Fano resonance reveals Percolation in photonic crystals

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Abstract

Percolation is a geometrical concept concerning end-to-end connectivity of a minority phase across a system which has brought new understanding to several areas of physics, mathematics and other areas of science. Percolation can have tremendous impact on the physical response of the system [1]. Although this effect is well understood for some systems (*e.g.* transition from insulating to conducting) the effects of percolation in the optical response (transport) of photonic structures is still a matter of study. Here we show how by using photonic crystals where precise amounts of random vacancies can be easily incorporated it is possible to reach the percolation threshold for an *fcc* while recording its optical response. We have found that these vacancies introduce a background of diffuse scattering which couples with the photonic band gap and give rise to asymmetric resonances in the optical spectra that follow the *Fano* line shape [2]. A fine control of the vacancies density [3] permits to prepare the systems so that different asymmetric profiles, characterized by the parameter *q*. We found that at the percolation threshold, probably due to the divergence of cluster size and subsequent enhanced diffuse scattering, *q* changes sign as signaled by the photonic band gap collapse.

References

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Figures

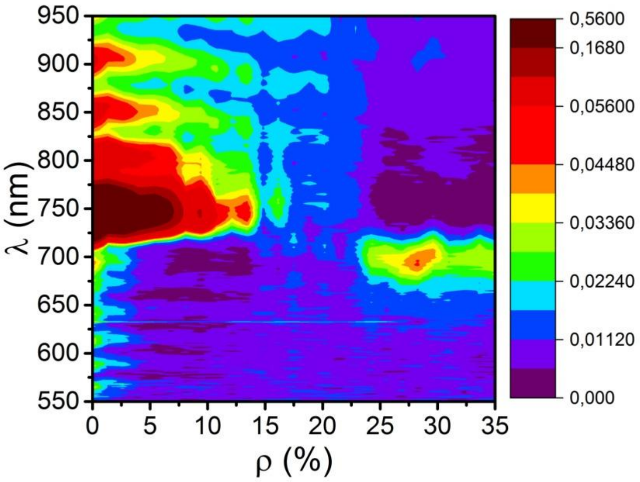

Figure 1. Vacancy concentration dependece of the reflectance.
Specular reflectance spectra evolution for a PMMA opal formed by 20 layers of 330 nm spheres as the density of vacancies increases. At percolation threshold (ρ_c = 15-22%), the band gap disappears and beyond the peak becomes a dip.