Supplementary Information for "Angle-multiplexed metasurfaces: encoding independent wavefronts in a single metasurface under different illumination angles"

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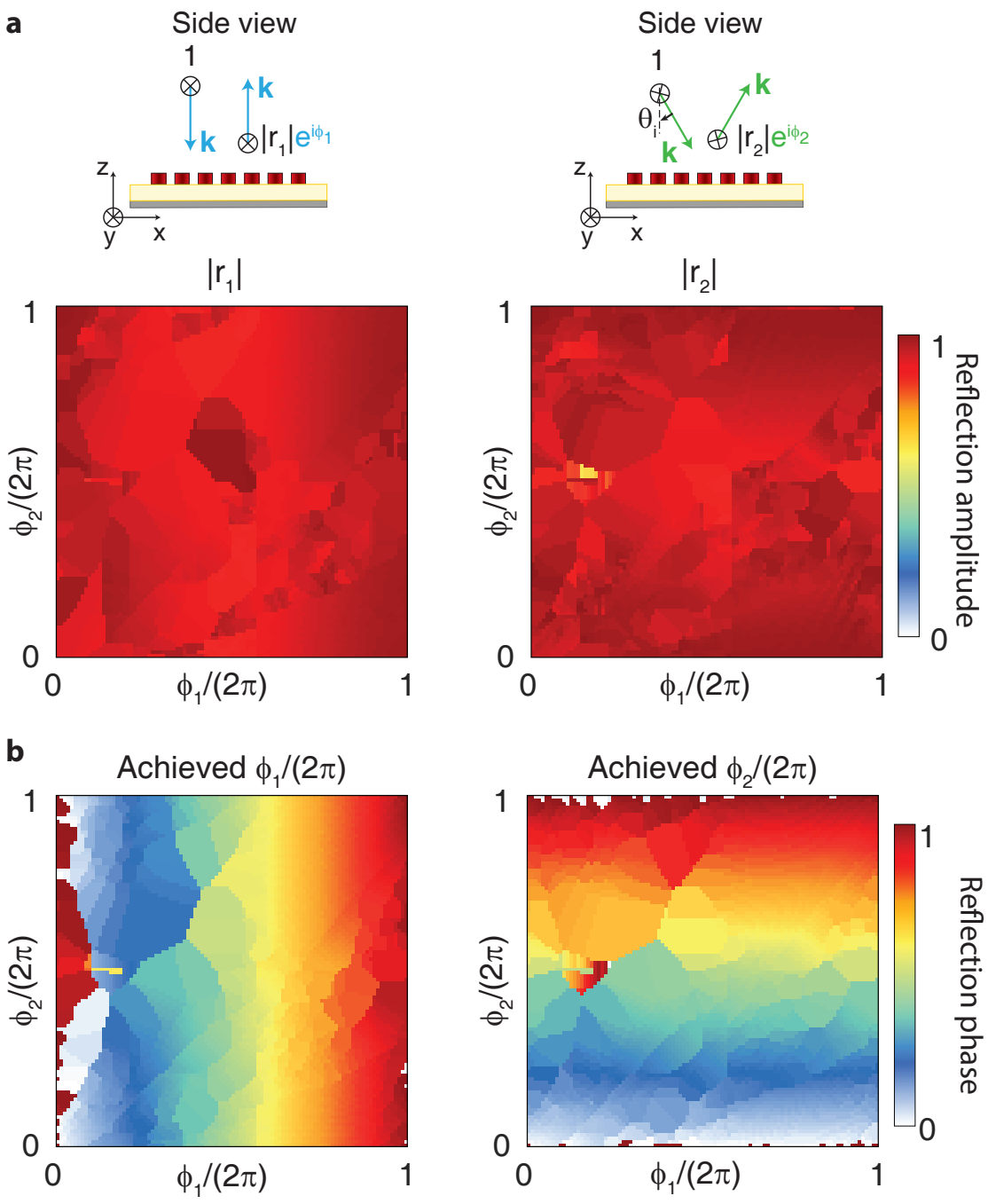
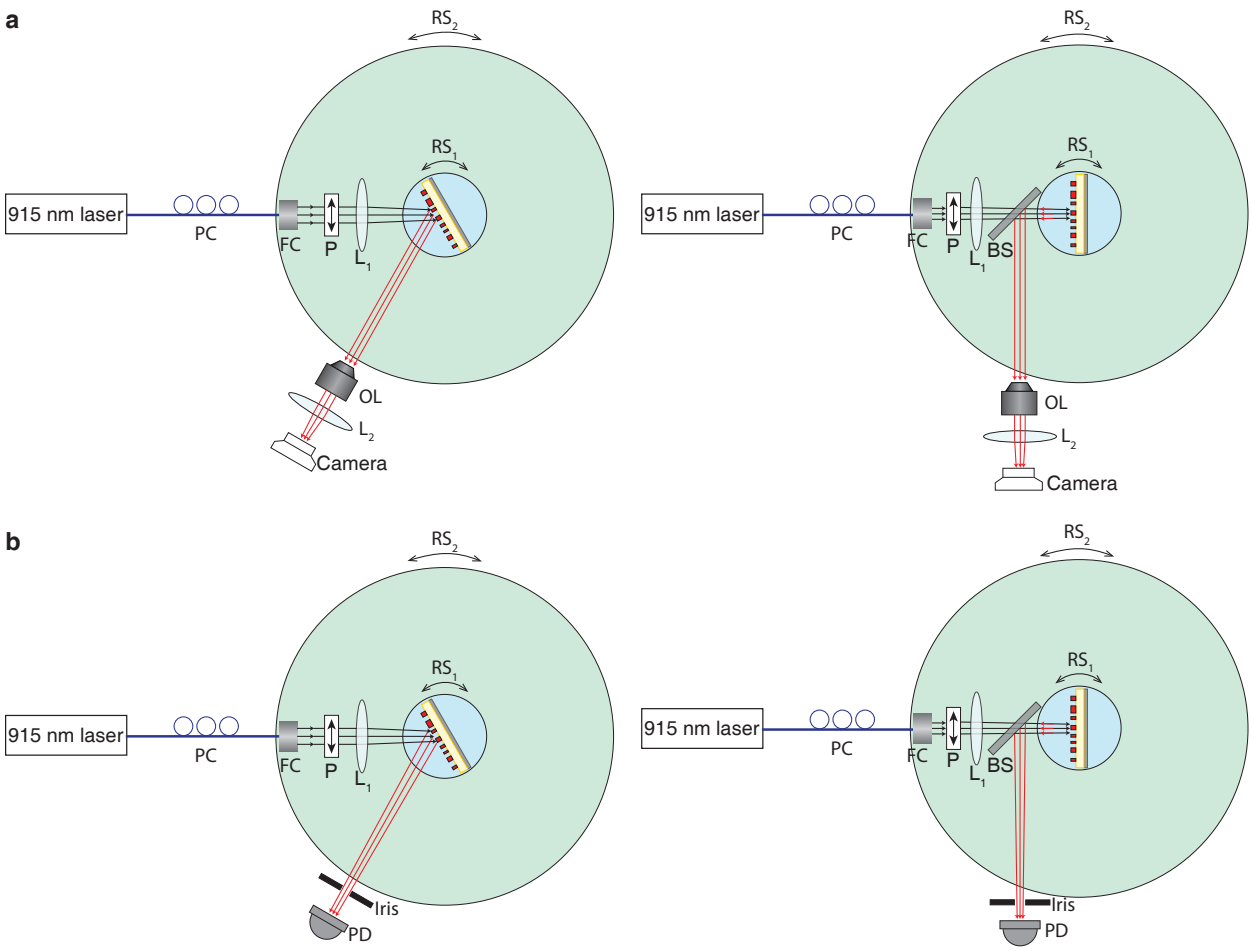
SUPPLEMENTARY NOTE 1: ANGLE-MULTIPLEXED GRATING SIMULATION RESULTS

The central $\sim$200-μm-long portion of the grating presented in the main text, was simulated for comparison. The simulated grating is 445 lattice constants long in the x direction and 1 lattice constant long in the y direction. Periodic boundary condition was considered in the y direction. The grating was simulated at the wavelength of 915 nm in MEEP [1] and normal and 30° incident y-polarized (TE) plane-waves were used as the excitation. Angular distribution of the reflected power at 0° and 30° incident angles are shown in supplementary Figs. 3a and 3b, respectively. The far field reflected power was analyzed by taking the Fourier transform of the reflected field above the meta-atoms. The deflection efficiency was calculated by dividing the deflected power to the desired order by the total input power. The simulated deflection efficiency for 0° and 30° incident angles were 63$\%$ and 54$\%$ respectively. Existence of no other strong diffraction order in supplementary Figs. 3a and 3b, and the high deflection efficiencies achieved demonstrate the independent control of the platform at each incident angle. To consider the possible fabrication errors, the grating with a random error added to all the in-plane sizes of the meta-atoms is also simulated. The error is normally distributed with a zero mean, a 4-nm standard deviation, and a forced maximum of 8 nm. Angular distribution of the reflected power at 0° and 30° incident angles for the grating with a random error are shown in supplementary Figs. 3c and 3d, respectively. The simulated deflection efficiencies with the added errors are 46$\%$ and 39$\%$ under 0° and 30° incident angles. Although the deflection efficiency of the grating drops by adding a random random, its general functionality remains the same according to the supplementary Figs. 3c and 3d.

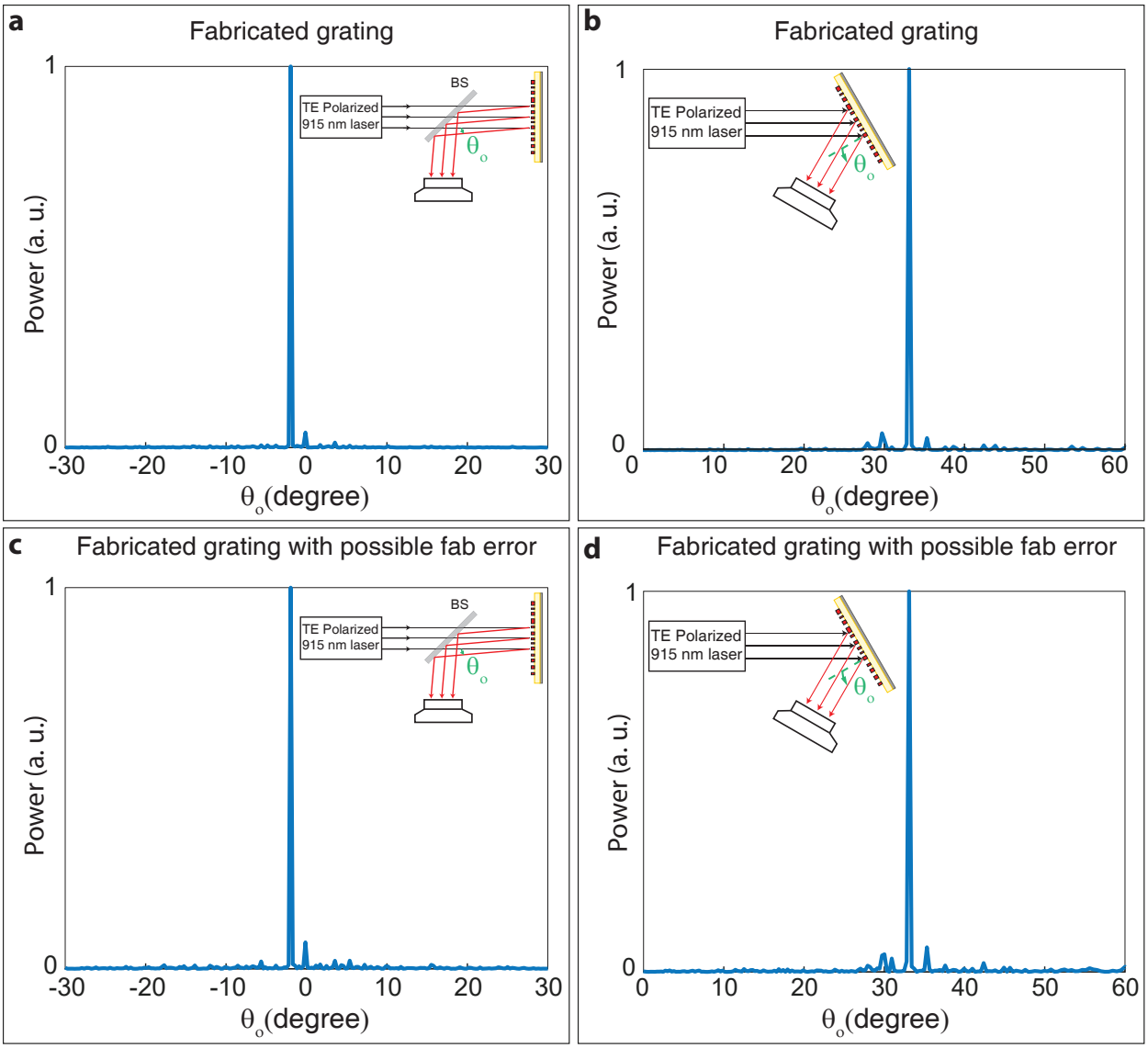
SUPPLEMENTARY FIGURES



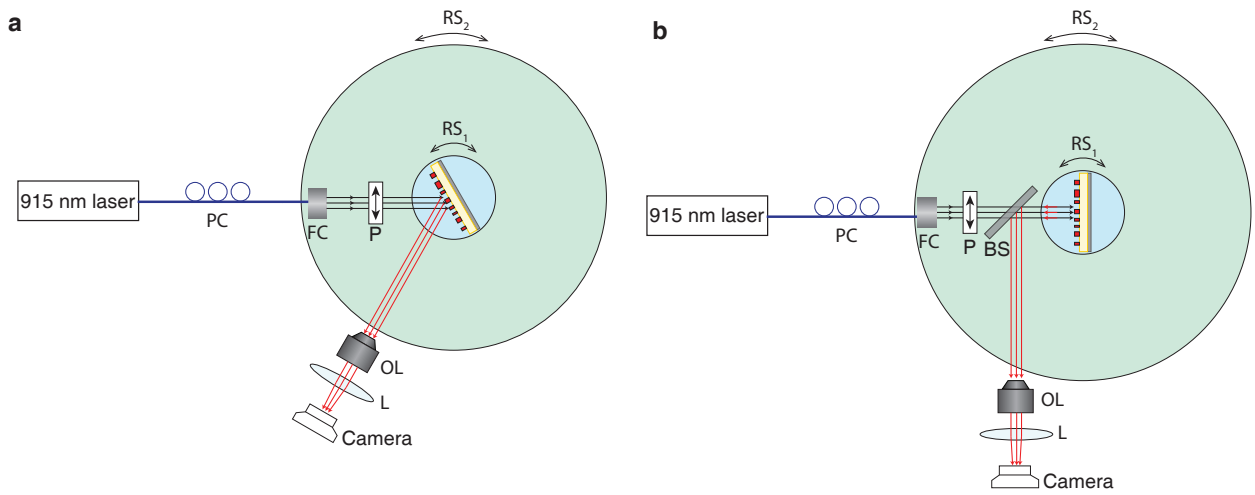
Supplementary Fig. 1. **Simulated achieved reflection amplitudes and phases for the selected meta-atoms.** **a**, Simulated reflection amplitudes at 0° and 30° incident angles as a function of required phase shifts for the periodic array of selected meta-atoms that can span the full 2π by 2π phases for both incident angles. **b**, Simulated achieved phase shifts of the chosen nano-posts versus the required phase shift values.



Supplementary Fig. 2. **Measurement setup used to characterize the grating.** **a**, Schematic drawing of the measurement setup used for characterization of the grating under oblique (left) and normal (right) illumination angles. **b**, Schematic illustration of the measurement setup used for characterization of deflection efficiency for oblique (left) and normal (right) illuminations. BS: beam splitter, L: lens, PC: polarization controller, FC: fiber collimator, P: polarizer, PD: photodetector. RS: rotation stage. OL: objective lens. The focal lengths of lenses L_1 and L_2 are $f_1 = 10$ cm and $f_2 = 20$ cm, respectively.



Supplementary Fig. 3. **Simulation results of the angle-multiplexed grating.** **a** and **b**, Distribution of reflected power versus observation angle under 0° (a) and 30° (b) incident angles for a ∼200-μm-long portion of the fabricated grating. **c** and **d**, The same graphs as (a) and (b), but with a random error added to the all in-plane sizes of the meta-atoms. The error is normally distributed with a zero mean, a 4-nm standard deviation, and a forced maximum of 8 nm.



Supplementary Fig. 4. **Measurement setup used for the hologram.** **a** and **b**, Schematic drawing of the measurement setup used for characterization of the hologram under oblique (a) and normal (b) illumination angles. BS: beam splitter, L: lens, PC: polarization controller, FC: fiber collimator, P: polarizer, PD: photodetector. RS: rotation stage. OL: objective lens. The focal length of lens L is $f_1 = 6\ \mathrm{cm}$.

SUPPLEMENTARY REFERENCES

[1] Oskooi, A. F. *et al.* MEEP: A flexible free-software package for electromagnetic simulations by the FDTD method. *Comput. Phys. Commun.* **181**, 687–702 (2010).