All-Optical Switching in 2-D Photonic Crystal Cavities with Defect Resonances.

G. D'Aguanno,[1,*] *N. Mattiucci,*[1] *M.J. Bloemer*[2]
1. AEgis Tech., Nanogenesis Division, 410 Jan Davis Drive, Huntsville AL 35806, USA
2. Charles M. Bowden Laboratory, Bldg 7804, Research Development and Engineering Command, Redstone Arsenal, AL 35898,USA
**Corresponding Author:* giuseppe.daguanno@us.army.mil

Abstract: We investigate the field localization in 2-D photonic crystals with defect resonances for all-optical switching applications. These resonances achieve extremely high Q factors ~10^8 and switching threshold ~W/cm^2 for realistic values of the cubic nonlinearity.
OCIS codes (160.5298) Photonic crystals ; (230.4320) Nonlinear optical devices.

The ability to confine light in extremely small volumes is crucial for enhancing many light-matter interaction phenomena such as surface enhanced Raman scattering [1], quantum-dot [2] and quantum-well emission [3]. In this work we investigate the field localization properties in a chalcogenide glass (As_2S_3), 2-D photonic crystal (PC) cavity with a defect line, as in Fig.1(a). Although based on a simple geometry, the structure gives rise to defect resonances with extremely high quality (Q)-factors ~10^8, as shown in Fig.1(b). In Fig.1(c) it is presented an example of all-optical switching at telecommunication wavelengths obtained for input intensity ~W/cm^2 and local field intensity in the crystal well below the photodarkening threshold of the material.

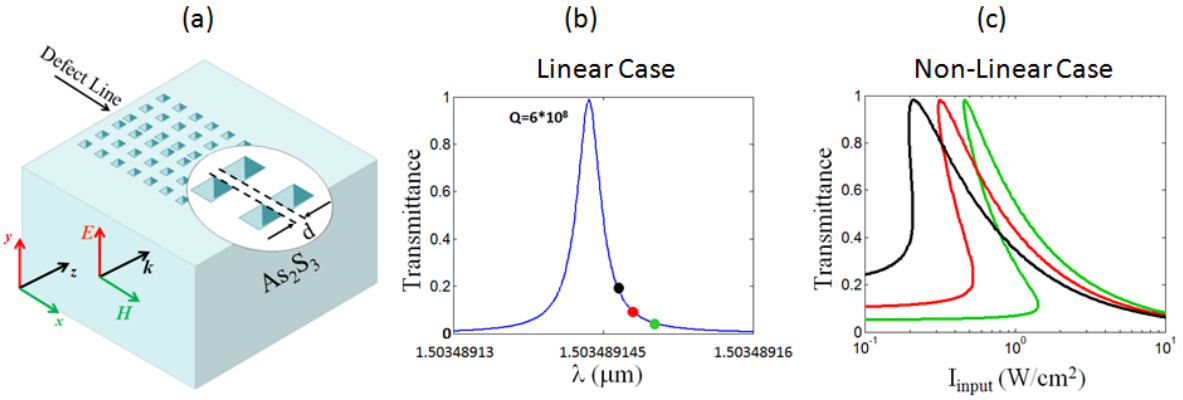

Figure 1: (a) 2-D PC slab with a line defect of thickness d located at its center. The slab is made of As_2S_3 for in-plane coupling of the incident radiation, i.e. the k-vector of the incident wave lies parallel to the (x,z) plane and forms an angle ϑ with the z axis. The PC is made by drilling holes of square section a×a arranged in a periodic array with periodicity Λ on both directions. The polarization of the electric field is along the y-axis, parallel to the axis of the holes. In our case a=450nm, Λ=900nm. The PC slab is finite along the z direction and has total length L=NΛ with N=30 periods, it starts at z=0 and ends at z=L=27μm. We consider As_2S_3 be the input medium (z<0) as well as the output medium (z>L). (b) Normal incidence linear transmittance vs. incident wavelength for the defect resonance that shows a quality factor Q~6*10^8. The black, red and green dots respectively indicate the tuning condition of the impinging wave used for the nonlinear calculation. (c) Nonlinear transmittance vs. input intensity for the tuning conditions described in (b).

References

[1] K. Kneipp, M. Moskovits, and H. Kneipp (Eds.), *Surface enhanced Raman scattering* (Springer, 2006).
[2] V. I. Klimov, A. A. Mikhailovsky, Su Xu, A. Malko, J. A. Hollingsworth, C. A. Leatherdale, H.-J. Eisler and M. G. Bawendi, " Optical Gain and Stimulated Emission in Nanocrystal Quantum Dots, " Science 290, 314 (2000)
[3] S. Nakamura, M. Senoh, N. Iwasa, and S. Nagahama, "High-Brightness InGaN Blue, Green and Yellow Light-Emitting Diodes with Quantum Well Structures, " Jpn. J. Appl. Phys. 34, 797 (1995