Near-Field Optical Studies of Photonic Crystal Functional Elements

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Near-field optical signals detection can offer a powerful way of extracting the intrinsic optical properties of photonic nanostructures with a fine resolution beyond the conventional diffraction limit. Here we describe our recent progress on near-field optical studies of photonic crystal functional elements. In one work, we have utilized a near-field scanning optical microscopy (NSOM) to probe the detailed propagation characteristics of infrared light propagating along a silicon based W3 photonic crystal slab waveguide [1]. The NSOM works on infrared wavelengths of 1500-1650nm and has a resolution of about 160nm. Our experiments showed that the optical near-field pattern strongly depends on the wavelength. Light can either disperse across the waveguide or localize at one side of the waveguide. Along the propagation direction the field exhibits a snake-like pattern. These features can be well explained by the multimode nature of the W3 waveguide with either even or odd symmetry and the superposition principle of field in both the transverse and propagation directions. In another work [2], we have considered extraordinary infrared light transmission through a two-order cross-dipole fractal slit array built on a 200 nm thick gold film. The structure has a lattice period of 1.5um and slit width of 120 nm. Due to the self-similarity of the fractal pattern, there appear two high-transmission pass bands around 1.7 and 5.2um. Deliberate investigations on the near-field pattern of the metallic nanostructures have clearly revealed that the short and long wavelength pass band comes from interaction of the incident light with the second- and first-order elements of the fractal structure. Studies over other metallic nanostructures with complicated geometries also show that near-field signals can significantly help to discern the physical mechanism of surface plasmon resonance peaks in the enhanced transmission spectrum. The near-field signal detection can be a powerful probe complimentary to the usual far-field transmission spectrum measurement.

[1] H. H. Tao et al., *Phys. Rev. B* **74**, 205111 (2006).
[2] M. Sun et al., *Phys. Rev. B* **74**, 193404 (2006).