Band gap formation and Anderson localization in hyperuniform disordered photonic materials

Frank Scheffold

Department of Physics, University of Fribourg, 1700 Fribourg, Switzerland

Frank.Scheffold@unifr.ch

I will discuss the properties, the fabrication, and the characterization of three-dimensional disordered hyperuniform silicon networks, a new type of metamaterials displaying photonic features for electromagnetic vector waves [1]. I will first present our results on the fabrication of polymer templates of the network structures using direct laser writing (DLW) lithography [2]. Next, by infiltration and double inversion, we converted the mesoscopic polymer networks into silicon structures with a refractive index near n=3.6. The resulting metamaterials display a pronounced photonic gap in the optical transmittance at λ=2.5µm [3]. To obtain a deeper understanding of the physical parameters dictating the properties of amorphous photonic materials, we have performed extensive numerical simulations of the density of states and optical transport properties [4]. To this end, we study the bandgap formation and Anderson localization in hyperuniform structures in two and three dimensions. We identify the evanescent decay of the transmitted power in the gap and diffusive transport far from the gap. Near the gap, we find that transport sets off diffusive but, with increasing slab thickness, crosses over gradually to a faster decay, signaling localization. We show that the transition to localization at the mobility edge can be described by the self-consistent theory of localization based on the concept of a position-dependent diffusion coefficient.

References

[1] M. Florescu, S. Torquato, P. J. Steinhardt, PNAS 106 (2009), 20658–20663

[2] J. Haberko, F. Scheffold, Opt. Express 21 (2013), 1057-1065, J. Haberko, N. Muller, F. Scheffold, Phy. Rev. A 88 (2013), 043822

[3] N. Muller, J. Haberko, C. Marichy, F. Scheffold, Adv. Opt. Mat 2 (2014), 115–119; N. Muller, J. Haberko, C. Marichy, F. Scheffold, Optica 4 (2017), 361-366

[4] L. S. Froufe-Pérez, M. Engel, P. F. Damasceno, N. Muller, J. Haberko, S. C. Glotzer, and F. Scheffold, Phy. Rev. Lett. 117 (2016, 053902; L. S. Froufe-Pérez, M. Engel, J.J. Saenz and F. Scheffold, PNAS 114 (2017), 9570.

Figures

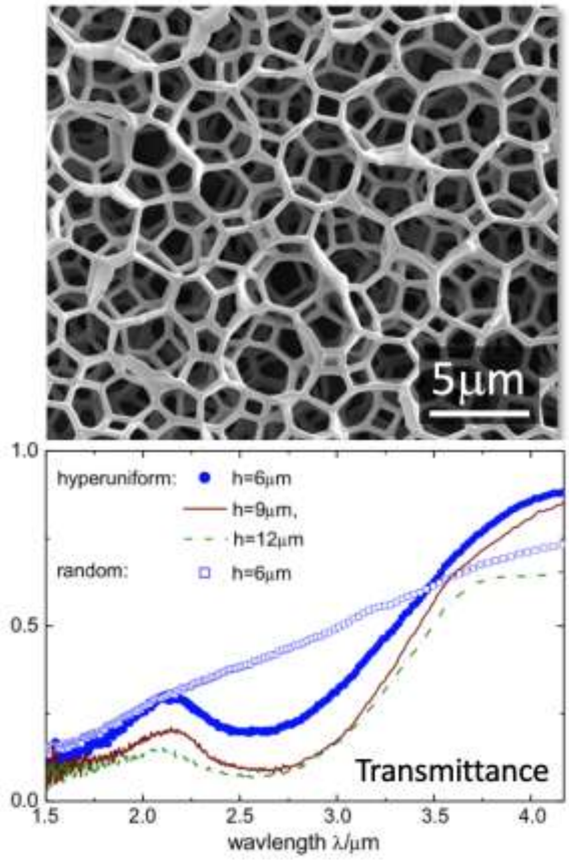

Figure 1: Upper panel: Electron micrograph of a polymer template obtained by direct laser writing of a designer hyperuniform network [2]. Lower panel: Optical transmittance spectra of disorderd & hyperuniform silicon networks of different thickness [3]