# Plasmonics enhanced water splitting in chiral selective metasurfaces

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## 1. Introduction

In recent years, the hydrogen was suggested as an alternate fuel source to produce clean and efficient green energy. Photoelectrochemical (PEC) water splitting is one of the green technologies for the hydrogen production [1].

Considering the ideal material which is suitable for PEC water splitting, hematite ($Fe_2O_3$) is a good candidate possessed a band gap of 2.0 - 2.2 eV. However, the reported Solar-to-Hydrogen efficiency of $Fe_2O_3$ is low mainly due to the short excited state lifetime (< 10 ps). Thus, there was research using plasmonic materials to enhance the efficiency of water splitting [2].

In this work, we combine gold chiral selective metasurface [3] with hematite thin film, which could enhance the efficiency of water splitting and also provide the circular dichroism.

## 2. Result and discussion

Figure 1(a) shows the results of the measured photocurrent with the PEC cell. It could be seen that the water splitting reaction was produced at the surface of photoanode at 1.23V vs. RHE. Figure 1(b) shows the chopped photocurrent measurements performed at 1.23V vs. RHE. The $Fe_2O_3$ photoanode also performed the high sensitivity of the light.

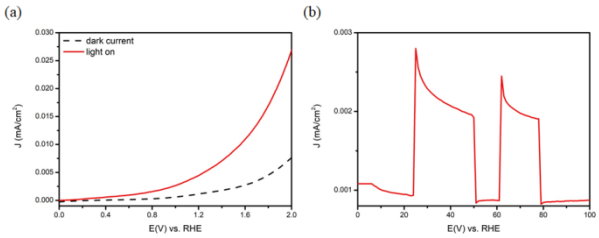


Fig.1 (a) Cyclic voltammetry with a 3 electrodes PEC cell photoanodes. (b) Chopped photocurrent measurement results at 1.23V vs. RHE for photoanode.

In this study, a 200 nm thick gold layer was deposited on the glass substrate. Then a 130 nm thick hematite was deposited by radio frequency magnetron sputter with a commercially available 99.9% pure $Fe_2O_3$ target. The designed Au chiral selective metasurface has been shown in figure 2(a). Figure 2(b) shows reflectance spectra with right-hand circular polarization (RCP) and left-hand circular polarization (LCP). In Fig. 2b, the highest circular dichroism (CD) could reach 60 % at 1390 nm because of the strong absorption by LCP incident light. The distribution of the electric fields are shown in figure 2(c). The pronounced circular-polarization-dependent field enhancement is at 1390 nm in metasurfaces by the incidence of LCP waves.

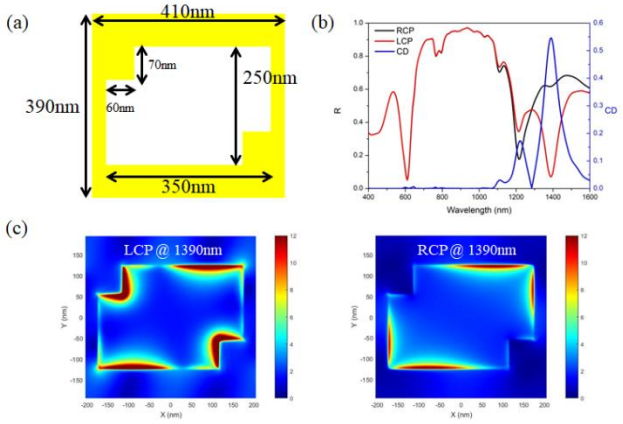


Fig.2 (a) Schematic of gold chiral selective metasurfaces. (b) Simulated reflectance spectra of gold selective chiral nanostructures with RCP and LCP incident, CD = $|R_{RCP}-R_{LCP}|$. (c) The electric field distributions of the metasurface at 1390 nm with different polarizations.

## 3. Conclusions

In summary, we use $Fe_2O_3$ thin films and gold nanostructures to manipulate the resonance wavelengths of RCP and LCP, and the CD reaches almost 60% at NIR wavelengths. In addition, this photoanode could demonstrate in water splitting by its high sensitivity of the light. We believed that this study can be applied not only in chemical detection but also in the water oxidation reaction.

## References

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