NANOSTRUCTURE MODELING AND APPLICATIONS

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The nanotechnology area holds much promise for the realization of ultra-small devices with a variety of interesting applications. The optical sector is an immediate beneficiary of nanotechnologies because of the wavelengths associated with optical devices. For instance, 1.5 μm represents a well-known optical communications wavelength. If one wants to structure a material or an environment to modify the behavior of the propagation of light, for instance with a photonic bandgap (PBG) structure, one needs to arrange features with spacings that are less than half that wavelength in size, or 750 nm, and to create the features themselves that are even smaller yet.

We will review several nanotechnology areas that we have been modeling. These will include PBG structures, optical data storage devices, and metamaterials for microwave applications. We have selected the finite difference time domain (FDTD) approach for much of this modeling effort. Its versatility in the choices and configurations of materials and structures makes it an excellent candidate for studying the behavior of these ultra-small systems.

One significant issue for PBG structures is the process of how one will insert light into them. Several groups have recently presented designs for this application. We will review the designs we have modeled and contrast them to others. One significant optical data storage application is the use of nanostructured features for very high capacity systems. The focus of our research has been to examine the benefits of excellent densities of features obtained through imprint nano-lithography or some other such process, and the ability to read data in parallel. Sub-wavelength surface-relief structures (binary and non-binary) have been investigated and will be described. These nanostructures are amenable to low-cost manufacturing processes and facilitate near-field parallel readout with optical power detectors. Several proposed double negative (DNG) metamaterial applications for antenna structures in the microwave regime have been shown to require nanometer feature sizes. Thin shells of DNG metamaterials can be used to enhance the performance of ultra-small radiators. Results for this metamaterial-antenna application will also be presented.