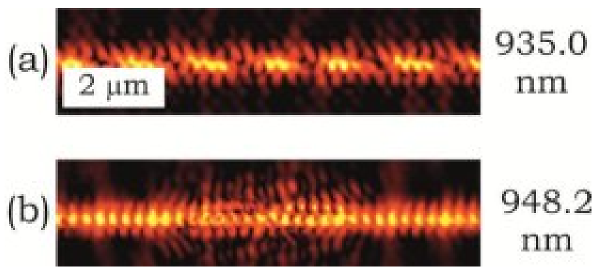
Light propagation on a chip like shopping before christmas

30 October 2012



(a) Light traveling through the periodic medium. (b) Light becoming trapped inside the medium at the encircled area. Credit: University of Twente

A team of scientists at the MESA+ Institute of Nanotechnology, the Niels Bohr Institute, and the FOM institute AMOLF have demonstrated that light becomes trapped in even state-of-the-art on-chip waveguides by the tiny amount of disorder that is always present.

The used methods provide direct information where and why light becomes trapped. These results are important for quantifying the influence of disorder on on-chip-structures and have direct impact for our understanding of semiconductors and light transport in integrated optical devices. The results are being published in the leading American journal *Physical Review B*. It turns out that light propagates in an integrated waveguide like people shopping on a busy day before Christmas.

"Passing through a shopping street can be tedious, especially on a busy day just before Christmas. With a steady pace you can make it through in a reasonable time, but the slower you walk, the higher the chance that you are diverted by not-to-miss offers." MESA+ researcher Pepijn Pinkse explains that this example illustrates what happens when light propagates in a nanostructure. Under normal conditions the propagation of light is strongly affected by the periodic order of the nanostructure. Energy gaps emerge where light is not allowed to propagate as a result of interference. The boundary between an energy gap and energies where light can still propagate is called the band edge. Light near the band edge travels at a lower velocity. Slowly propagating light enhances the sensitivity of nanoscale sensors and is of interest for controlling optical information. However, even the smallest amount of disorder in a structure, which is fundamentally unavoidable, significantly alters the transport of light near the band edge. Up till now, it has been a major challenge to directly measure this effect.

Pinkse's team of scientists have studied light transport in integrated nanophotonic waveguides. They have completely measured the energy-dependent transport properties of these nanostructures near the band edge. "We make a complete energy-space map to show the propagating waves and the positions and energies where light is trapped." Even for state-of-the-art periodic structures, the scientists observed that the band edge is not a sharp boundary anymore. The band edge becomes an energy range where light waves travel slower and sometimes become even trapped. The probability to get trapped increases when the waves travel slower. "In fact, the results are not limited to light waves, but are valid for wave propagation in general. We can now directly observe the interplay between trapped waves and slowly traveling waves with the newest microscopy methods developed by MESA+." To come back to the analogy of the shopping street, if you are more and more fascinated by the incredible sales offers, you might end up being trapped in one of the attractive shops.

The paper is entitled "Measurement of a Band-Edge Tail in the Density of States of a Photonic-Crystal Waveguide" and is being published in *Physical Review B*.

Provided by University of Twente