Field Enhancement by Thin Dielectric Nanodisks as Mie Resonator

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1. Introduction

Metasurface is one kind of material with engineered optical properties which is not naturally found. Metasurfaces made of metals, such as gold and silver, are well investigated in recent years. However, it is limited by high ohmic loss with increasing frequency. Hence, metasurfaces composed of lossless dielectric materials emerge as a competitor recently. Metasurfaces based on dielectric materials with high refractive index support resonances that are referred to as Mie resonances. The schematic diagram of low-order Mie resonances consists of Electric Dipole (ED) mode and Magnetic Dipole (MD) mode resonances are shown in Fig. 1(a) and Fig. 1(b) respectively. Mie resonators have varieties of applications such as high-resolution color printing [1], color filter [2], and light emission [3]. However, the aspect ratio of conventional Mie resonators is higher than 0.6 which means their structures are close to cylinders or rods rather than disks.

In this paper, we investigate a dielectric disk as a thin Mie resonator with a reduced aspect ratio to get access to the enhanced field inside the resonator.

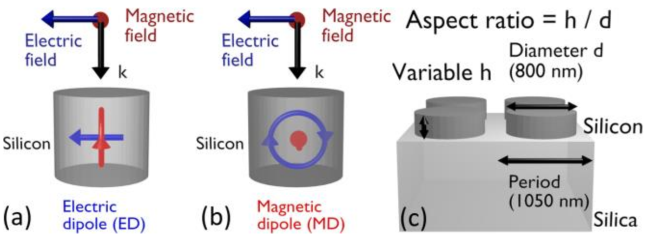

Figure 1: Schematic diagram of (a) ED and (b) MD modes supported by Mie resonators. (c) Schematic diagram of the Mie resonators array.

2. Results and discussion

To investigate the influence of aspect ratios on the Mie resonance, numerical simulations are operated with the constant period of the unit cell and the diameter d of the resonators when varying the thickness h. The schematic diagram of the Mie resonators array is shown in Fig.1 (c). The simulated results of the reflection spectra in Fig. 2(a) show that relative positions of the ED and MD modes are changed concerning the different thicknesses. The electric field distribution of the ED and MD modes with the aspect ratio of $c=h/d=0.3$ approximately are shown in Fig. 2(b) and Fig. 2(c). The field enhancement factor of the ED mode increases by a factor of 2 from 3.5 to 7 approximately. The enhanced field of the ED mode in Fig. 2(b) is closer to the upper surface of the resonator compared to cylindrical Mie resonator. Hence, one can make use of enhanced field when combing the Mie resonators with other materials stacked over the resonators.

In the meanwhile, the Mie resonators with lower aspect ratio support MD resonances as well. According to the reflection spectra in Fig.2 (a), the wavelengths of the MD mode decrease with reduced thicknesses which are relevant to the aspect ratios. MD mode of Mie resonators arises from a circular displacement current loop. When the thicknesses of the Mie resonators decrease, the wavelengths of the MD modes are decreasing to meet the requirement of retardation of forming a circular displacement current loop.

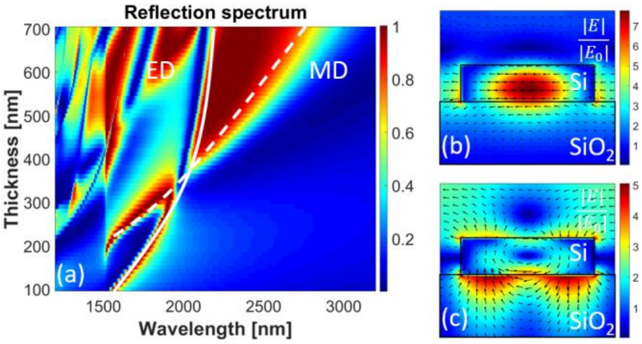

Figure 2: (a) Reflection spectral map with sweeping thickness from 100 nm to 700 nm. Electric field distribution of (b) ED and (c) MD modes supported by a thin nanodisk with c=0.3.

3. Conclusions

Thin dielectric nanodisks still support Mie resonances with exchanged ED and MD positions in wavelength. Meanwhile, the resonator with a reduced aspect ratio shows a stronger field enhancement which is two times as high as cylindrical Mie resonators. Strong field enhancement is crucial for the applications relying on high local fields, such as light emitter and sensing.

Acknowledgements

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References

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