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Novel Optical Properties of Synthetic Opals and Replicas Infiltrated with Nonlinear Optical Material

Katsumi YOSHINO

Department of Electronic Engineering, Graduate School of Engineering, Osaka University
Yamada-Oka 2-1, Suita, Osaka 565-0871 Japan
E-mail: yoshino@ele.eng.osaka-u.ac.jp

Recently photonic crystals with three-dimensional periodic structure of the order of optical wave length has attracted much attention from both fundamental and practical view points. We have prepared a synthetic opal by the sedimentation of SiO_2 spheres of several hundreds nm in diameter and studied it as one example of photonic crystals. Replicas of opals which are prepared by infiltrating various materials in the percolated periodic array of voids in the synthetic opal and then removing SiO_2 spheres by HF, also exhibit unique characteristics as photonic crystals. We have also demonstrated that synthetic opals and replica opals infiltrating with various functional material, exhibit novel properties.

Here in this paper, we discuss the property of synthetic opals and replicas infiltrated with non-linear optical materials. Under intense light irradiation optical properties of the non-linear optical material such as refractive index and absorption coefficient changes with increasing light intensity. On the other hand, light intensity (photon density) in the photonic crystal is considered to be effectively much enhanced because of a confinement effect. It should be mentioned that the photonic crystal also play roles as a distributed feed back system and a cavity. Indeed, we have demonstrated that upon optical excitation of the opals infiltrated with a fluorescent conducting polymer, poly(2,5-dialkoxy-p-phenylenevinylene) (ROPPV) exhibits lasing with low threshold excitation intensity.

Therefore, various interesting effects can be observed in the opals infiltrated with non-linear optical materials. In such infiltrated opals or replicas, non-linear optical effects occur even at weak light intensity.

For example the second harmonic generation (SHG) in the opals takes place highly efficiently even at low excitation compared with the SHG material without opal matrix. Saturable absorption effect of dye takes place at low light intensity in the opal matrix.

Induced Raman scattering, induced Brillouin scattering and multi-photon absorption also take place under low optical excitation level. Indeed we have observed intense Raman scattering in

ROPPV infiltrated opal under relatively low excitation.

In the opals and replicas infiltrated with the material with non-linear refractive index, that is the material whose refractive index changes with increasing light intensity, various interesting effects can take place. This infiltrated opal and replica has non-linear periodic structure and plays a role just as a non-linear distributed feed back system. Replicas made of non-linear optical material also exhibit same characteristics

In these systems with materials of non-linear refractive index, various novel phenomena such as optical bistability, pulse compression, soliton propagation, self-pulsation and chaos can take place. That is, with changing irradiation light intensity the transmission light intensity can exhibit bistability, pulse compression, soliton propagation, self-pulsation and chaos. These effects are also very important from practical view points for the application to

The opal infiltrated with the material which exhibits both electro-optic effect and non-linear optical effect is also quite interesting.