Light propagation in a polymer photonic crystal slab

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Control of optical modes in photonic crystal structures has attracted much attention. Especially, slabs of two-dimensional photonic crystal (PC) structure have high potential for use in photonic integrated devices. Semiconductor PC slabs have been fabricated and studied by several groups. We have fabricated a PC slab made of polymer, which is transparent in the visible spectral region. Dye doping in this structure is useful for the study of emission properties in various cavity structures, since it is relatively easy to process the organic media. We have fabricated a two-dimensional triangular-lattice photonic crystal in a polymer film. The samples have a three-layer structure. Al_2O_3 was deposited on a silicate glass substrate to a thickness of 0.18 μm. Copolymer of α-methylstyrene and α-methylchloroacrylate was spin-coated to a thickness of 0.5 μm on it from an o-dichlorobenzene solution. The Al_2O_3 layer is used to maintain waveguided photonic modes, and the polymer layer is for the fabrication of the PC structure. Cylindrical holes of a triangular lattice were patterned in the polymer layer by electron-beam exposure. The lattice constant of the pattern was 288 nm, and the radius of the holes was 100 nm. Two types of samples were fabricated, where light can propagate in Γ-J or Γ-X direction. The number of periods of the lattice in the light propagation direction was 80 in both Γ-J and Γ-X samples.

White light was coupled to the waveguiding layers from a side edge by focusing light with a lens. The spectrum of the light which was guided within the polymer and the Al_2O_3 layers was observed from the other side edge of the substrate by using a confocal microscope and a spectromator. The transmittance spectra of light in Γ-X direction are shown Fig.1 with results of FDTD simulations. These are the spectra of light which passed through the region of the photonic crystal structure divided by the spectra of light which passed through the area where no PC structure is fabricated. Almost all structures of each spectrum were reproduced by the FDTD simulations.

This work was partly supported by NEDO within the framework of the Femtosecond Technology Project.

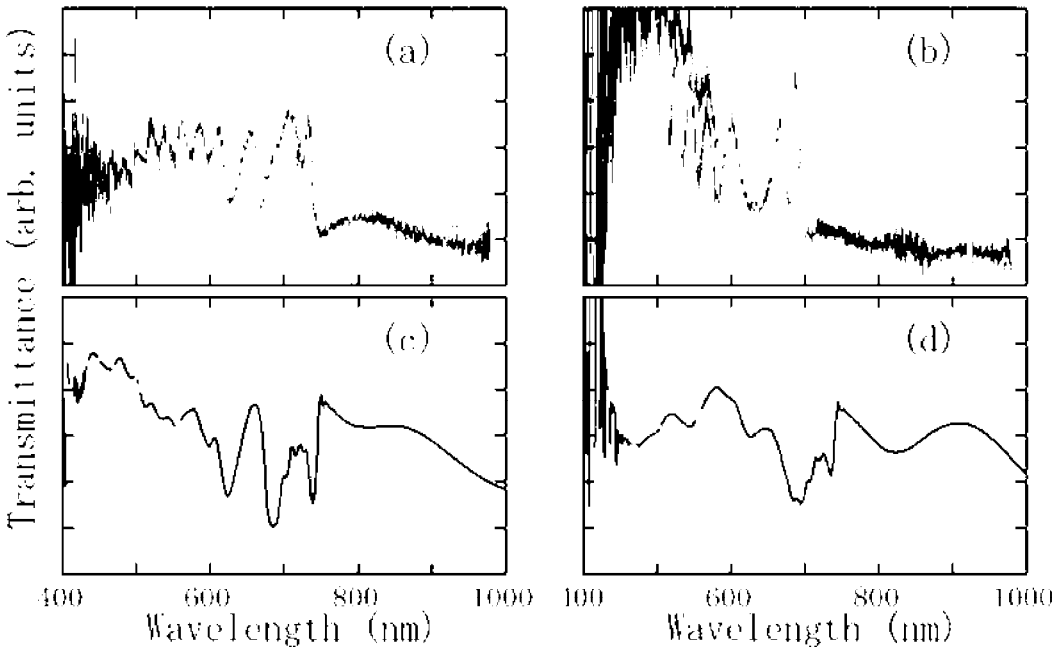

Fig. 1: Transmittance spectra of Γ-X direction; (a) experiment, TE polarization, (b) experiment, TM polarization, (c) FDTD calculation, TE polarization (d) FDTD calculation, TM polarization