Institute for Molecular & Nanoscale Innovation
Division of Engineering

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Monday, February 18, 2008

Barus & Holley Room 190
10:00 – 11:00 am

High-Quality Optical Resonators and their Applications

High-quality optical resonators confine significant optical powers in small spaces for extended time periods. As a result, interactions of light with matter are greatly enhanced in these structures. They have attracted considerable scientific and technological interest due to their potential applications in optical signal processing, sensing and nonlinear optics. In the first part of the talk I will focus on whispering-gallery microresonators (silica microspheres) and will describe how we have employed them to monitor molecular transformations in complex biomembranes. In the second part I will discuss miniaturized optical cavities in photonic crystals (PhCs). Two-dimensional PhCs are periodic dielectric structures (usually air-holes in a high-refractive-index material) that inhibit light propagation in bands of frequencies commonly referred to as photonic bandgap. Intentional breaking of the lattice periodicity introduces engineered local defects in which light is trapped by the total internal and Bragg reflections. The possibility of highly-efficient photon confinement has established PhCs as a popular platform for designing optical nanocavities. We have recently explored a conceptually different approach to photon localization in these structures. The design concept applies random structural perturbations uniformly throughout the artificial crystal by changing shapes and orientations of the lattice elements. The disorder created this way represents random scatterers which impede propagation of Bloch-waves through the underlying periodic lattice. Optical modes guided along line-defects in disordered crystals experience strong backscattering which gives rise to localization. The effect is observed around the stop-band of PhC waveguides where the modes propagate with a slow group velocity and interactions with disorder are the strongest. We have measured optical resonances with ultra-small modal volumes and the effective Qs of up to ~250,000. I will briefly discuss applications of disordered PhC waveguides for ultra-sensitive biodetection.

Bio: Dr. Topolancik received the B.A. degree in physics from Berea College, Berea, KY, in 1999, and the M.S and Ph.D. degrees in applied physics from the University of Michigan, Ann Arbor, MI, in 2002 and 2005, respectively. Currently, he is a postdoctoral research associate at the Rowland Institute at Harvard where he works in the biofunctional photonics group run by Rowland Junior Fellow Dr. Frank Vollmer. His research interests include nanofabrication, photonic crystal structures, high-Q optical micro- and nanocavities and their interactions with biological systems.