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Visible to Ultraviolet Enhanced and Tunable Broadband Chiral Response by Helical Metamaterials

Ufuk Kilic(1), Matthew Hilfiker(1), Rene Feder (1), Eva Schubert(1), Mathias Schubert(1)
Christos Argyropoulos* (1)
(1) University of Nebraska-Lincoln, Lincoln, NE, USA;
e-mail: ufuk.kilic@huskers.unl.edu, christos.argyropoulos@unl.edu

Circular dichroism and optical activity are fundamental chiral processes to understand handedness in molecules and control the spin angular momentum of photons [1]. However, chiral light-matter interactions have an extremely weak nature, are difficult to be controlled and enhanced, and cannot be made tunable or broadband [2]. In addition, planar ultrathin nanophotonic structures to achieve extremely strong, broadband, and tunable chiral light-matter interactions at visible and ultraviolet (UV) frequencies are still difficult to be realized [1-2]. In our presentation, we will demonstrate that we tackled these important problems by experimentally realizing and theoretically verifying spectrally tunable, extremely large, and broadband circular dichroism by designing new nanohelical metamaterial configurations operating at the technologically important visible to UV spectrum. The reported novel designs of ultrathin bottom-up fabricated all-dielectric and dielectric-metallic (hybrid) plasmonic metamaterials permit wide tunability with one of the largest and broadest ever measured chiroptical response achieved by a large-scale nanophotonic structure. The demonstrated ultrathin optical metamaterials are expected to provide a substantial boost to the broad fields of classical and quantum optics leading to significantly enhanced chiral light-matter interactions at the nanoscale with applications in biosensing, topological photonics, quantum communications, and photonic circuits [2-4].

The presented new large-scale hybrid metamaterials are fabricated by using an emerging bottom-up nanofabrication approach, named glancing-angle deposition (GLAD), that is free of masks or templates and permits fast, simple, cost-effective, and scalable mass-production of nanoscale 3D structures [5]. In addition, comprehensive and accurate experimental optical characterization and theoretical simulations are performed by using the generalized Mueller matrix spectroscopic ellipsometry in transmission and reflection mode and finite element modeling, respectively. The currently presented work sets new benchmarks in the assembly of ultrathin broadband plasmonic chiral metamaterials which are poised to efficiently control and enhance the chiral light-matter interactions at the nanoscale. It provides a comprehensive road map for designing hybridized plasmonic helical metamaterials with unprecedentedly high and broadband chiroptical properties that can be used in a plethora of diverse emerging classical and quantum optical applications, such as in the design of ultrathin polarization filters [6], chiral sensors, circular polarized single- or multi-photon radiation sources, and directional spin-dependent nanophotonic waveguides.

References

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