Robust future in chiral sensing

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One of the most interesting mysteries of the universe and of life itself is the ubiquity of the chiral nature of the molecules that form the building blocks of life as we know it. For example, amino acids, which are critical to the formation of proteins, are left-handed while deoxyribose, the sugar molecule essential to DNA, is right-handed. A fascinating aspect of chiral molecules is how a change in the handedness, e.g., from left-handed to right-handed or vice-versa, could lead to a radically different reaction in a living system or the toxicity of a drug. This is especially important in light of the fact that ~60% of the drugs on the market today are chiral compounds.[1,2] It is for this reason that researchers continue to intensely study the properties of naturally occurring enantiomers—a chiral molecule and its mirror opposite—especially for drug development while also raising concerns about the potential harms that may arise with synthesizing biomolecules with handedness opposite to those found in nature.[3] Thus, it may come as no surprise that there have been equally strong interests in developing technologies and techniques that facilitate sensitive and accurate detection of the handedness of enantiomers.

In recent years, there have been several articles demonstrating photonic-based chiral sensors, especially by leveraging resonance effects and subwavelength light confinement associated with plasmonics and metamaterials.[4–12] However, the article by Abdoulaye Ndao and coworkers points out that these approaches rely on the use of intensity, thereby making them vulnerable to parasitic noise effects and compromising sensitivity to the analyte of interest.[13] Furthermore, Ndao and his team argue that such intensity-based methods must deal with the tradeoff between sensitivity and robustness (in fabrication), the latter of which they refer to as "noise-immune stable states."

To overcome this tradeoff, they propose and subsequently demonstrate an alternative approach that uses the phase response of a carefully designed bilayer of twisted plasmonic nanorods (see Fig. 1 concept). Fabrication is achieved by two-step electron beam lithography, and the bottom layer of nanorods is embedded in the polymer substrate, whereas the top layer is exposed to air; the top and bottom layers are oriented with a relative twist angle and lateral shift. The team shows that by taking advantage of phase singularities, their device achieves high sensitivity to chirality, irrespective of changes to nanorod geometric parameters such as variation of the nanorods' length, width, and twist angle. In their research, it is shown both in simulation and experiments that even with a 10-nm distortion in the length or width, and 10 deg of variation in twist angle, the phase singularity is also detected for both left- and right-circularly polarized light. This "noise-immune stable state" makes large-scale fabrication of this sensor possible, which has been a long-standing challenge in nanofabrication because the optical response is highly sensitive to the nanostructures' shape.

Finally, sensing chirality has long been an important issue in improving human lives through the development of new drugs, and thus, a sensitive and robust sensor remains in high demand. Although preliminary, the work presented here opens possibilities for the fabrication of sensitive chiral detectors with reduced cost, thereby leading to a robust future in sensing chiral molecules.

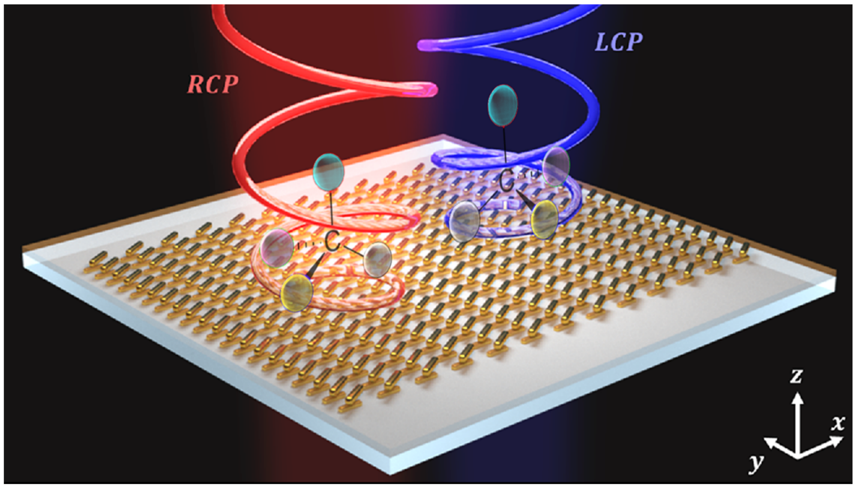

Fig. 1 Schematic illustration of the designed nanostructure and chiral sensing (adapted from Ref. 13).

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