Supplemental Document

Optics EXPRESS

Amorphous silicon carbide high contrast gratings as highly efficient spectrally selective visible reflectors: supplement

HALEY C. BAUSER,[1] MORGAN D. FOLEY,[2] MEGAN E. PHELAN,[1] WILLIAM WEIGAND,[3] DAVID R. NEEDELL,[1] ZACHARY C. HOLMAN,[3] AND HARRY A. ATWATER[1,*]

[1] *Department of Applied Physics and Materials Science, California Institute of Technology, 1200 E California Blvd, Pasadena, CA 91125, USA*
[2] *Department of Physics, California Institute of Technology, 1200 E California Blvd, Pasadena, CA 91125, USA*
[3] *School of Electrical, Computer, and Energy Engineering, Arizona State University, Tempe, AZ 85287, USA*
[*] *haa@caltech.edu*

Supplement DOI: https://doi.org/10.6084/m9.figshare.20022017

Parent Article DOI: https://doi.org/10.1364/OE.456898

Supporting Information

AMORPHOUS SILICON CARBIDE HIGH CONTRAST GRATINGS AS HIGHLY EFFICIENT SPECTRALLY SELECTIVE VISIBLE REFLECTORS

HALEY C. BAUSER[1], MORGAN D. FOLEY[2], MEGAN E. PHELAN[1], WILLIAM WEIGAND[3], DAVID R. NEEDELL[1], ZACHARY C. HOLMAN[3], HARRY A. ATWATER[1]*

1 DEPARTMENT OF APPLIED PHYSICS AND MATERIALS SCIENCE, CALIFORNIA INSTITUTE OF TECHNOLOGY, 1200 E CALIFORNIA BLVD, PASADENA, CA 91125, USA
2 DEPARTMENT OF PHYSICS, CALIFORNIA INSTITUTE OF TECHNOLOGY, 1200 E CALIFORNIA BLVD, PASADENA, CA, 91125, USA
3 SCHOOL OF ELECTRICAL, COMPUTER, AND ENERGY ENGINEERING, ARIZONA STATE UNIVERSITY, TEMPE, ARIZONA 85287, USA
**haa@caltech.edu*

Additional Measurement Details

Reflectivity measurements were performed on each metasurface to experimentally validate our simulation results. In order to cover the wide wavelength range of the reflectivity spectra, a supercontinuum laser light source (NKT Photonics SuperK Fianium) was used, together with a monochromator (Oriel MS257) to provide a narrow bandwidth (10μm) around each wavelength, thus enabling us to accurately characterize the reflectivity of the metasurfaces at each wavelength. The optical diagram is shown in Figure S1.

Reflectivity measurements were taken between 450nm and 1100nm at normal incidence with a wavelength resolution of 1nm. A visible-to-near IR photodiode was optimally positioned for maximum sensitivity to the reflected light, and the current at the optical chopper frequency was measured by the lock-in amplifier. The intensity of the laser light reaching the metasurface was of the order of 50 μW, at which a good signal-to-noise ratio could be obtained whilst remaining within the linear regime of the photodiode; hence, a linear relationship between the current and intensity of reflected light could be assumed. The spot size of the laser beam was approximately the size of the entire metasurface (700μm); thus the impact of anomalous effects from any local defects in the metasurface could be greatly diminished, and only a holistic reproducible response from the metasurface was recorded.

The measurement was paused for 4s after each wavelength increment to account for the finite response time of the photodiode and lock-in amplifier. An integration time of 1s for the measurement of the photodiode current mitigated the impact of temporal fluctuations. The optical chopper frequency was set to a prime number (677 Hz) to remove harmonic noise from the measurement.

Two non-polarizing 50:50 beamsplitters were used for the visible (450nm-700nm) and infrared (700nm-1100nm) regimes of the measurement, so that part of the reflected beam could be deflected towards the photodiode. A slight twist of a few degrees was applied to each beamsplitter so that the reflected light from the metasurfaces and light directly from the laser could be spatially segregated in the vicinity of the Si photodiode.

A mirror, compliant with NIST Specular Reflectance Standards (Ocean Insight STAN-SSH-NIST Specular Reflectance Standard) was used to normalize our raw reflectivity data, thus removing the frequency-dependence of several components in our setup (photodiode response, laser output power, and monochromator efficiency) from our results. Using the absolute reflectivity data of the mirror provided by the manufacturer, we were thus able to obtain absolute reflectivity spectra for each metasurface. Figure S2 shows the reflection of the mirror across the relevant wavelengths.

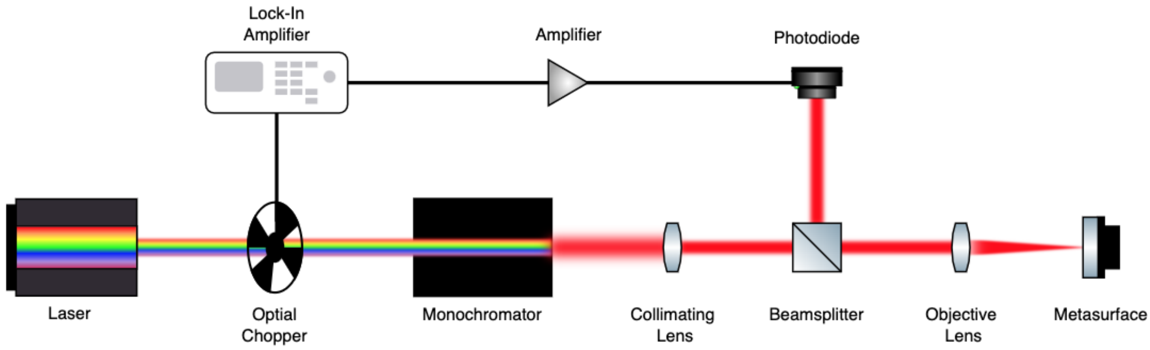

Figure S1: Schematic of the measurement set up

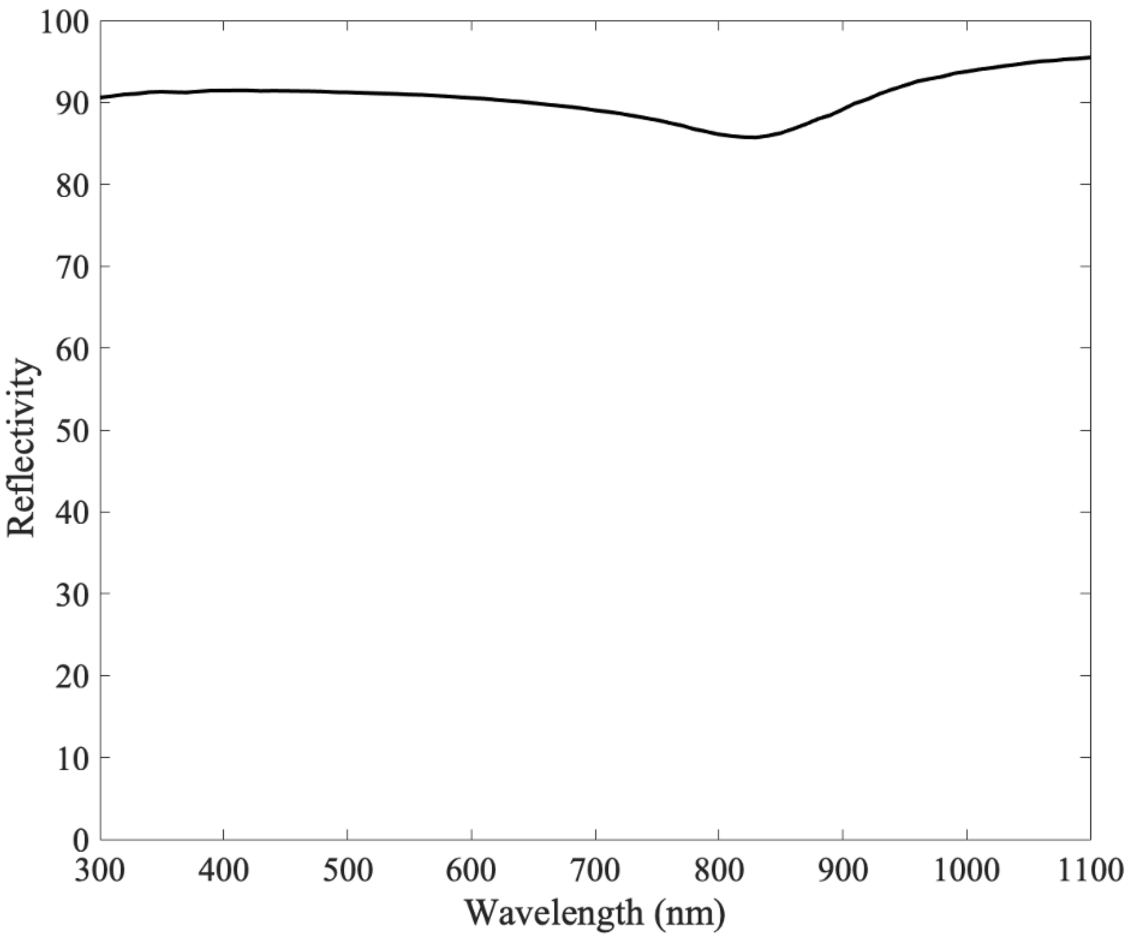

Figure S2: Absolute reflection of the reference mirror for the reflection measurements.

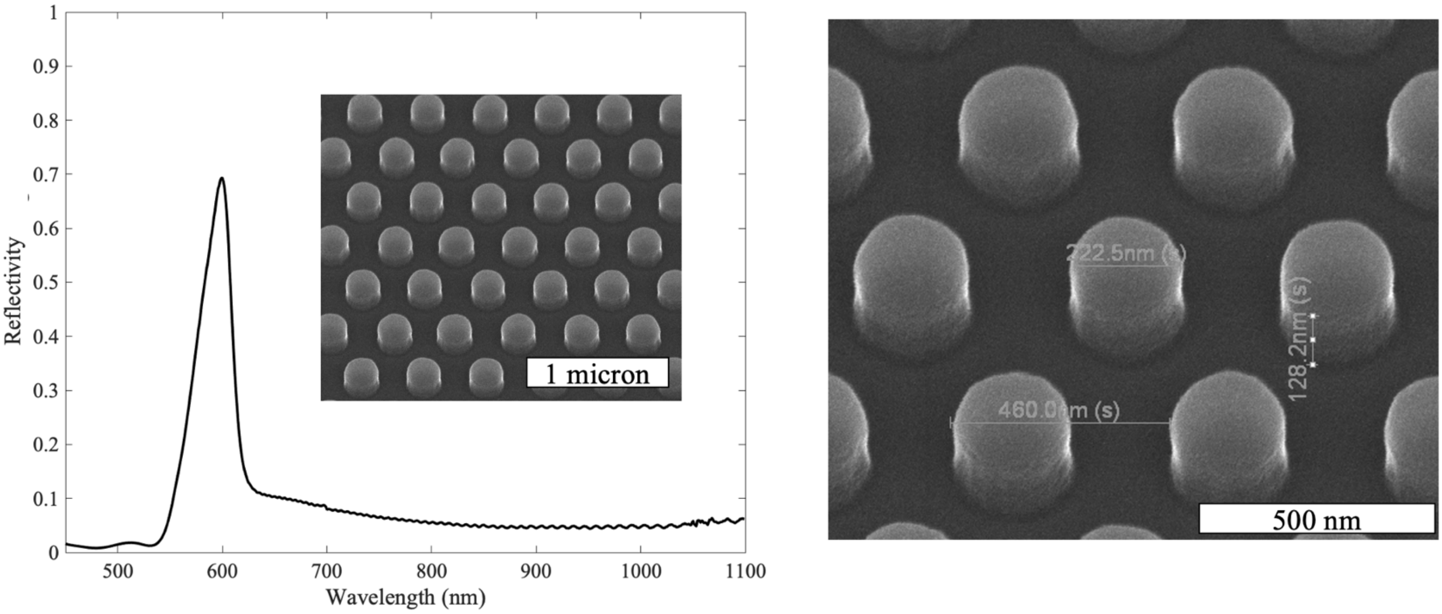

Figure S3: Reflection peak of a HCG with smaller features than the optimized HCG in the main text. The smaller features result in a reflection peak in the shorter wavelength range. The SEM on the left shows the individual measurements of the geometric features.

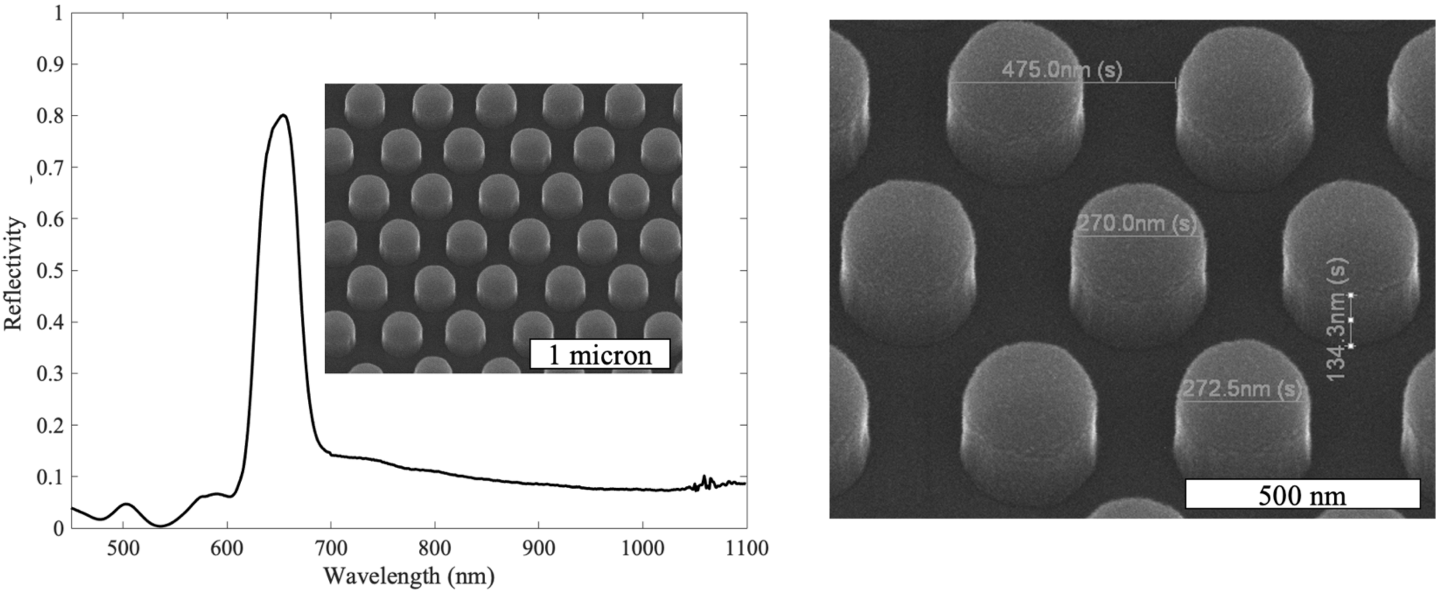

Figure S4: Reflection peak of a HCG with larger features than the optimized HCG in the main text. The larger features result in a reflection peak in the longer wavelength range. The SEM on the left shows the individual measurements of the geometric features.