# Magnetic Light and All-Dielectric Nanophotonics

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**ABSTRACT**
We review a new, rapidly emerging field of all-dielectric nanophotonics aimed at manipulating strong optically-induced electric and magnetic resonances in high-refractive-index dielectric and semiconductor nanostructures. Unique advantages of dielectric nanostructures over metallic plasmonic structures are their low dissipative losses that provide new and competitive alternatives for nanoantennas and optical metamaterials. We will demonstrate that resonances in such dielectric nanostructures can boost performance of many photonic devices in the visible and near-IR frequency spectra.
**Keywords**: Mie resonances, nanoparticles, Fano resonances, magnetic response, oligomers.

Since Lord Rayleigh explained blue colours of the sky, the study of nanoparticles became an important part of optical science, with this first example of how nonresonant dipolar scatterers can provide visible colors. Later, Gustav Mie explained a variation in colours of colloidal solutions of gold nanoparticles in terms of their size distributions, opening up a possibility to employ resonant nanoscatterers to control an optical response. Recent decades have witnessed a growing research interest in the study of *resonant plasmonic nanoparticles* made of gold or silver. The resonant light-matter interaction that is at the origin of the spectacular colour changes of such structures has multiple applications ranging from bio-imaging and thermotherapy to solar cells and information storage. However, only a small fraction of applications has materialized into real products, mainly due to high losses of metals at visible frequencies and their incompatibility with the CMOS fabrication processes.

According to the theory of light scattering by spherical particles developed independently by Mie, Lorenz, and Debye, both metallic and dielectric particles can possess strong scattering resonances. However, till now the research on dielectric particles was mainly limited by the study of large (size >> wavelength) transparent microspheres made of dielectrics with low refractive index ($n < 2$) which support high-order whispering gallery resonant modes. Recently, a new field of *resonant dielectric nanophotonics* has emerged demonstrating a huge promise to substitute plasmonic elements with low-loss *high-refractive index* dielectric materials [1]. It has already been demonstrated that nanoparticles with relatively high refractive index (> 3) may have strong scattering (Mie-type) resonances, opening up a new route to access tunable optical resonances in visible/infrared spectral range. In contrast to plasmonic nanoparticles, dielectric nanoparticles can support strong electric and magnetic resonances even for spherical geometries. These modes are associated with the excitation of displacement currents with no real current flows and, thus, no Ohmic losses. In high- index semiconductor nanostructures, optical absorption of above-bandgap photons results in the generation of photo-carriers that are much longer lived than in metals and thus can be extracted as valuable photocurrent. As such, engineering of optical resonances enables a new generation of photodetectors and solar harvesting devices with improved performance. In addition, one can also tailor Mie resonances in semiconductor nanostructures to enhance and control thermal emission or fluorescent decay of excited carriers. Another unique peculiarity of dielectric nanoparticles with high refractive index is their ability to scatter light *unidirectionally*. This property is a consequence of far-field Kerker-type interference of electric and magnetic dipoles that can be excited coherently inside these nanoparticles. Following the similarity between distributions of electric and magnetic dipole modes, one may achieve ultra-high *near-field* enhancement of the magnetic field at the nanoscale in such resonant dielectric nanostructures. The distinct resonant properties of high-index dielectric nanostructures make them the first potential candidates for a possible future replacement of plasmonic components in multiple applications.

In this talk, we will review some of the recent research directions of the rapidly developing field of resonant dielectric nanophotonics. In particular, we discuss the resonant properties of single dielectric nanoparticles and nanorods, their unique property of directional scattering, dielectric nanoantennas and metamaterials.

**REFERENCES**

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