Supplementary Note 1 - Thermal conductivity measurement

The thermal conductivity of the single-crystal diamond substrate was measured using a Laser Flash Analyzer (LFA 467 HyperFlash). The sample had a density of 3.520 g/cm^3 and a thickness of 3.007 mm. A relatively thick sample was employed to improve the accuracy of the thermal conductivity measurement.[1] The measurement was conducted at 25.3 °C with a laser voltage of 250 V, a pulse duration of 0.1 ms, and a detection area diameter of 3.7 mm. Three independent measurements yielded thermal conductivity values of 2254.957, 2243.996, and 2251.039 W/mK, respectively. The average thermal conductivity was determined to be 2249.997 W/mK, with a standard deviation of 5.554 W/mK.

Supplementary Fig. 1 - Simulated magnetic field distributions

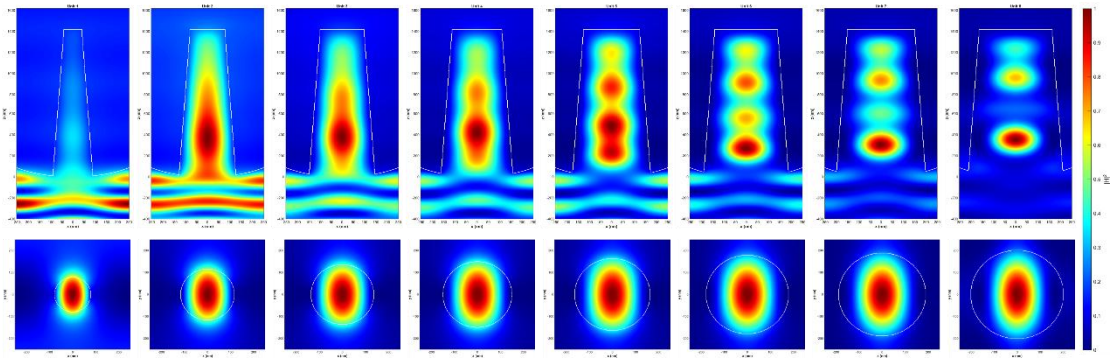

Figure S1. Normalized magnetic field distributions of the eight selected meta-atoms. The field profiles indicate negligible coupling between adjacent meta-atoms.

Supplementary Fig. 2 - Optical characterization setup

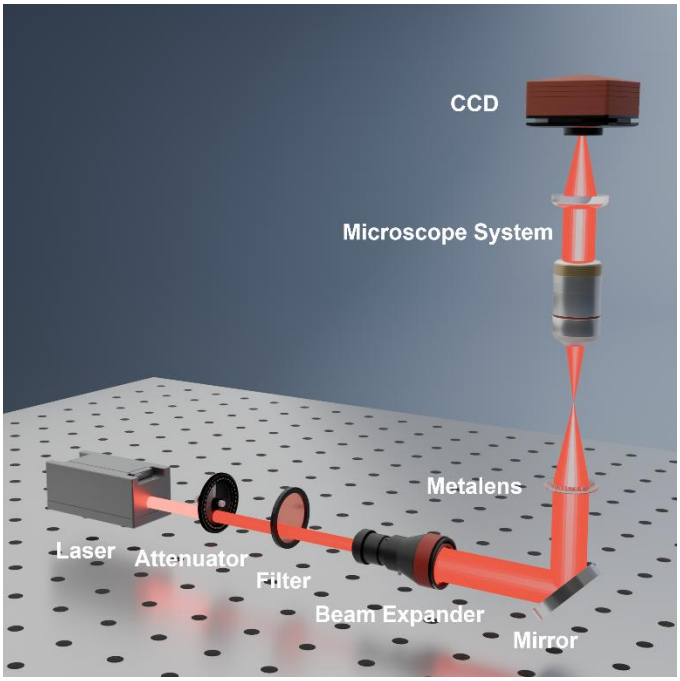

Figure S2. Schematic of the custom-built optical characterization setup. The laser beam, after attenuation and beam expansion, is normally incident on the metalens, and the focal spots are observed

by a CCD camera through the microscope objective.

Supplementary Fig. 3 - Experimental Focal Characterization

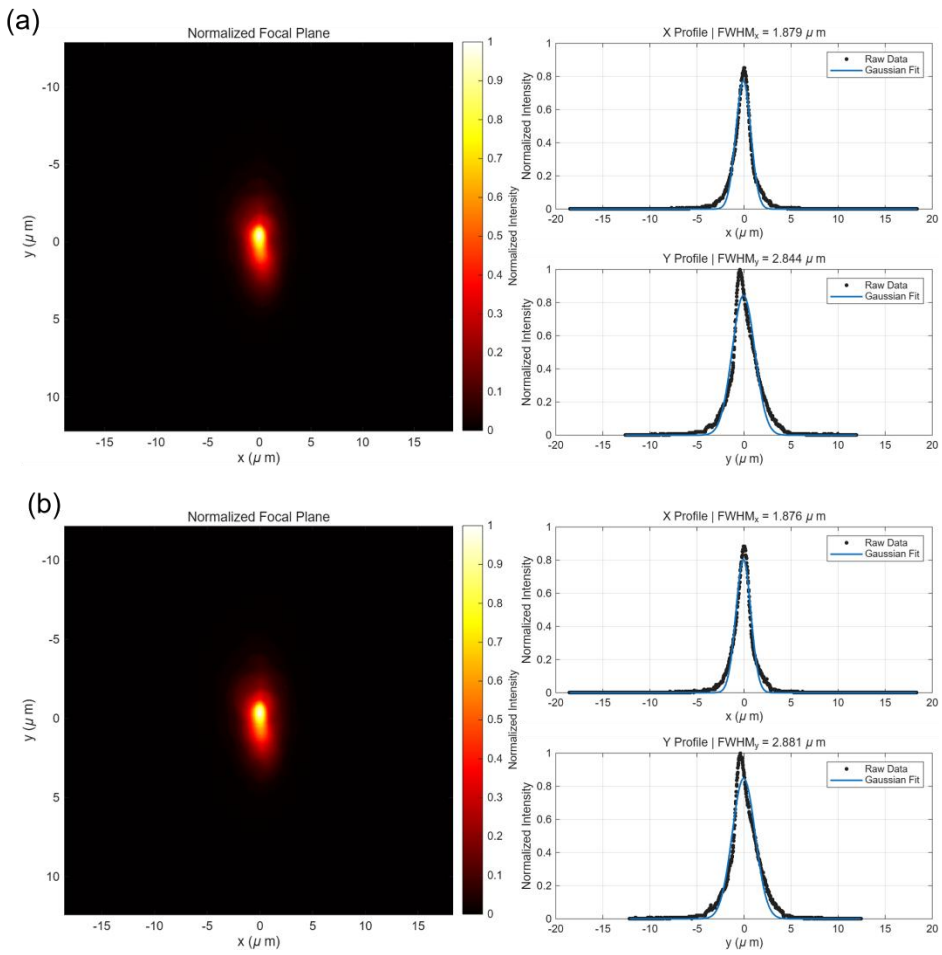

Figure S3. Measured focal intensity distributions in the *x*-*y* plane acquired using a 100× objective lens. (a) Normalized focal-plane intensity distribution of the left focal spot, together with the corresponding intensity profiles along the x and y directions and their Gaussian fits. (b) Normalized focal-plane intensity distribution of the right focal spot, together with the corresponding intensity profiles along the x and y directions and their Gaussian fits.

Supplementary Fig. 4 - Long-term stability of the dual-focus focusing performance

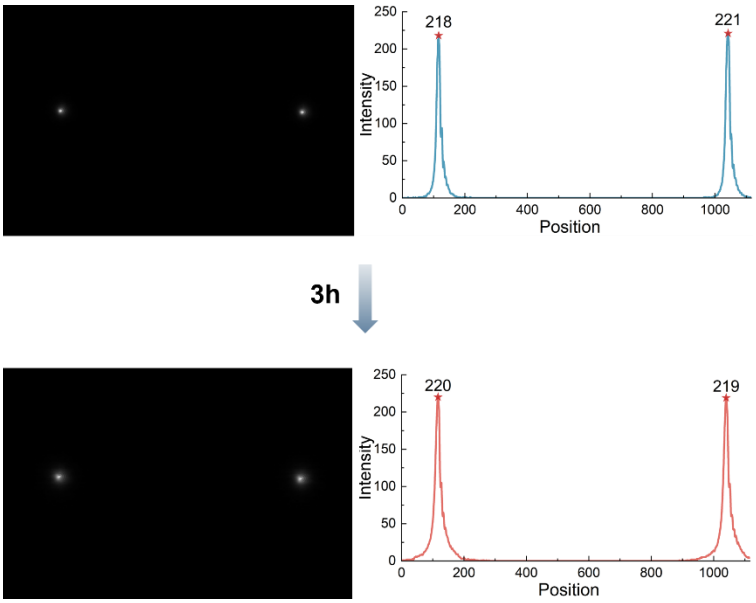

Figure S4. Dual foci of the diamond metalens and their cross-sectional intensity profiles. The left panels show raw CCD images of the two focal spots, and the right panels present the corresponding cross-sectional intensity profiles taken along the line connecting the two focal centers. The top panels correspond to the initial state, while the bottom panels are recorded after 3 h of continuous irradiation at a laser power of 25 W.

Supplementary Fig. 5 - Laser processing tracks during pulsed-laser irradiation

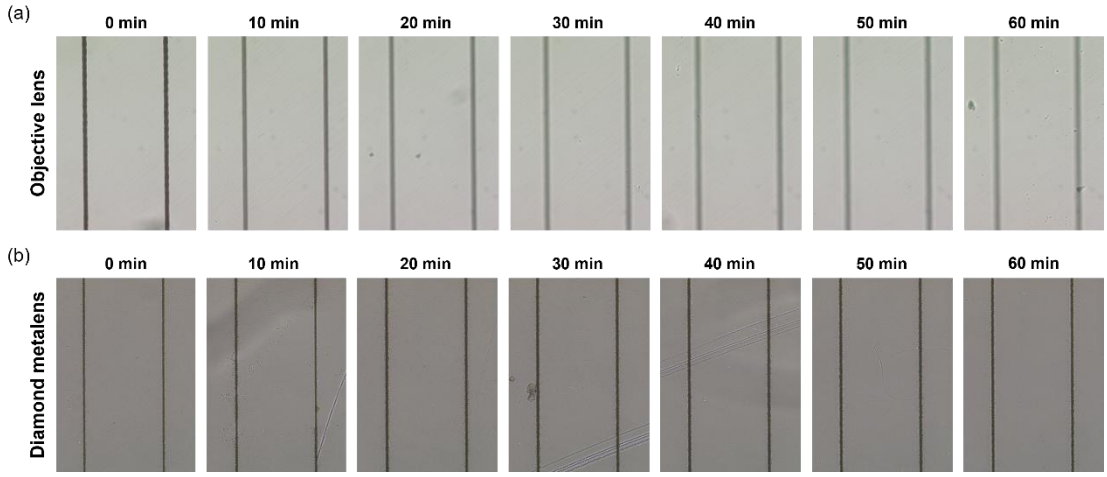

Figure S5. Optical microscopy images of laser-scribed tracks generated on semi-insulating 4H-SiC using (a) a conventional objective lens and (b) the diamond metalens during 1 h of continuous pulsed-laser processing.

Supplementary Fig. 6 - Effect of high-power CW laser irradiation

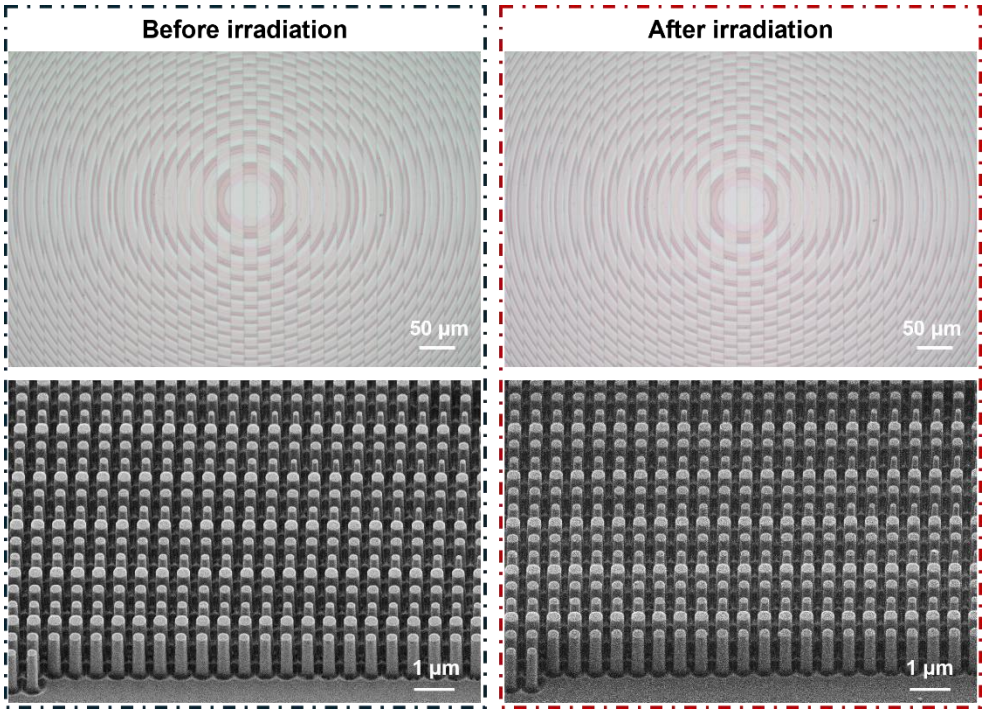

Figure S6. Optical microscopy and SEM images of the diamond metalens before and after 30 s exposure to an 8.25 kW laser beam. No damage features are observed in the central irradiated region, and the nanopillars remain intact with no signs of deformation or morphological alteration.

1 Cape, J. & Lehman, G. Temperature and finite pulse-time effects in the flash method for measuring thermal diffusivity. *Journal of applied physics* **34**, 1909–1913 (1963).