금속 나노복합 결함구조를 갖는 1차원 광자결정의 비선형 광학특성 연구

Nonlinear optical characterization of a 1-D photonic crystal with a metal nanocomposite defect

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We investigate the nonlinear optical (NLO) change of a defect mode which 1−D photonic crystal (PC) with a Au:SiO_2 nanocomposite structural defect owns. A optical defect mode appears in the photonic bandgap (PBG) due to the modification of the index periodicity. Strong filed localization at a structural defect in PC provides the nonlinear optical applications. Various NLO materials have been employed as defect structures in PCs, and ultrafast all−optical switching of defect modes has been realized by altering the refractive index of the defect.(1−3) Metal−dielectric nanocomposites have been developed as NLO materials allowing reasonable transmittance for optical applications. The metal−dielectric nanocomposites were reported to reveal saturable absorption or reverse saturable absorption behavior depending on wavelength.(4,5) Furthermore, surface plasmon resonances lead metal nanostructures to exhibit an enhanced NLO response.(6)

Three structures are designed and fabricated to characterize the linear and NLO properties of 1−D PCs with a defect layer. They are a 1−D PC with a Au:SiO_2 nanocomposite layer as the defect layer, a 1−D PC with an SiO_2 film as a defect layer, and an isolated Au:SiO_2 nanocomposite layer. The bandgap structures are identified from transmission measurement as shown in Fig. 1. The center of the bandgap appears at 610 nm with a bandgap width of 180 nm. The location of optical defect mode is determined as 629 nm for the PC with the Au:SiO_2 defect (solid curve) and 601 nm for the PC with the SiO_2 defect (dashed−dotted curve). The dashed curve is the spectrum of AuSiO_2 nanocomposite film, which shows a surface plasmon resonance peak at 554 nm. Two sets of experiments are performed. First, femtosecond Z−scan measurements are performed on the isolated Au:SiO_2 nanocomposite defect layer to independently characterize its nonlinear refraction and absorption. Second, pump−probe measurements on the 1−D PC cavity with the Au:SiO_2 nanocomposite defect layer show an increase and blueshift of the defect transmittance peak. Such measurements on the same structure with the SiO_2 defect layer without gold show no such NLO response at similar laser input energies. An analysis based on a transfer matrix method is employed to model the contribution of the NLO response occurring in the defect layer to the optical defect mode within the 1−D PBG.(7)

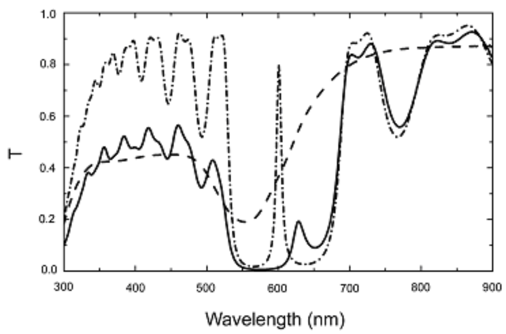

FIG. 1 Transmission spectra of a 1-D PC with a $Au:SiO_2$ defect layer (solid curve), a 1-D PC with a SiO_2 defect layer (dashed-dotted curve), and the $Au:SiO_2$ layer (dashed curve).

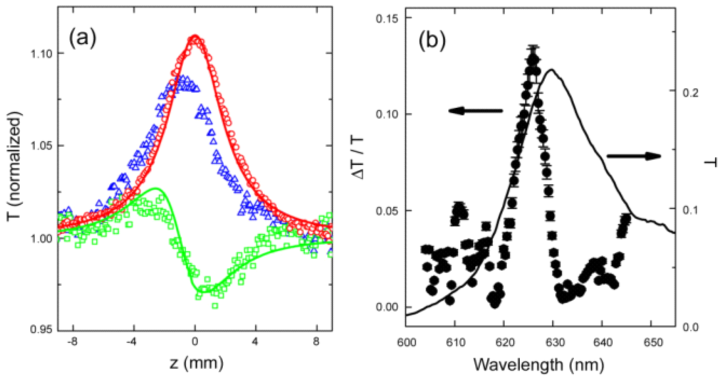

FIG. 2 (a) Z-scan measurement data of a isolated $Au:SiO_2$ nanocomposite layer. Red circles, blue triangles, and green squares correspond to Z-scan data with open aperture, closed aperture, and closed aperture data divided by open aperture data, respectively. The solid curves are theoretical fits.(b) Pump-probe data of the 1-D PC with a $Au:SiO_2$ defect layer. The symbols represent the normalized transmittance changes, while the solid curve is the linear transmission spectrum.

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