ENHANCED CHIROPTICAL ACTIVITY WITH DIELECTRIC CHIRAL NANOSTRUCTURES: APPLICATIONS IN RACEMIC-MIXTURE SENSING

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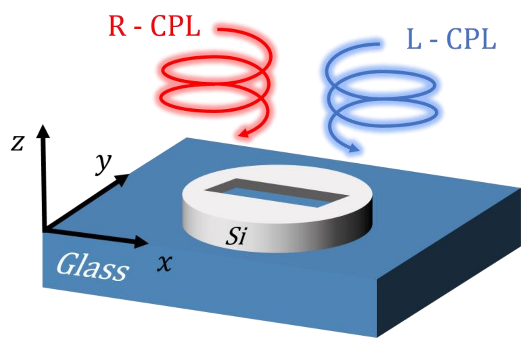
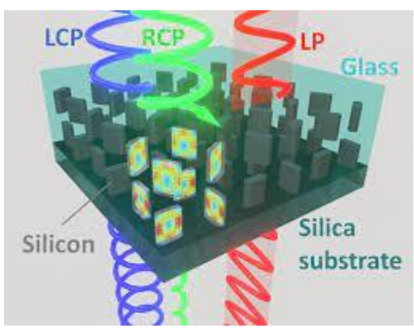
Motivation and state of art

- Chirality, related to objects which present non-superimposable mirror images (or enantiomers), is an important aspect in life sciences. Distinction of enantiomers is key in the pharmacological industry.
- The use of dielectric nanostructures to enhance the otherwise weak chiroptical effects is a hot research topic nowadays [1] [2].

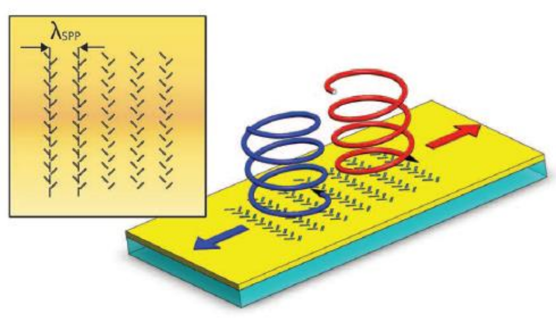


Phys. Rev. B 2020, **101**, 155403



ACS Nano 2020, **14**, 11, 15926–15935

- The use of Surface Plasmon Polaritons (SPPs) has been a common approach towards all biosensing applications.
- Launching SPPs directionally has attracted some attention recently [3] [4] and could be also exploited in chiral sensing.



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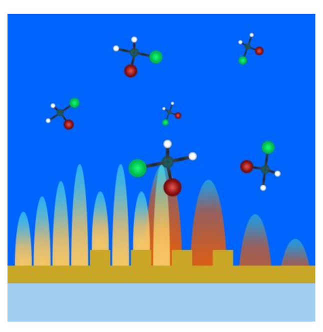


Optics Express 2021, **29**, 9, 13733-13745

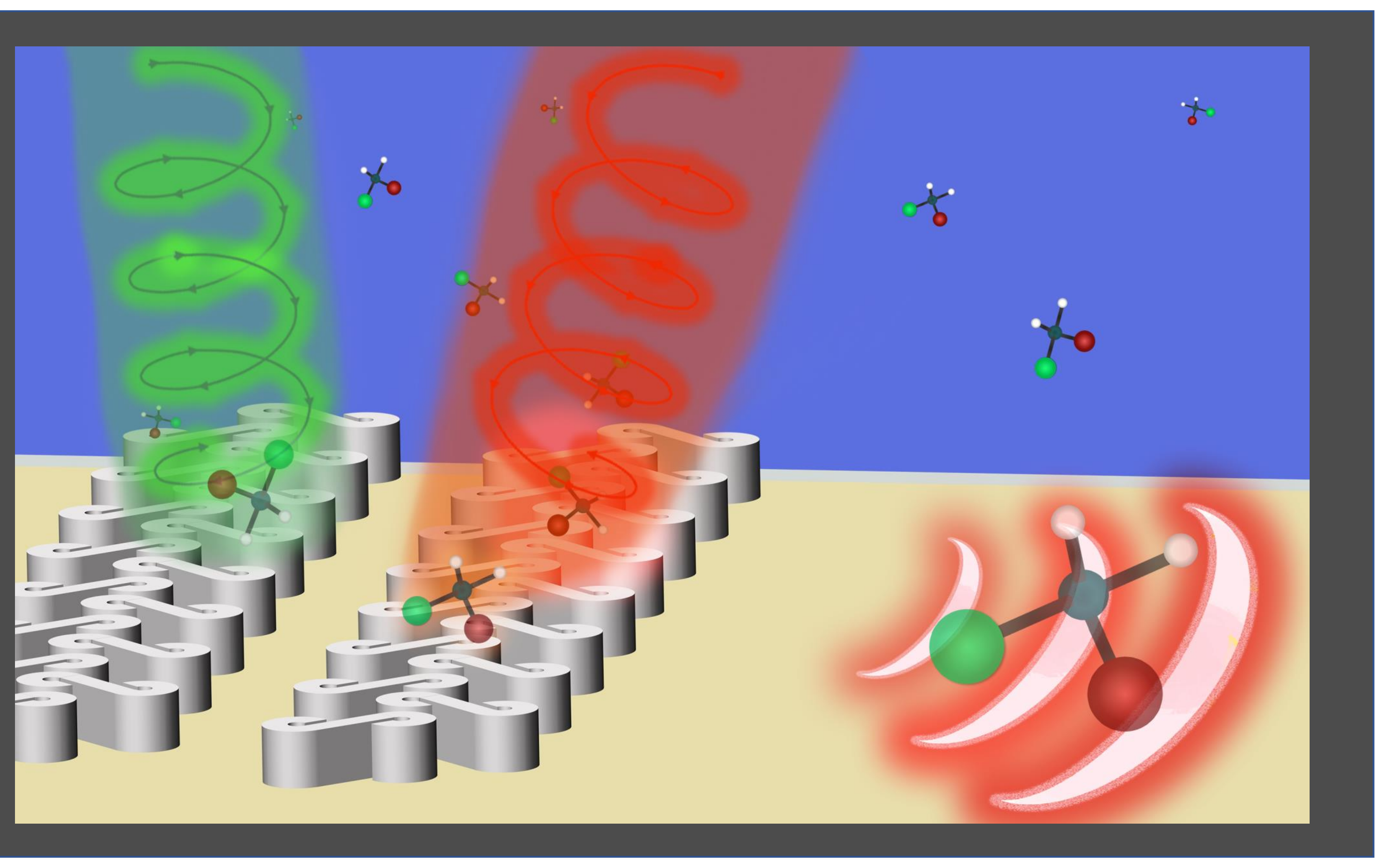
Theory

- Chirality manifests itself when chiral elements interact with other chiral elements, such as circularly polarized light (CPL).
- When chiral molecules are illuminated with both right and left CPL's, a difference in absorption between polarizations can be measured. This is called the Circular Dichroism (CD) effect.
- Chiral metamaterials are engineered to enhance the CD effect. Two magnitudes are defined to describe how the chiroptical properties are enhanced:
  - Far field: CD signal. ⟶ $CD(°) = \tan^{-1}\left(\frac{\sigma_{RCP} - \sigma_{LCP}}{\sigma_{RCP} + \sigma_{LCP}}\right)$
  - Near field: $\hat{g}$ factor. ⟶ $\hat{g} = -c\frac{\mathfrak{Im}(\boldsymbol{E}^* \cdot \boldsymbol{B})}{|\boldsymbol{E}|^2}$
- SPPs are TM waves travelling along a metal-dielectric interphase upon interaction of light with such an interphase and a coupling device such as a grating [4].
- Directional SPP launching can be achieved by means of a double column-patterned grating [3]. The dipole-like emitting unit cells in a column interact with the other, causing a phase dependency in SPP coupling that can be manipulated through the incident polarization.

All-dielectric chiroptical enhancement and plasmonic directionality

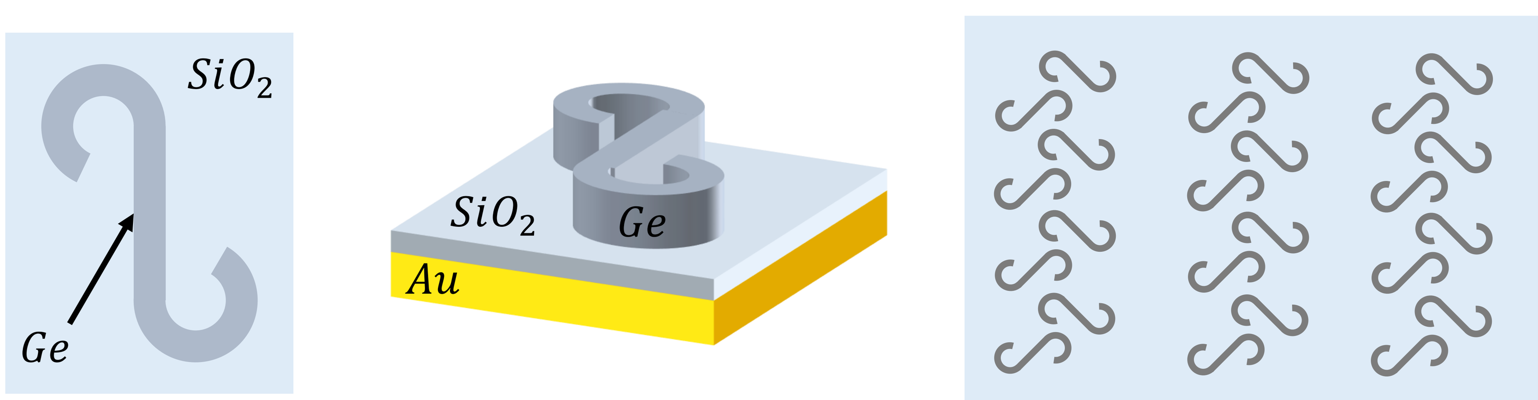
Abstract

We design a metasurface formed by chiral unit cell structures capable of enhancing the Circular Dichroism (CD) effect, with high values of the CD signal in the far field regime and accesible high dissymmetry *g* factor areas in the near field regime. The metasurface is then capable of emitting SPPs depending on the incident polarization. The chiral enhancement information is carried by the SPPs, thus the enantiomeric proportion of a mixture can be inferred from the SPP intensity difference at both sides.



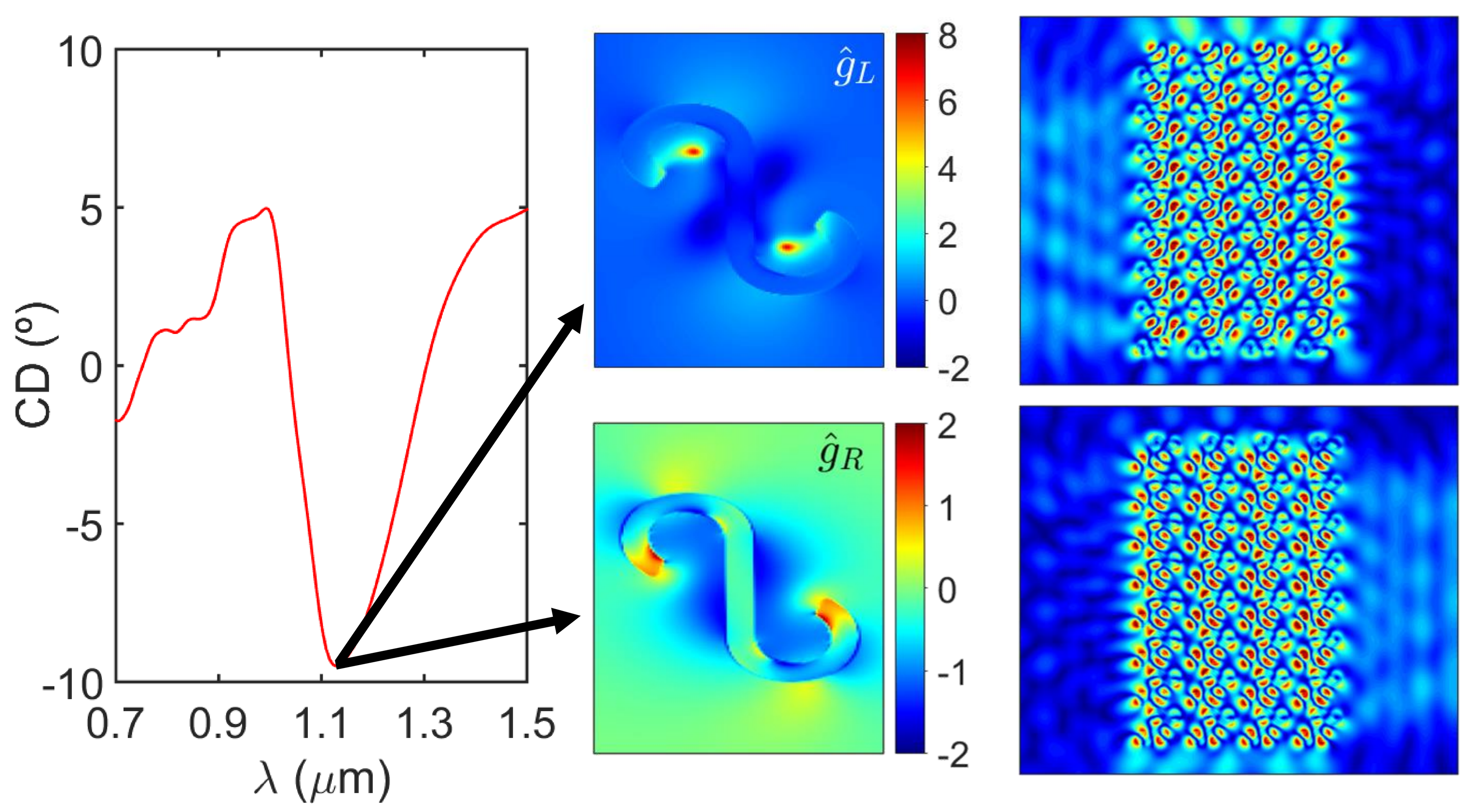
Results

- We propose a Ge "S-like" structure over thin glass and gold layers.



This novel configuration shows promising optical properties:

- *In Far field:* CD signal with a peak of -10º at 1130 nm.
- *In Near field:* for the peak CD wavelength (1130 nm), accessible high $\hat{g}$ areas appear.
- We can use this unit cell structure in the double column pattern to create a metasurface capable of launching SPPs directionally depending on the polarization handedness.



Conclusions

- The unit cell analysis demonstrates an outstanding chiroptical enhancement, both in near and far field regimes.
- The use of this structure in a spike pattern allows to launch plasmons directionally.

References

[1] F. Reyes Gómez et al. Phys. Rev. B **101**, 155403, 2020.
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