Flexible and reconfigurable silicon carbide metasurface stickers

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Reconfigurable metasurfaces refer to the metasurfaces that change their optical responses by external stimuli. Such tunability is highly advantageous in controlling light, and thus many innovative approaches have been reported. One major approach utilizes adaptable materials, such as liquid crystals, with intrinsically tunable optical properties toward temperature, pressure, electric field and so on. Another and more direct approach is mechanical reconfiguration, which has a broad material applicability. Flexible matrix can serve as a direct platform for mechanically reconfigurable metasurfaces. Based on this concept, several metasurfaces comprising plasmonic metals and dielectrics of high refractive index embedded in flexible polymers have been developed, and tunable structural colors, radiation patterns of photoluminescence (PL) and lasing wavelengths have been reported [1-5].

PL manipulation is one promising application of the metasurface. Both plasmonic and dielectric metasurfaces, in combination with optical emitters, show a notable modulation in PL, i.e., spectral and spatial tuning in radiation patterns. Low absorption (k) and high refractive index (n) are critical prerequisites for dielectric PL enhancers. TiO_2 is one material that satisfies such requirements and is thus mostly used in the visible region for both static and dynamic PL modulation. Silicon carbide (SiC) can be a better substitute because of its higher n and a lower k than those of TiO_2. Even though some pioneering works have already applied SiC to nanophotonics, especially in the context of phonon polaritons, it is still far less explored compared to its potential as the dieletric metasurfaces working in the visible.

In this study, we fabricate mechanically reconfigurable SiC metasurface for PL-control application (Fig. 1), starting from a 3C-SiC film epitaxially grown on Si wafer (Air-Water Inc., Japan). The metasurface consists of SiC nanoparticle array embedded in polydimethylsiloxiane (PDMS). Due to the self-adhesive properties of PDMS, the flexible metasurface works as a sticker that can be attached to any clean surfaces and act as a metasurface. By mechanically stretching the sticker, the optical resonances due to surface lattice resonances supported by the periodic lattice, spectrally shift in accordance with the change in particle arrangement. Furthermore, we place the sticker on a phosphor plate to observe a directional out-coupling of PL through the sticker.

References

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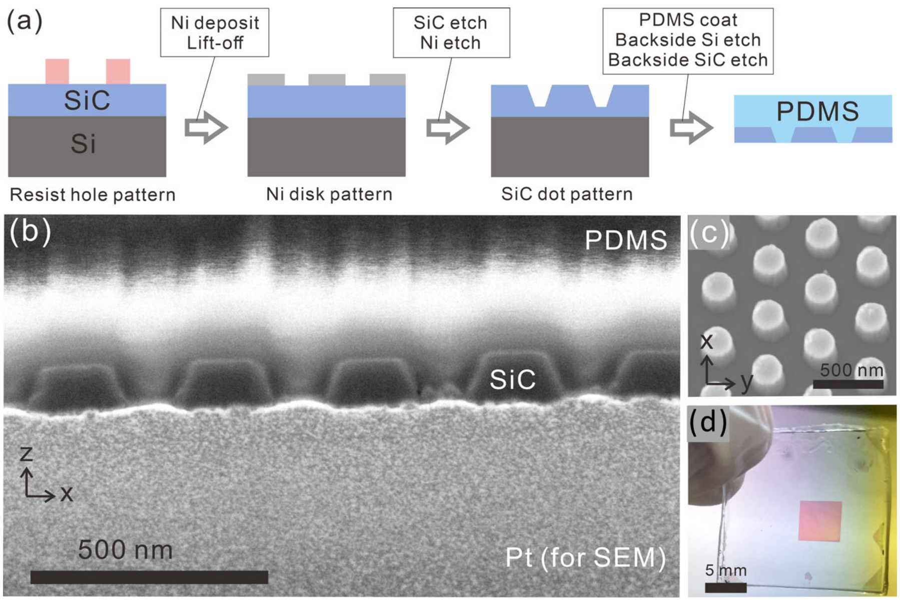

Figure 1. (a) Sketch of the fabrication scheme of the SiC nanoparticle array supported on the PDMS layer. (b,c) SEM images. (b) Cross-sectional view before embedded in the PDMS. (c) Top-view before Ni etching. (d) Optical view of the nanoparticle array embedded in the PDMS layer.