Photo-Induced Optical Attenuation in Single-Mode Optical Fiber by Irradiation of Femtosecond Pulse Laser

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Fixed optical attenuators are widely used to control optical power of light signals in the optical communication systems. Co^{2+} ion doped fiber (CoDF) attenuators with optical absorption of Co^{2+} ions at the optical communication wavelengths have been utilized due to their simple fiber structure and high input power endurance [1,2]. However the fabrication of the CoDF attenuators with desired attenuation property needs fiber preforms with one to one controlled Co^{2+} ion concentration.

Recent year, it has been found that focused irradiation of femtosecond infrared laser pulses whose duration shorter than 1000 fs results in inductions of structural changes leading to an increase in the refractive index at the focal point inside transparent materials [3,4]. This localized modification phenomenon with femtosecond pulse laser is very attractive since it gives the potential to the fabrication of three-dimensional photonic devices inside transparent materials [3,4]. In this paper, we report on the fabrication technique of the novel optical attenuation fiber by the irradiation of femtosecond pulse laser to silica glass single-mode optical fibers.

A regeneratively amplified mode-locked Ti-sapphire laser operating at a wavelength of 800 nm was used in the present experiments. The pulse duration was 120 fs and the repetition rate was 200 kHz or 1kHz. The optical fiber used in the present experiments was a standard commercial silica glass single-mode optical fiber of which core was doped with Ge ions. The laser beam was guided into a microscope and focused by objective lenses (numerical aperture, NA: 0.30 – 0.90) on the core inside the optical fiber mounted on a computer-controlled XYZ stage. The focused femtosecond laser was irradiated point by point and the irradiation time was 2 s for each irradiation point. The optical power of the light emitted from the fiber irradiated femtosecond pulse laser was monitored in situ by using an optical power meter.

Photo-induced optical attenuations in the optical fibers were observed by the irradiation of femtosecond pulse laser. Figure 1 shows the relationship between optical attenuation at 1.55 μm and number of irradiation point formed inside the fibers. The optical attenuations proportionally increased with the increase in the number of irradiation point and were controllable up to about 20 dB. Larger optical attenuations per one-irradiation point were observed by the irradiation of higher average power of the laser. From the analysis of near-field patterns at 1.55 μm, it was confirmed that single-mode waveguide properties and mode field diameters of the fabricated optical attenuation fibers were identical to those of non-irradiated optical fibers. It is suggested that the optical attenuations result from the scattering of propagating light by the photo-induced refractive index increasing regions.

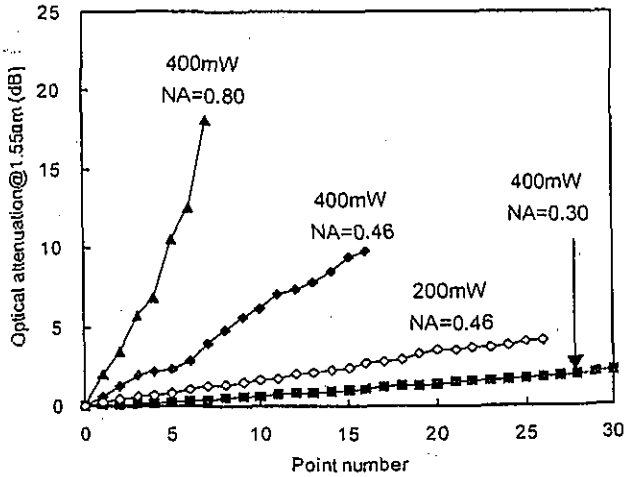

Fig.1 Relationship between optical attenuation and numbers of irradiation point formed inside optical fibers by using 200kHz-120fs pulse laser.

References

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