Effect of disorder on transmission characteristics of finite inverse-opal photonic crystals

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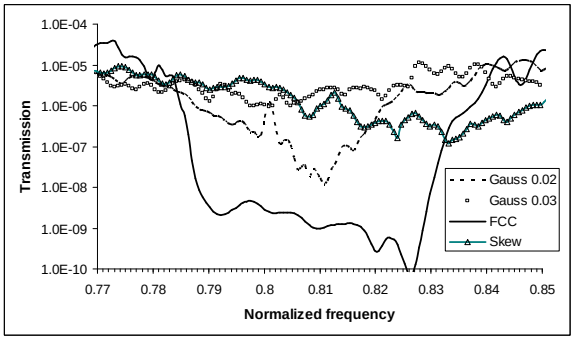
We report on the quantitative study of disorder influence on light transmission in three-dimensional photonic crystals having a complete PBG like Si-inverted opals. The straight transmission in ΓL direction through 18-layers thick inverted opal cell is simulated by the 3D FDTD method. Transmission in the perfect FCC structure (deep 50 dB gap in the range 0.785-0.83) is shown by the solid line in the figure (Curve "FCC"). Disorder is implied as fluctuation in sizes and/or sites of air spheres. Two kinds of disorder distributions are used in modelling: Gaussian and a skew one obtained from checking colloidal particle size distribution before the crystallization into polystyrene opal template.



For finite structures fragility of complete PBGs are worse than predicted for infinite crystals[1]. Our simulations show that attenuation of transmission in the PBG is severely distorted even with 2% Gaussian disorder ("Gauss 0.02"), while 3% Gaussian disorder closes the gap completely ("Gauss 0.03"). The skew distribution, which can fit more or less to the 2% Gaussian is likely to be the worst case ("Skew"). This signals that more refined technology is required to keep band gap open, pretending 3D photonic crystals to be a template for photonic integrated circuits.

[1] Z.-Y. Li, and Z.-Q. Zhang, *Physical Review B*, **62**, 1516 (2000).