Supporting information

Multi-band optical resonance of all dielectric metasurfaces toward high-performance ultraviolet sensing

Jie Zheng*[a], Cheng Zhang[a], Hong Li[a], Xianchao Liu[b], Yijia Huang[a], Jianqi Zhu[a], Zhilin Yang[c] and Ling Li*[a]

[a] Laboratory of Micro-Nano Optics, School of Physics and Electronic Engineering, Sichuan Normal University, Chengdu 610101, PR China.

[b] School of Optoelectronic Science and Engineering, University of Electronic Science and Technology of China, Chengdu, 610054, PR China.

[c] Department of Physics, Collaborative Innovation Center for Optoelectronic Semiconductors and Efficient Devices, Jiujiang Research Institute, Xiamen University, Xiamen, 361005, PR China.

E-mail: zhengjie@sicnu.edu.cn; lingli70@aliyun.com

1. The fabrication of size-controlled hexagonal PSs arrays

The highly uniform polystyrene spheres (PSs) with 750 nm diameter were assembled onto the silicon substrate. The size of PSs can be decreased by controlling etch time, power and gas flow in the reactive ion etch (RIE) process. In this study, the power adopted 50 W and O_2 gas flow was 30 sccm. The size-controlled hexagonal PSs arrays have been successfully fabricated by controlling etch times with 4, 5, 6 and 7 min. The corresponding results can be found in Figure S1. Cross-sectional scanning electron microscopy (SEM) image of PSs demonstrates that profiles of etched PSs represent cup shaped, as shown in Figure S2.

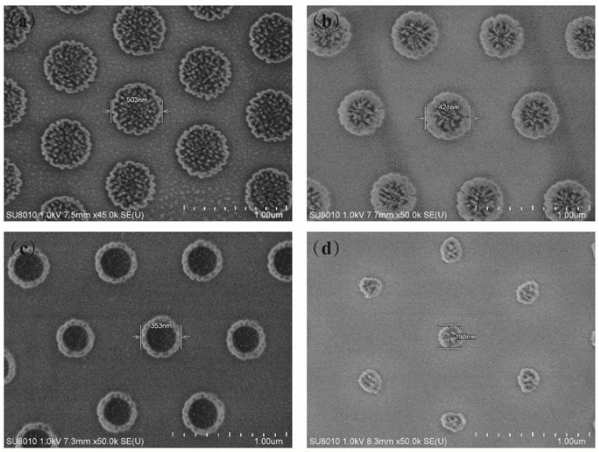

Fig. S1. Size-controlled of PSs profiles under etch time (a) 4 min, (b) 5 min, (c) 6 min and (d) 7min. Corresponding sizes of nanoparticle are 503, 353, 421, and 198 nm, respectively.

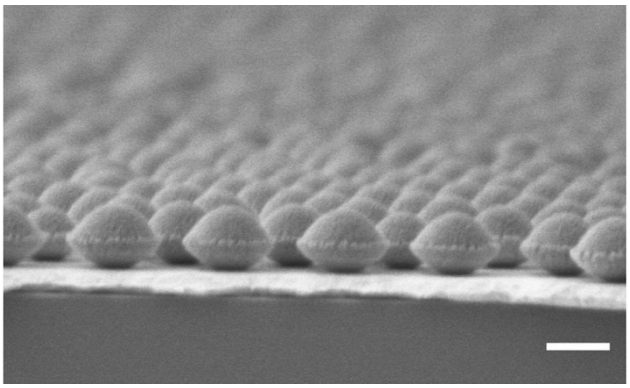

Fig. S2. Cross-sectional SEM image of PSs under etch 4 min. The scale bar represents 500 nm.

2. The optical characteristic of size-dependence Si_3N_4 arrays

For individual Si_3N_4 nanoparticle, its optical resonant mode represents a broad reflectance peak in the entire DUV to visible wavelength (see Figure S3). As continuously reducing nanoparticle size, the optical properties of individual Si_3N_4 nanoparticles will dominate.

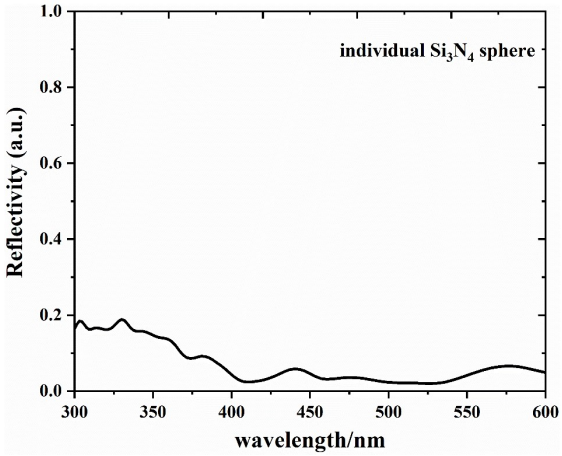

Fig. S3. Optical property of individual Si_3N_4 nanoparticle at normal illustration (0°).

3. The optical characteristic of Si_3N_4 material

Si_3N_4 material contributes to mid-index ADMs because its refractive index is approximately 2.4 and extinction coefficient is zero in the deep-ultraviolet (DUV) to near-infrared (NIR) wavelength (see Figure S4). Si_3N_4 material is widely used in semiconductor technologies and has substantial CMOS-compatible fabrication process. In this study, highly uniform Si_3N_4 all-dielectric metasurfaces were fabricated by adopting nanosphere self-assemble processes integrated with plasma enhanced chemical vapor deposition techniques. The Mie-type electric and magnetic resonant modes of Si_3N_4 metasurfaces are broadband. Therefore, Si_3N_4 all-dielectric metasurfaces show excellent optically resonant properties in the DUV to the NIR regions.

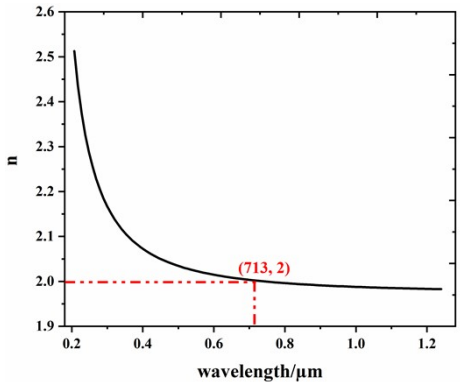

Fig. S4. The refractive index (n) of Si_3N_4 material in the ultraviolet to the near-infrared wavelength.