PLASMONIC NANO-CYLINDER WAVEGUIDES TO ACHIEVE SUBWAVELENGTH LOCALIZATION OF OPTICAL FIELDS

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The nanotechnology area holds much promise for the realization of ultra-small and ultra-fast devices with a variety of interesting applications. The optical sector is an immediate beneficiary of nanotechnologies. Consider, for instance, a coated nano-cylinder or nano-sphere whose outer radius is $a = 50\,nm$. At an excitation wavelength of $\lambda_0 = 500\,nm$, its radius is only $a = \lambda_0 / 10$. One could use arrays of such nano-cylinders or nano-spheres as inclusions in a substrate to realize optical metamaterials. On the other hand, because of their subwavelength sizes, such arrays could be used for several nano-photonic circuit concepts.

We have been studying analytically and with the finite difference time domain (FDTD) approach, the scattering of Gaussian beams from sets of nano-cylinders and nano-spheres. We selected the FDTD approach because of its versatility in the choices and configurations of materials and structures that can modeled. This versatility makes it an excellent candidate for studying the behavior of these ultra-small systems. One strong design goal has been to determine whether or not an array of plasmonic nano-cylinders could be used as an effective waveguide to localize efficiently an electromagnetic field to subwavelength dimensions.

It has been shown theoretically with canonical plane wave scattering problems that the total scattering cross-section of an electrically small dielectric cylinder (sphere) (i.e., Rayleigh scatterers that are much smaller than the wavelength) is resonant for $\varepsilon = -1.0\varepsilon_0$ $(\varepsilon = -2.0\varepsilon_0)$. One typically realizes these *plasmon* resonance effects at optical frequencies and at nano-meter length scales with cylindrical (spherical) dielectric scatterers that are coated with metals whose permittivity is $\varepsilon_r = -1.0$ $(\varepsilon_r = -2.0)$ at the wavelength of interest. We have used our FDTD simulator to study the enhanced scattering from plasmonic cylinders. We have combined together an array of these cylinders to form a nanometer waveguide environment that can capture a significant amount of power from an incident optical beam and can then transform it into a localized field with a highly subwavelength spot at the output of the waveguide.

The FDTD modeling of these plasmonic nano-cylinder waveguides will be discussed. The plasmonic effects associated with dielectric cylinders coated with metals at optical frequencies will be emphasized. The results of varying the parameters that characterize the waveguiding environment will be described. The subwavelength localization of the optical fields using the nano-cylinder waveguides will be demonstrated.