ESTIMATION OF DIFFUSION COEFFICIENT OF Pb IONS IN Pb/Ge-CODOPED EXPANDED CORE OPTICAL FIBER

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Abstract: Diffusion coefficient of Pb ions in Pb/Ge-coded optical fibers was estimated by using the change in mode field diameter of the fiber upon heat treatment for core expansion. The diffusion coefficients, D, of Pb ions in the germano-silicate glass optical fiber at 1200°C was found to be about 1.09x10^{-10} cm²/s.

1. INTRODUCTION

Diffusion of dopant in the fiber core of an optical fiber is important as the dopant distribution in the core and inner cladding determines the transmission properties and amount of mode field expansion upon heat treatment in the expanded core optical fiber.

In this paper, we report a new method to estimate diffusion coefficient of Pb by analyzing the measured mode field diameter of the Pb/Ge-coded optical fibers with different core sizes upon heat treated by halogen lamps as a heat source at 1200°C.

2. EXPERIMENTS

The Pb/Ge-coded fibers were manufactured using the Modified Chemical Vapor Deposition (MCVD) and Drawing Tower (DT) process. Various Pb/Ge-coded fibers of the different core sizes were fabricated and their core diameters/cutoff wavelengths were 4.3 μm/1.0 μm for Fiber-1 and 9.5 μm/1.1 μm for Fiber-2, respectively. The optical fiber doped with only Ge was also fabricated with the core diameter and the cutoff wavelength of 3.6 μm and 1.1 μm, respectively. After the heat treatment of these fibers using the halogen lamps, the fiber was cut at the center of the heated section into two pieces and the MFD was measured at 1.55 μm using the far-field pattern method. The diffusion coefficient of dopants in germano-silicate glass optical fibers was calculated by using the MFD.

3. RESULTS

Figure 1 illustrates the effect of heat treatment time on the MFD of fibers that were heat treated at 1200°C. It can be noticed that the MFD increased with increasing the heat treatment time. The MFDs of the Pb/Ge-coded fibers were found to be larger than that of the Ge-doped fiber because the Pb-ions in the core diffused out radially faster than Ge-ions. The diffusion coefficient of dopant was estimated by the Fick's law. After heat treatment of 10 minutes, the calculated diffusion coefficient was 4.48x10^{-12} cm²/s for the Ge-doped optical fiber (the MFD of the Ge-doped fiber was 4.08 μm after heat treatment for 10 minutes). In the case of the small core Pb/Ge-coded fiber (Fiber-1), the diffusion coefficient of Pb was D=1.45x10^{-11} cm²/s (the MFD of the fiber was 5.32 μm after heat treatment for 10 minutes). In the case of the large core Pb/Ge-coded fiber (Fiber-2), the MFD of the fiber was 12.5 μm after heat treatment for 10 minutes and the diffusion coefficient of Pb was calculated to be 1.08x10^{-10} cm²/s. Therefore, in the optical fiber, the diffusion coefficient of dopant depends on more dopant concentration than initial diffusion area because the dopant in the fiber core diffuses out radially.

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