Anderson-localization of Visible Light in Disordered Photonic Crystal Waveguides

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Light confinement in optical cavities is of great importance for a range of applications, from fundamental investigations of light-matter interaction to applications in sensing, imaging and quantum information technology [1]. The development of efficient cavities that operate at visible wavelengths is needed for carrying out cavity quantum electrodynamic (QED) experiments, as well as to explore potential applications in energy harvesting and sensing [2].

Engineered 2D photonic crystal cavities in silicon nitride confining visible light have shown quality factors around 1000 [3], reaching 3400 in photonic crystal heterostructures [4]. We use a different approach that makes use of fabrication imperfections to trap visible light via multiple scatterings: disorder is intentionally introduced in a silicon nitride photonic crystal waveguide by displacing the position of the air holes in order to achieve Anderson localization of light.

We spectrally characterize the localized modes, by means of micro-photoluminescence spectroscopy: by moving the laser excitation spot along the waveguide, tens of resonances are visible, showing a distribution of quality factors and confinement wavelengths. We measure quality factors exceeding 5000, with a record value of 9300±800 [5], up to one order of magnitude higher than engineered photonic crystal cavities.

We demonstrate, for the first time, Anderson localization of visible light on a nanophotonic chip and a nanoscale-accurate imaging of the localized modes and report quality factors of disorder-induced optical cavities exceeding highly engineered photonic crystal cavities.

[1] K. J. Vahala, *Nature* **424**, 839 (2003)
[2] O. Trojak et al., *Appl. Phys. Lett.* **111**, 141103 (2017)
[3] M. M. Murshidy et al., *J. Opt. Soc. Am. B* **27**, 17231 (2010)
[4] M. Barth et al., *Appl. Phys. Lett.* **93**, 021112 (2008)
[5] T. Crane et al., *ACS Photonics* **4**, 2274 (2017)