Unit 8 “Metamaterials and metasurfaces”

Optical chirality enhancement with dielectric metasurfaces

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Light-molecule interactions with metallic and dielectric nanostructures make it possible to effectively enhance their sensitivity. For example, circularly polarized light (CPL) interacts with chiral molecules in different ways that allow determining their handedness and structural information. Circular dichroism (CD) spectroscopy (measures the different absorption of light from the left and right circular waves) is used as an effective tool to study chiral molecules. However, CD signal from molecules is very difficult to detect due to their weak internal chirality. These problems impose significant restrictions on the achievable measurement sensitivity. To enhance the CD response from low concentrations or even a single molecule, a new approach based on the formation of superchiral fields interacting with molecules to enhance their optical chirality has been used [1 – 3].

In this work, we numerically investigate the generation of superchiral fields with achiral dielectric metasurface for further enhancement of CD signals from chiral molecules. The high-refractive-index dielectric metasurface is used to enhance localized electric and magnetic fields simultaneously inside the disk under the CPL excitation at visible wavelengths (Figure 1(a)). As a result, the spatially overlapped electric and magnetic fields with an appropriate phase condition lead to the generation of superchiral fields that in a result maximized optical chirality. The design of a dielectric metasurface consists of TiO_2 disks arranged into a lattice with a period of 450 nm. By changing the diameter (d) of the disk with remaining the height (h = 195 nm), we can spatially overlap electric and magnetic fields (Figure 1(b)). Due to the low lossy TiO_2 invisible range, the transmittance of metasurface with optimized parameters (d = 200 nm) at the wavelength of 598 nm tends to one while the reflection remains zero. Meanwhile, the optical chirality enhancement reaches up to 485-fold (Figure 1(c)), which can amplify the CD signal from molecules by over two orders of magnitude. We believe that our work could inspire novel on-chip photonic components for surface-sensing in CD spectroscopy, enantioselectivity, and sorting applications.

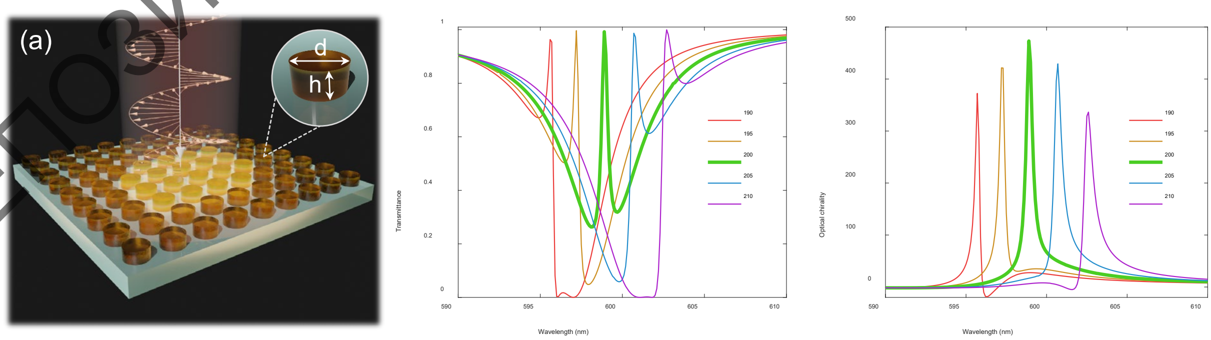

Fig. 1. (a) An illustration of the dielectric metasurface excited by CP light. (b) Simulated transmittance spectra at different diameters of TiO_2 disks. (c) Spectra of optical chirality enhancement

References

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