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QTuA7 9:45 am

Resonant cavity-enhanced detectors embedded in photonic crystals

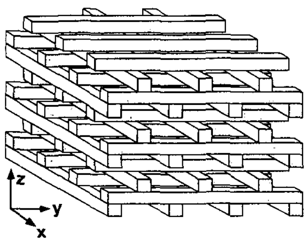
B. Temelkuran, E. Özbay, *Department of Physics, Bilkent University, Bilkent Ankara 06533 Turkey*

There is a great deal of current interest in the possibility of creating three-dimensional photonic band crystals in which no electromagnetic (EM) propagation is possible for certain frequencies.[1] Recently, Ho *et al.* have proposed a new photonic crystal based on stacked dielectric rods (Fig. 1), which can be fabricated at smaller scales by conventional methods.[2] Defects or cavities around the same geometry can also be built by addition of removal of rods from the crystals.[3] The electrical fields in such cavities are usually enhanced, and by placing active devices in such cavities one can obtain novel properties. This effect has been used already in optoelectronics to achieve novel devices such as resonant-cavity-enhanced (RCE) photodetectors and light-emitting diodes.[4] In this paper, we demonstrate the RCE effect by placing microwave detectors in a layer-by-layer photonic crystal.

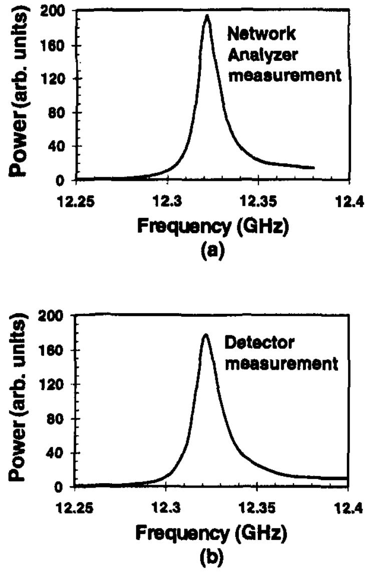
We used the output of a network analyzer as the microwave source, and fed the output to a horn antenna to obtain EM waves. The crystal was then replaced in the beam-path of the EM wave, and the electric field inside the cavity was measured by a probe that consisted of a monopole antenna. The output of the antenna was measured by use of two different techniques: network analyzer and microwave detector within the cavity.

The first cavity structure was similar to a one-dimensional 1d Fabry-Perot resonator made of two mirrors separated by a distance. The front mirror structure was six layers thick, and the back mirror was eight layers thick, with a 7-mm separation between the two mirrors. Both techniques have shown a typical power enhancement factor of 180, with a quality factor of 1200 (Fig. 2). The agreement between two measurements also showed the reliability of the microwave detector.

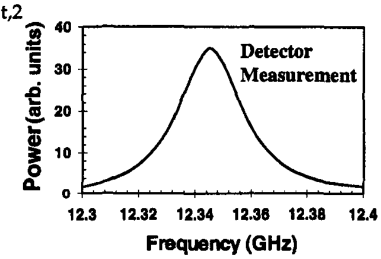
To obtain a localized defect, we modified a 16-layer crystal structure in the following manner. Parts of the rods on the 8th and 9th layer were removed such that we obtained a rectangular prism-like cavity. The dimensions of the cavity were $4a \times 4a \times 2d$, where a is the center-to-center distance between parallel rods and d is the thickness of the alumina rods. A microwave detector was placed in the photonic crystal, and a monopole antenna was connected to the input of the detector. The hybrid antenna-detector was then used to probe the EM field inside the localized cavity. Figure 3 shows the measured magnitude of the EM field with the detector. A power enhancement factor of 35 was measured for this cavity, which clearly indicates the resonant cavity enhancement for a localized defect.



QTuA7 Fig. 1 Schematic of the layer-by-layer photonic crystal.



QTuA7 Fig. 2 Measured power of the EM field inside a one-dimensional defect structure with use of (a) network analyzer or (b) microwave detector.



QTuA7 Fig. 3 Measured power of the EM field inside a localized defect structure with use of a microwave detector.

Our results suggest the possibility of use of the embedded detector as an RCE detector. By use of a smaller size photonic crystal and a higher-frequency detector, the effect can also be shown at millimeter and far-infrared frequencies. Such RCE detectors will have increased sensitivity and efficiency when compared with conventional detectors and can be used for various applications where sensitivity and efficiency are important parameters.

1. E. Yablonovitch *et al.*, Phys. Rev. Lett. **63**, 1950 (1989).
2. K. M. Ho *et al.*, Solid State Comm. **89**, 413 (1994).
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JTuB 8:30 am

Salon F

Joint Symposium on Quasi-Phase Matching

Nasser Peyghambarian, *University of Arizona, Presider*

JTuB1 (Tutorial) 8:30 am

Microstructured media for nonlinear optics: Materials, devices, and applications

M. M. Fejer, *E. L. Ginzton Laboratory, Stanford, California 94305*

The past decade has seen a renaissance in coherent sources based on nonlinear optical frequency conversion, fueled by improved pump lasers and improvements in available nonlinear materials. Microstructured nonlinear materials, especially those in which the nonlinear susceptibility is periodically reversed to quasi-phasematch (QPM) the nonlinear interaction, are playing an increasingly important part in these developments. Application of periodically poled ferroelectrics, the most important class of QPM materials, has allowed qualitative improvements in coherent sources from the ultraviolet to the mid-infrared. The increase in conversion efficiency available with these materials also enables effective application of quadratic nonlinear optics beyond simple sources of coherent radiation, in fields such as quantum optics, wavelength conversion for WDM systems, and cascade nonlinearities. By shifting the emphasis from materials with appropriate birefringence to those with patternable nonlinear properties, the use of QPM opens opportunities to take advantage of the attractive properties of materials not traditionally used in frequency conversion applications, such as cubic III-V and II-VI semiconductors, polymers, and glasses.

This tutorial will review basic ideas of QPM nonlinear optics, characteristics of available microstructured media, and recent device results in QPM bulk and waveguide SHG, DFG, and OPOs. Opportunities in novel microstructured materials and in applications beyond sources of coherent radiation will also be discussed.