Study on optical circuit using heat-resistant polymer

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Recently, polymeric optical circuits have been attracted about the high potential application in the optical communication. Polymeric materials have many advantages over other materials: ease of processing, high flexibility, ease of refractive index control, and high consistency to plastic optical fiber.

Polyarylate polymers (PAR) with high glass-transition temperature have the high optical transparency and thermal stability of the refractive index and the absorption. PAR can be processed by electron-beam (EB) exposure and thermal development. I study the optimum conditions of EB dose, temperature and time of thermal development, and film thickness, in order to achieve the high-resolution processing in submicron size. I successfully fabricated a high-resolution surface relief grating on the PAR thin film. The grating has a coupling efficiency of 9.1% as a coupler to the PAR waveguide. The diffraction efficiency was unchanged by heating for 100 hours at 100℃. This process is possible even for fluoridated PAR.

The thermo-optic coefficients of polymer films were measured by a newly proposed method, that is a 3-m-lines method with a grating coupler. This method is free from the temperature change of grating period due to thermal expansion. The method has a high accuracy better than 1×10^{-5}. The measured temperature dependence of the refractive index (dn/dT) of polycarbonate ($-0.6\sim-0.8\times10^{-5}$℃-1) and polymethyl methacrylate (-0.8×10^{-5}℃$^{-1}$) is strongly dependent on the waveguide structure of the sample, compared with the previously reported value. The dn/dT of PAR polymer, U-100, is $-1.4\sim-1.7\times10^{-5}$℃-1. This result shows that the more low-electric-powered thermo-optic switch can be realized.

The PAR polymers, the fabrication process, and the measuring method of dn/dT will be useful for realization of low-cost optical circuits.