Direct and Indirect Coupling Mechanisms in a Chiral Plasmonic System

Zhongyue Zhang[1], Yuyan Chen[1]

[1]School of Physics and Information Technology, Shaanxi Normal University, Shaanxi Xi’an , China

Abstract

手性等离激元纳米结构被广泛研究并用于生物监测、分析化学和负折射率介质方面。在该结构中直接耦合的机制已经在相关研究中被发现。我们提出由金膜分隔两个金纳米棒(TNMF)的结构(图1),并发现了间接耦合机制。
在COMSOL Multiphysics中，射频电磁波，频域接口用于求解正弦时变电磁场分布，选此接口计算TNMF结构的光学响应。插值函数用来设置金的折射率；设置边界条件模拟周期性结构阵列。结果可通过端口2对端口1的响应获得，并可查看每个数据点的电场、电荷等分布。应用程序库中射频模块的"Plasmonic wire grating"教程是初始指导我们计算纳米结构的例子。
用软件模拟圆偏振光照射，得到透射曲线和圆二色性（CD）曲线（图2）。加入金膜的结构产生新模式2。通过B-K模型分析电荷分布（图3），发现模式1是直接耦合，模式2是间接耦合。对间接耦合模式,上、下纳米棒形成谐振器可视为接收、发射器（图4）。当接收器和发射器的阻抗匹配,间接耦合模式的CD信号达到最大值。
在TNMF结构中，透射、CD光谱和电荷分布表明由于直接和间接耦合模式产生CD。在间接耦合模式中,被视为接收、发射器的金纳米棒增强了透射、产生直接和间接耦合机制的圆二色性(CD)。这些结果可以帮助阐明手性等离激元机理和设计新型光学材料。

Reference

[1]Yongkai Wang, et. al., "Direct and Indirect Coupling Mechanisms in a Chiral Plasmonic System", Journal of Physics D: Applied Physics, 49,405104 -405110(2016).
[2]W. Ma,et. al., "Attomolar DNA detection with chiral nanorod assemblies," Nat. Commun. 4, 141-155(2013).
[3]Y. Zhu, et. al.,"A one-step homogeneous plasmonic circular dichroism detection of aqueous mercury ions using nucleic acid functionalized gold nanorods," Chem. Commun. 48, 11889-11891 (2012).
[4]J. B. Pendry, "A chiral route to negative refraction," Science 306, 1353-1355 (2004).
[5]M. Decker, et. al.,"Circular dichroism of planar chiral magnetic metamaterials," Opt. Lett. 32(7), 856-858 (2007).
[6]X. Yin, et. al., "Interpreting chiral nanophotonic spectra: the plasmonic Born–Kuhn model," Nano Lett. 13, 6238-6243 (2013).
[7]J. Hao, et. al., "Design of an ultrathin broadband transparent and high-conductive screen using plasmonic nanostructures," Opt. Lett. 37(23), 4955-4957 (2012).
[8]S. PingáYeo, "Theoretical realization of robust broadband transparency in ultrathin seamless nanostructures by dual blackbodies for near infrared light," Nanoscale 5(8), 3373-3379 (2013).

Figures used in the abstract

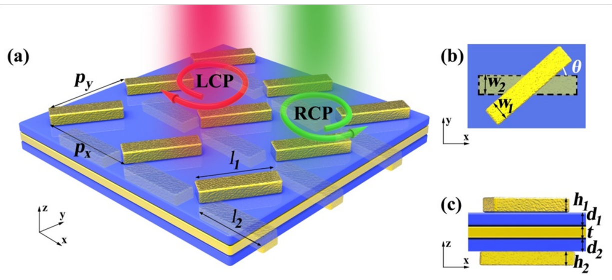

Figure 1: Schematic of (a) TNMF arrays and parameters definition, where the unit cell with the associated geometric features is designated in (b) x-y plane and (c) x-z plane.

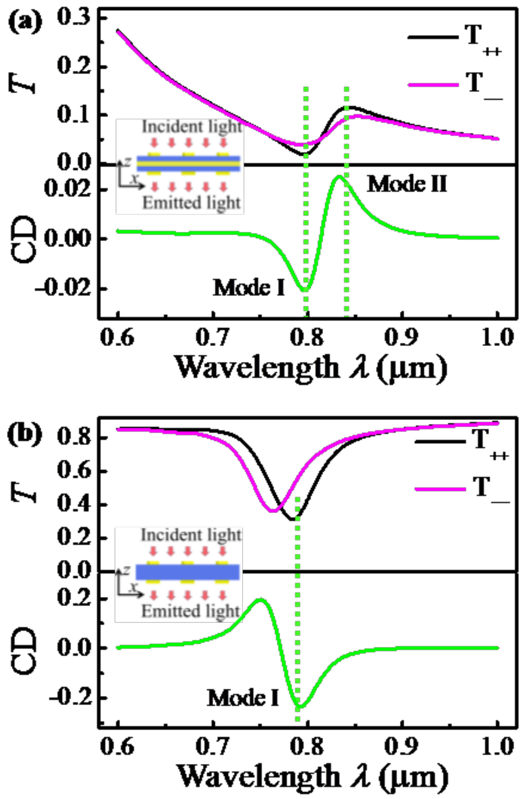

Figure 2: Simulated T++, T−−, and CD spectra of (a) TNMF arrays and (b) TNGF arrays. Insets are the schematic of TNMF arrays and TNGF arrays in the view of x-z plane.

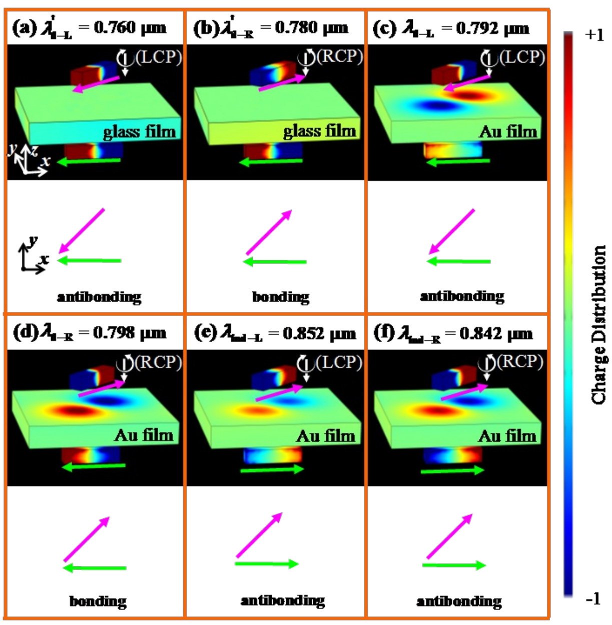

Figure 3: The charge distributions (color distributions) and Born–Kuhn modes (magenta and viridity arrows) at resonant wavelength for (a) and (b) TNGF arrays and (c)–(f) TNMF arrays. The resonances are labeled mode I and II.

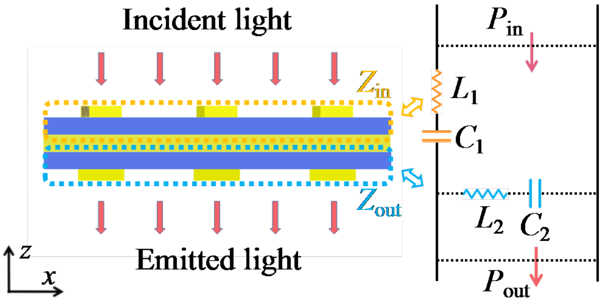

Figure 4: Schematic of TNMF arrays in x-z plane and schematic of equivalent transmission line.