DETECTING SINGLE PARTICLES USING GUIDED-RESONANCE MODES IN PHOTONIC CRYSTAL MEMBRANES WITH FINITE AREA

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Simulations, fabrication, and optical characterization all show how a submicron-thick dielectric membrane with a well-designed pattern of holes can be used to detect single particles trapped in the holes (Grepstad et al., 2011 *Opt. Express* **20** 7954, Jon Olav Grepstad, *Patterned Dielectric Membranes Designed for Optical Sensing of Nanoparticles*, Ph.D. Thesis, Trondheim: NTNU-trykk 2014, (ISBN 978-82-326-0140-0) 165s, NTNU). The current limit of detection is particles with a size of 26 nm.

In combination with chemical surface functionalization, the detector can arrange for specific capture and detection of particles in the form of proteins, DNA, RNA or viruses, permitting detection of low levels of disease specific molecules in human samples like blood, urine or spinal fluid. The final aim is to create an automated desktop appliance, removing the need for today's labor intensive and expensive analysis done manually in laboratories.

The patterned membrane is a two-dimensional photonic crystal (2D PC). Our current model suggests that particles trapped in such crystals are detected by Rayleigh scattering enhanced by optical modes in the 2D PCs called guided resonance modes: The intensity of the signal they produce is proportional to the square of their volume, and to the square of the amplitude of the field where they are located. This has motivated a study on how the resonantly enhance field supported by guided-resonance modes can be maximized, e.g. a study on high-Q guided-resonance modes.

In this study we show, both by simulations and experiments, how the Q-factor of guided resonance modes is fundamentally limited by the area of the hole pattern, due to edge related losses (Grepstad et al., 2013 *Opt. Express* **21** 23640). We further demonstrate how these edge losses can be suppressed by bounding the PC by in-plane Bragg mirrors. In addition to presenting a way around a fundamental limitation on Q-factors for guided resonances in finite-area PCs, the new design gives a clear demonstration of the physics of the coupling between the normally incident light and the guided resonance modes.