Monolithic Metalenses in Mono-Crystalline Silicon Carbide

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Silicon carbide (SiC) has attained increased attention over the last decade due to its attractive optical properties, including a low loss in the visible and infrared spectrum, strong nonlinearity and room-temperature quantum emitters [1]. To increase the collection efficiency of such emitters, the conventional solid immersion lenses can be replaced by monolithic metalenses, as recently shown for quantum emitters in diamond [2]. Such metalens integration can open opportunities for large-scale photonic applications of SiC quantum emitters. However, to date there is no demonstration of SiC metalenses to collect light from deep within the material.

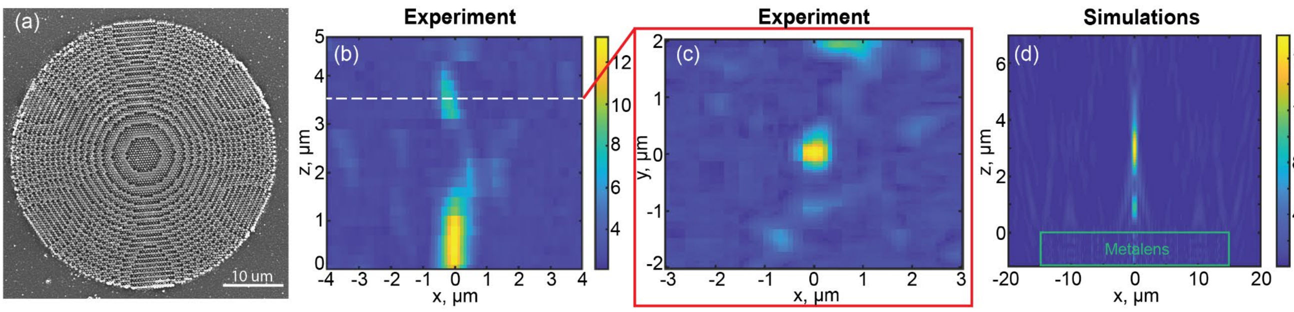

Figure 1: Fabricated metalenses and their optical characterization. (a) SEM image of parabolic and cubic metalenses. (b) Light propagation intensity from 980nm laser after the parabolic metalens. (c) The cross-section from (b), taken at the designed focal distance 3.5μm. (d) Simulated light propagation of parabolic metalens.

In this work, we design and demonstrate experimentally two types of monolithic SiC metalenses, (*i*) parabolic-phase metalens and (*ii*) extended-focus metalens with cubic transverse profile, to elicit a response deeply into material from the light at the NIR wavelength range. The motivation behind these two designs is that conventional metalens can provide high efficiency, accurate small focal point, and the extended focal length metalens can couple to emitters that are located at different depths. Figure 1 shows the fabricated parabolic metalens and its optical response in the experiment and the corresponding numerical simulations. Both lenses show sufficient performance and can be used to capture light from quantum emitters embedded close to the surface of the mono-crystalline SiC material.

[1] W Koehl *et al*., Room temperature coherent control of defect spin qubits in SiC, Nature 479, 84 (2011).

[2] T-Y. Huang *et al*., A monolithic immersion metalens for imaging solid-state quantum emitters, Nat. Commun. 10, 2392 (2019).