Strong Photon Localization in Disordered Photonic Crystal Waveguides

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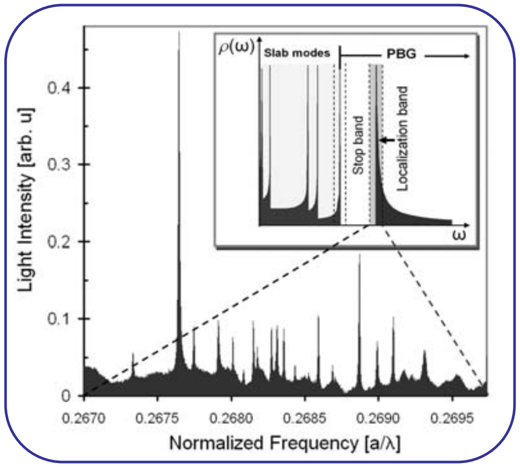
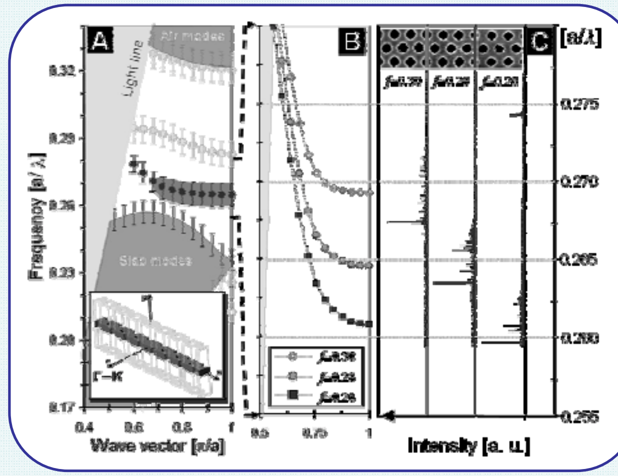
Anderson Localization in Quasicrystals

- A photonic crystal confines light by Bragg-scattering in a perfect lattic.
- Disorder is considered a source for scattering loss.
- Counter-intuitively, however, multiple scattering from random impurities can provide an alternative mechanism for light localization, a process known as Anderson localization.
- We have discovered one realization of this phenomenon in disordered photonic crystal waveguides (Quasicrystals)



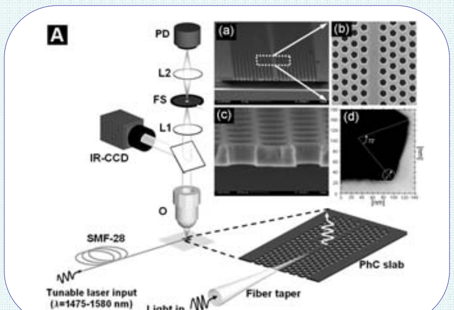
Localization in Disordered Photonic Band Gap

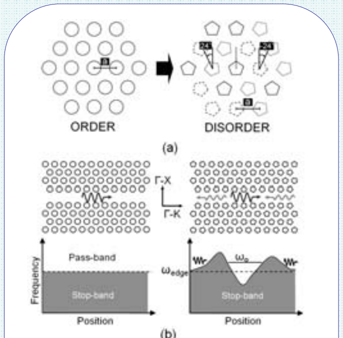
- The effect is observed in a narrow frequency band close to the guided mode's cutoff where the light propagates with a slow group velocity (slow light regime).
- Optical cavities with Qs approaching one million and sub-wavelength-cubed modal volumes are observed along disordered waveguides.
- Preliminary 2D FDTD calculations performed on random structures yield modal volumes that are comparable to photonic-crystal-heterostructure cavities.
- We believe our experiments can find various applications e.g. in optical sensing systems and random nano-lasers..

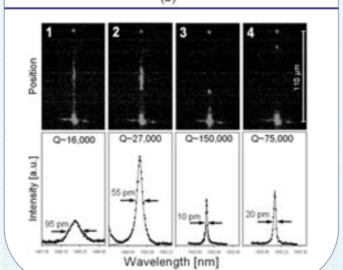


Disordered Photonic Crystal Waveguides

- Our design concept introduces structural perturbations uniformly throughout the fabricated crystal by deliberately changing the shape of elements that form the lattice.
- Such nanometer-scale disorder effectively represents randomly-distributed strong scatterers that affect propagation of Bloch-waves through the otherwise periodic lattice.
- We show that the guided modes in line-defect waveguides defined in such disordered photonic crystals experience coherent backscattering that leads to Anderson localization. .







Line Splitting

- Curiously, we find that that all randomly localized modes are split in frequency by 530 MHz.
- We theorized that the phenomenon could be caused by strain-induced anisotropy of refractive index in the Silicon (Si) slab, a hypothesis that was disproved in experiments that use waveguides fabricated at different orientations in the [001] plane.
- The observed phenomenon might instead be related to symmetry-breaking processes in mesoscopic optical systems. In an alternative hypothesis, the line-splitting could be caused by modal coupling between Bragg-guided transverse-electric modes and index-guided transverse-magnetic modes.