기계적으로 형성된 연속 파장가변 장주기 광섬유 격자 필터
Mechanically Formed Continuously Tuned Long-period Fiber Grating Filters

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The fiber gratings have been developed into a critical component for many applications in fiber-optic communication and optical sensor systems. The gratings written by ultraviolet light into the core of the optical fiber have been well-established(1). Other techniques to fabricate gratings include a mechanically formed long-period fiber gratings (LPFGs) which have applications such as an optical loss filter and a fiber sensor. Most of mechanically formed micro-banding of the LPFGs is formed by an etched Si V-groove(2) or an arrayed cylindrical rod(3,4). In spite of attractive interesting of these methods, it has not been widely applicable to the active devices because its structural limitation made it difficult to realize a fine and wide tuning function. For tuning, the grating blocks should be tilted to ambient angles for changing their periods. The tuning range is, therefore, narrow. Thermally tuned method was also reported(5). But, the temperature-controlled optical filter could have potential problem of instability of peak wavelength.

In this study, we present the novel continuous-tuned fiber filter using mechanically formed LPFGs. The concept is based on the arrayed metal-wire having smaller diameter than the period of LPFGs and a rubber plate to control their periods. LPFGs have large grating periodicities of several hundred microns and the HE_{11} core mode is strongly coupled to the co-propagating HE_{1m} cladding modes. Herein, the distributed refractive index in the single-mode fiber (SMF) is formed by mechanically induced strain. The basic structure of the proposed LPFGs is shown in Fig. 1. The wires of 250-㎛-diameter are arrayed on the rubber plate at equal intervals of 550-㎛-periods and glued on it. The SMF, removed its coating, is placed on the substrate. And then the rubber plate is covered on. The index modulation of the fiber is formed by pressuring the rubber plate with a grating to an optical fiber. The pressing force decides the filtering-rejection strength. As the rubber is a kind of latex, it is restored to the former state within the limited stretchy range of sub hundred microns. To vary the grating period, the one side of the rubber is clamped on the substrate and the other is connected with a micro-translation stage to be stretched the rubber. The resonance wavelengths can be accurately tuned by adjustment of the micrometer.

In the proposed structure, the number of gratings of LPFGs and an applied line-force decide a filter-contrast and a bandwidth. Herein, the 0.9 N/㎜ of line forces are applied and 55-gratings are used to measure the tunable properties At HE_{13}-mode, 13-dB-rejection depth and 5-㎚-bandwidth (FWHM) are obtained. Fig. 2 shows the tunable spectral responses with respect to the period variation of the grating. Stretch of the rubber is able to change the period of grating continuously. The resonance wavelengths are shifted to shorter or longer position by the movement of the micro-translation. The resonance dip is linearly shifted in terms of the variation of the grating period. Since the period can be adjusted as fine as a micron order, the dip wavelength can be accurately tuned. In this case, the tuning step of 1.3 nm per one-micron translation of the grating period is obtained. Rejection depth slightly decreases while the grating period increases. We think that the reason is mainly based on the variation of the applied line force per unit grating length.

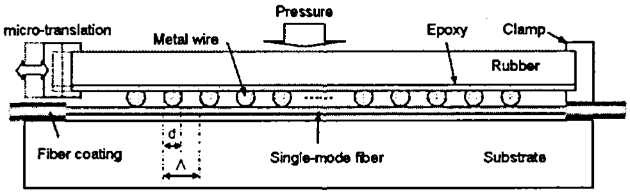

Figure 1. Basic schematic diagram of the proposed tunable filter

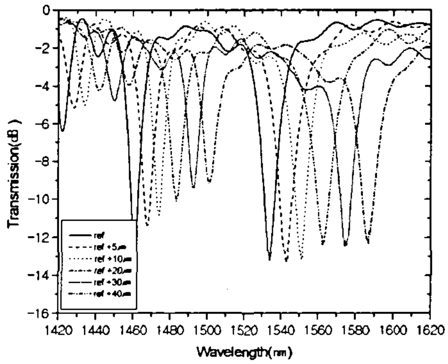

Figure 2. Tunable spectral responses with respect to the period variation of the grating by pulling of the rubber

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