Dissymmetry between left- and right-handed circularly polarized photoluminescence enhancement of plasmonic nanostructures

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1. Introduction

We report here strong dissymmetry between left- and right-handed circularly polarized photoluminescence enhancement (PLE) induced by two-dimensional chiral gold nanostructures, which can be utilized to provide circularly polarized luminescence. We employed the dye molecule IR-125 as an emitter whose photoluminescence was enhanced by a near-field interaction between the chiral plasmon and the molecule. The difference between the PLE factors for left- and right-handed circular polarizations induced by the near-field enhancement was correlated to the dissymmetry of left- and right-handed extinction of the gold nanostructures.

2. Results

Planar plasmonic chiral nanostructures

Chiral dual-blade-like shape plasmonic gold nanostructures were adopted to excite chiral plasmons. Left- and right-handed enantiomers (noted as LH and RH) were fabricated on a glass substrate with electron beam lithography and lift-off techniques as illustrated in Fig. 1 (a-d).

Circular dichroism (CD) spectra of the chiral gold nanostructures

The CD of the chiral nanostructure is defined as the difference between LCP and RCP light extinction. We obtained CD spectra of the chiral gold nanostructures with two measurement systems. One is a home-made system based on ellipticity measurement of light. The chiral nanostructure was illuminated with a linearly polarized white light from a stabilized halogen lamp impinging on the sample from the top side. We collected the transmitted light in the forward direction and analyzed its ellipticity using an achromatic quarter-wave plate and a linear polarizer. The ellipticity obtained was numerically converted into CD, and then dissymmetry of extinction was evaluated. The other system is a commercial CD spectrometer. We confirmed that the both measurement systems gave essentially the same results. Figure 1 (e) shows the CD of the two LH (black) and RH (red) enantiomers obtained with the home-made system. The CD spectra are bisignate (change of sign within the band) for both LH and RH enantiomers.

Dissymmetry between left- and right-handed PLE

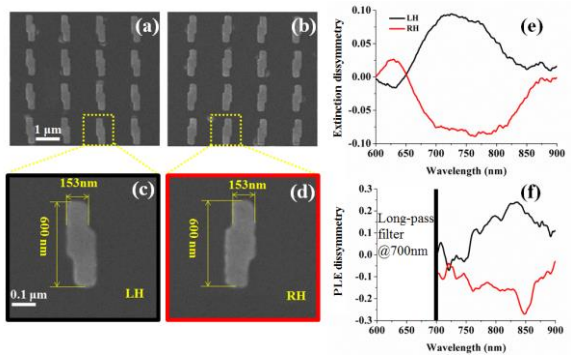

Fig. 1. (a-d) SEM images of the investigated plasmonic chiral nanostructures. (e) Dissymmetry spectra between left- and right-handed circularly polarized extinctions and (f) PLE induced by the chiral nanostructures.

The IR-125-dye-doped polyvinyl alcohol (PVA) polymer film was deposited on the nanostructures by a spin coating and baking process. PLE is defined as a ratio of the photoluminescence (PL) intensity on the nanostructures to the corresponding reference PL intensity measured at an area of the dye-doped PVA film without nanostructures. The dissymmetry between left- and right-handed PLE factors are measured and computed on the way similar to its extinction counterpart. We pumped the dye molecules with a linearly polarized 780 nm cw laser diode impinging on the sample from the polymer side for PL measurements. The luminescence from the dye molecules was detected and its ellipticity was analyzed, and the result was converted into the dissymmetry of PLE. The resulting PLE dissymmetry (Fig. 1(f)) was nearly 3 times higher than that of the extinction. The PLE dissymmetry induced by the near-field enhancement is correlated to the extinction dissymmetry of the gold nanostructures as seen in Figs. 1(e) and (f).

3. Conclusions

We experimentally demonstrated strong dissymmetry between left- and right-handed circularly polarized PLE for the dual-blade-like plasmonic chiral gold nanostructures. The dissymmetry was found to be correlated with the dissymmetry between left- and right-handed extinction of the gold nanostructure.