Enhanced chiral sensing using gain metamaterials

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Detecting the chirality of molecules and biomolecules is of great interest for many branches of science and technology, especially for life sciences and pharmacology; in the latter, very often, only one of the two enantiomers of a chiral substance is associated with therapeutic action while the other can be even toxic. Therefore, an efficient discrimination of the different enantiomers of a chiral substance is of crucial importance. Since chiral light-matter interactions are extremely weak (natural chiral materials have chirality parameter $\kappa \sim 10^{-4}$) this detection can be very challenging. A way to overcome this problem in optical detection schemes, as has been demonstrated in many recent studies, is the involvement of nanophotonic or metamaterials structures [1]. The capability of such structures to enhance the chiro-optical signal of molecules placed in their vicinity is connected mostly to their capability to create strong local chiral fields. The existing research has demonstrated a variety of structures associated with enhanced chiral near fields and, thus, enabling enhanced chiro-optical response, mainly enhanced *circular dichroism (CD)* signal (Note that $CD=A_{RCP}-A_{LCP}$ is the absorption (A) difference between left- and right-handed circularly polarized waves (denoted by LCP and RCP respectively) passing through a chiral medium; chiral materials of opposite helicity give opposite *CD*). Here we propose an alternative and novel approach towards chirality detection. This is involving active (gain) materials and components. As we show proper employment metamaterial structures incorporating gain materials (i.e. gain metamaterials) can greatly enhance the circular dichroism signal obtained by natural chiral media.

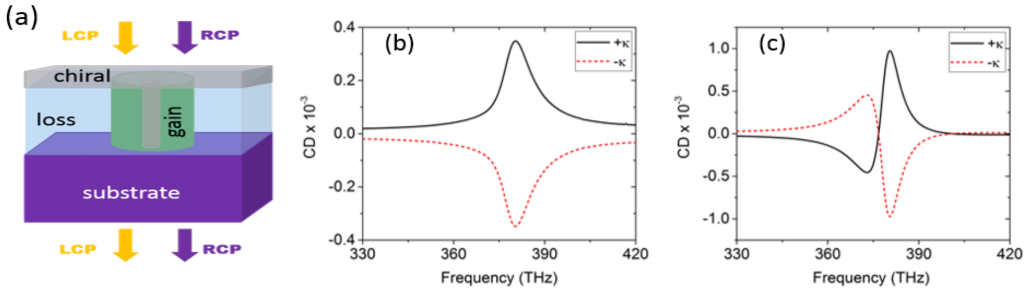

Figure 1: Panel (a) shows a potential setup (unit cell) of a chirality sensing platform/metamaterial composed of holey silicon disks (refractive index n=3.5) of diameter 300 nm, arranged periodically with a lattice constant of 500 nm and placed on top of a glass substrate with refractive index 1.5. The central holes are 20 nm in diameter and their height is the same as the disks (l=130 nm). The background medium on top of the glass substrate is considered of refractive index of 1.33. The thin chiral layer to be investigated (grey-color) is placed above the metamaterial structure and described by its refractive index (n = 1.45+0.01i), and chirality parameter $\kappa=+/-5\text{x}10^{-4}(1+0.1i)$. Panel (b) shows the *CD* for the system of Panel (a), where a thin chiral layer (of thickness 10 nm) is placed on top of the holey lossless silicon disk (without gain). Panel (c) shows the *CD* for the same system as panel (b) but with incorporation of gain (n=3.5-0.02i) in the holey silicon disk.

References

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