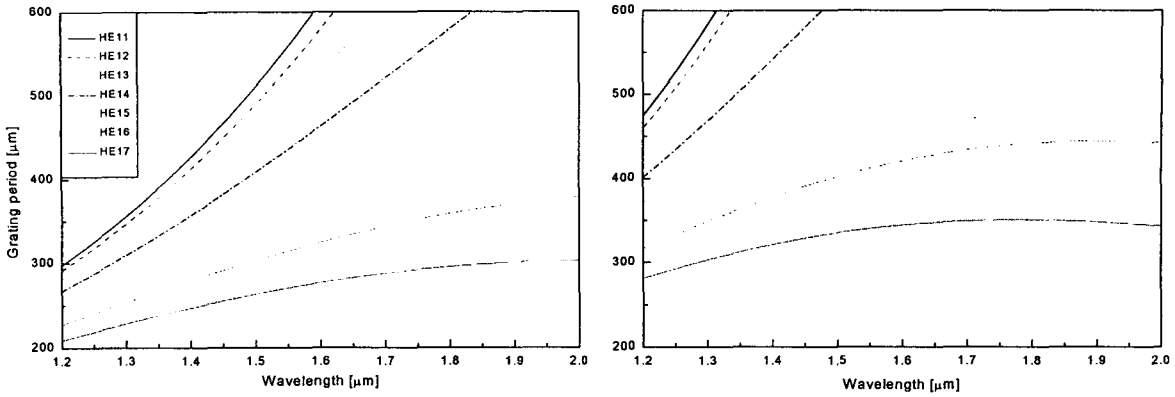
1. Introduction

Optical fiber gratings have been intensively studied for applications in optical fiber communications and sensor systems due to their all-fiber configuration, low insertion loss, low cost, and high flexibility. Especially, cladding mode coupling fiber devices such as long period gratings (LPG) and acousto-optic tunable filters (AOTF) have been developed as a gain equalization filter in erbium doped fiber amplifier (EDFA) for wavelength division multiplexing (WDM) systems[1-2]. Recently the gain bandwidth of optical amplifier expands over the conventional EDFA gain band 1530-1560 nm. The relatively close spaced resonance peaks of cladding modes in a LPG optimized for 1530 nm gain filtering, thus, could result in a high insertion loss in the neighboring gain bands. Controls of free spectral range of the resonance peaks in LPGs are in need for wide gain band optical communication systems. In this work we propose a new method to control the LPG spectrum by introducing material dispersion into cladding modes. Previous studies in LPGs were focused only on the change of refractive index profiles of the core region leaving the cladding modes behind. To change material dispersion of cladding modes, we propose transition metal doping, such as Cr^{3+}, into the cladding region. Because the transition metals have absorption peaks in visible range, they effectively introduce changes of refractive index and dispersive characteristics in silica host at the optical communication windows.

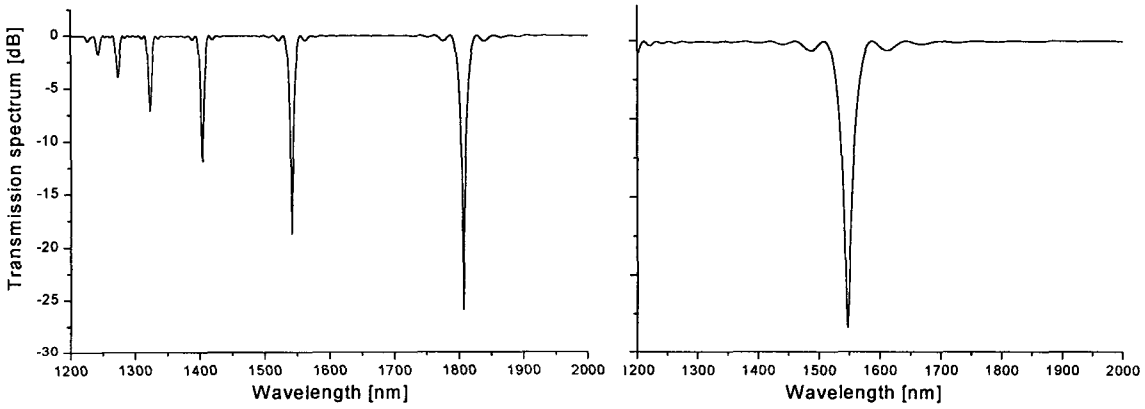
2. Simulation results and discussion

In figure 1 the calculated spectral positions of cladding mode coupled by various grating periods are compared with pure silica cladding and 5000ppm Cr doped cladding structure. The refractive index of core is 1.4516, the pure silica cladding and 5000ppm Cr doped cladding are 1.4442 and 1.4461 at 1550nm respectively. From this figure, we can confirm that Cr change the effective index and grating period slope with respect to wavelength effectively. And this is attributed to strong absorption peaks of Cr in visible range. Figure 2 shows the calculated transmission spectra for the pure silica cladding and the Cr doped cladding fibers. In this calculation the core radius, grating length, AC index change, and duty cycle were 3.14 m, 25.4 mm, 0.0005, and 0.5, respectively. And the gratings in Figs.2(a) and 2(b) have periods of =273m and =252m, respectively. By doping Cr, we could isolate only one cladding mode resonance peak in the spectal range of 1200 nm to 2000 nm. The free spectral range was estimated over 400 nm. In this LPG strucutre, selective filtering of gain bands without incurring insertion loss in the neighboring gain band could be achieved. This



(a) (b)

Figure 1. The peak position of clad modes for (a) pure silica clad(b) 5000ppm Cr doped cladding



(a) (b)

Figure 2. Calculated transmission spectrum for long period grating inscribed on (a) pure silica cladding (b) 5000ppm Cr doped cladding. The inscription conditions are explained in the text.

result is attributed to the change of cladding mode dispersion by Cr doping that affects the required grating period and the number of cladding modes which are coupled with the core mode.

Conclusions

We proposed for the first time, to the best knowledge of authors, a new optical fiber for application of cladding mode coupling fiber filters that can individually isolate the resonance of cladding modes. When doped in the silica cladding, Cr ions were found to effectively change the dispersion of cladding modes. Suppression of unwanted coupling in LPG and enhancement of free spectral range over 400 nm could be achieved in the Cr doped cladding fiber structure, which would be in need for a wide gain band optical communication systems.

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References

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