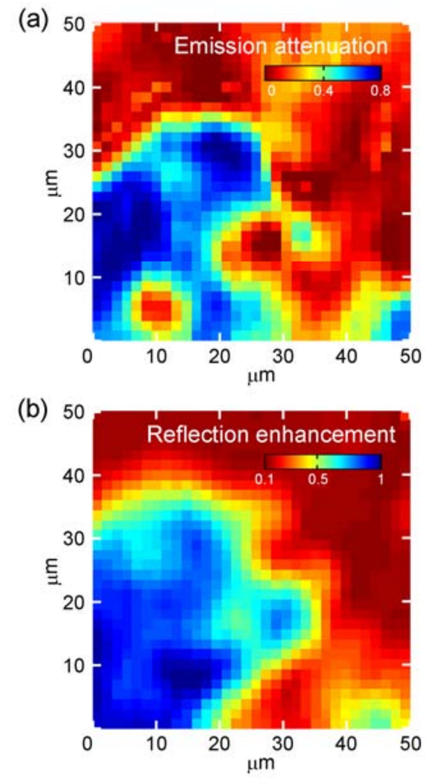
Looking deep into photonic crystals

To control light is critical in many high-tech applications, and is the objective of the new discipline of nanophotonics. Three dimensional periodic nanostructures, so called photonic crystals, exert firm control over light. The photonic crystals studied in this work consist of highly ordered air spheres with a skeleton of titanium dioxide. The air spheres have a size comparable to the wavelength of light. Interference effects such as Bragg diffraction make it impossible for light of certain colors to propagate along specific directions (the so-called stop-band).

Although tremendous progress has been made in the fabrication of ordered nanophotonic materials, these structures are never perfect. Imperfections lead to unwanted inhomogeneity of the photonic properties. The visualization of this inhomogeneity and its effect on the photonic properties has so far been limited to the surface or the first few layers of 3D photonic crystals.



Comparing subsurface photonic properties (a) to surface properties (b), of identical areas. Blue stands for high crystal quality, red for low crystal quality. It has for the first time been possible to look below the surface of the 3D photonic crystal, revealing essential differences between the properties on the crystal surface and from deep within the crystal.

Subsurface mapping

A team of researchers from the MESA+ Institute for Nanotechnology at the University of Twente and the FOM Institute for Atomic and Molecular Physics (AMOLF) succeeded in mapping the photonic properties inside a photonic crystal. They infiltrated proteins that emit visible light (fluorescent proteins) into the photonic crystals. Fluorescent proteins are primarily used as extremely important tools in the life sciences for visualizing cellular processes, but as the researchers have demonstrated, can also be of great use in other fields. They showed that light that was emitted by the stimulated natural fluorescent proteins deep inside the photonic cystal strongly interacted with the surrounding photonic crystal.

Spectral imaging, a technique that records the spectral characteristics from each sampled point of the specimen, was used to quantitatively visualize the local interaction of light emitted by the fluorescent proteins and the photonic crystal. From these characteristics the researchers contructed maps vizualizing the subsurface properties of the photonic crystal.

This new method is expected to become a valuable new tool to characterize photonic structures, and to quantitatively determine their local properties. Such quantitative determination is important for the accurate analysis of the interaction between embedded chromophores and the photonic crystal.

Reference:

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The work is highlighted on the OSA OpticsInfoBase homepage of the journal.

http://www.opticsinfobase.org/josab/abstract.cfm?uri=josab-26-11-2101

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