Supplementary Information for

Influence of order to disorder transitions on the optical properties of aluminum plasmonic metasurface

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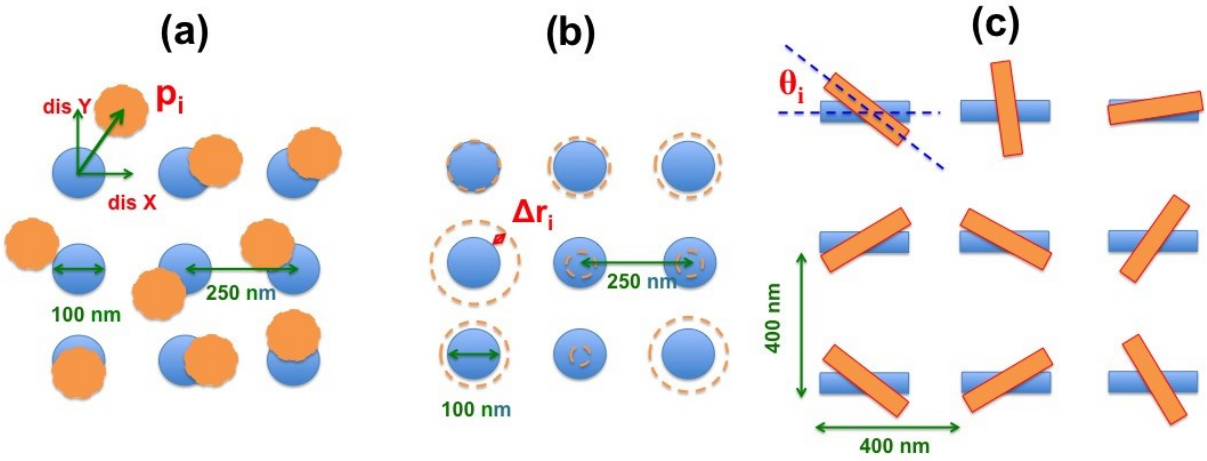

Fig. S1. Schematics to introduce the randomness in a periodic array in term of (a) displacement, (b) size, and (c) rotation of nanostructures.

The schematic about the random generation based on a periodic array can be found in Fig. S1. Disordered patterns were generated by adding a random number to the basic parameter (movement both on x and y direction for displacement disorder (Fig. S1a), radius change on each nanodisk for size disorder (Fig. S1b), and rotating angle along the long axis of each nanorod for rotation disorder (Fig. S1c)) in the periodic array. The coordinates were obtained by the script of *Matlab* software and then inputted into the EBL system to generate designed patterns for experimental fabrications.

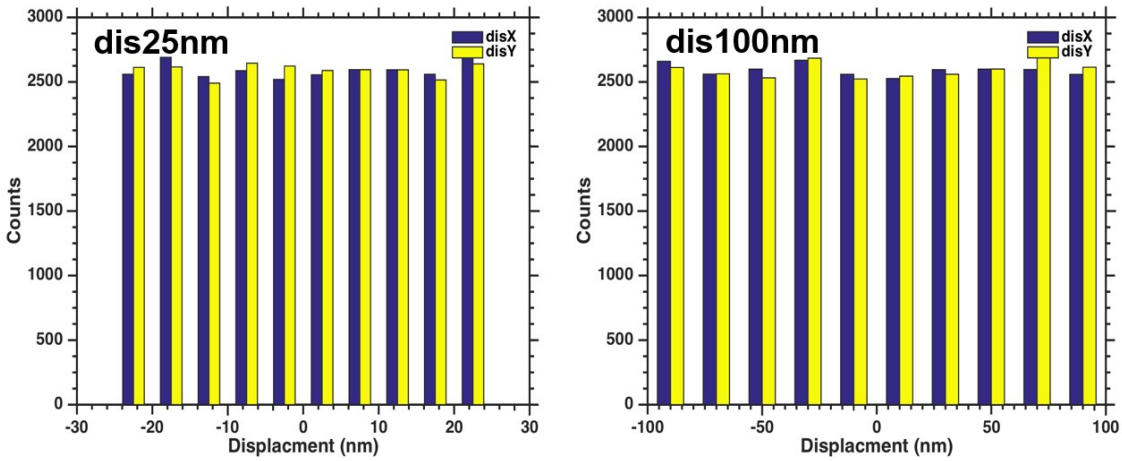

Fig. S2. Exampled statistical distribution of uniform random numbers used for x and y displacement (disX and disY, as shown in Fig. S1a) for 25 nm (dis25nm) and 100 nm (dis100nm) of maximum displacement of nanodisks in experiment (base pitch 250 nm).

Table S1. The calculated mean-square-error (MSE) value on the parameter variation (shown in Fig. S1) both in experiment and simulation for (a) displacement disorder ($MSE = \sum_{i=1}^{i=N} (P_i)^2/N$), (b) size disorder ($MSE = \sum_{i=1}^{i=N} (\Delta r_i)^2/N$), and (c) rotation disorder ($MSE = \sum_{i=1}^{i=N} (\theta_i)^2/N$). N is the total number of NPs in the array.

(a)

MSE [$\times 10^3$ nm^2]	dis0nm	dis25nm	dis50nm	dis75nm	dis100nm
Experiment	0	0.42	1.67	3.76	6.70
Simulation	0	0.41	1.63	3.67	6.52

(b)

MSE [nm^2]	size0nm	size10nm	size20nm
Experiment	0	33.1	134.3
Simulation	0	32.3	134.1

(c)

MSE [square of radian]	R0	R30	R60	R90
Experiment	0	0.09	0.37	0.83
Simulation	0	0.09	0.35	0.86

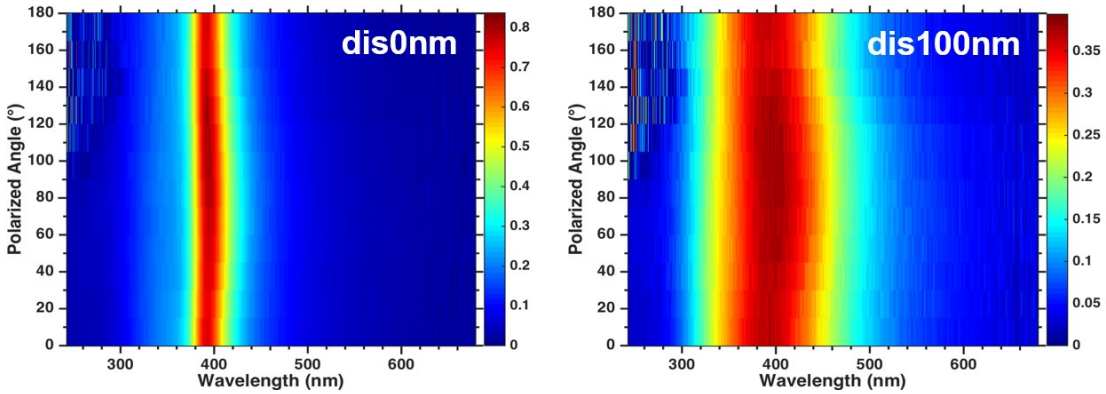

Fig. S3. The experimental polarization-dependent extinction spectra for dis0nm and dis100nm.

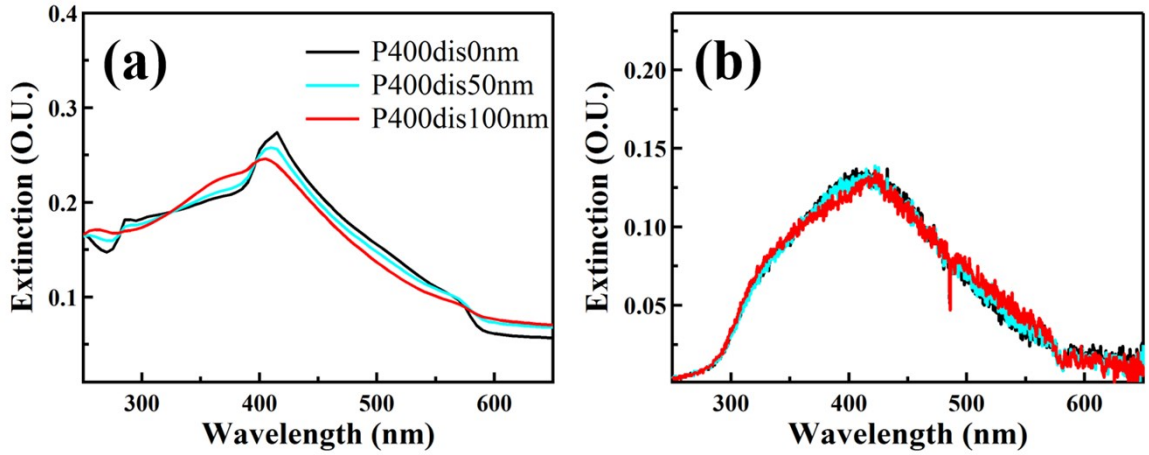

Fig. S4. Calculated (a) and experimental (b) extinction spectra for nanodisk arrays (100 nm diameter) with 400 nm base pitch (P) as a function of displacement disorder.

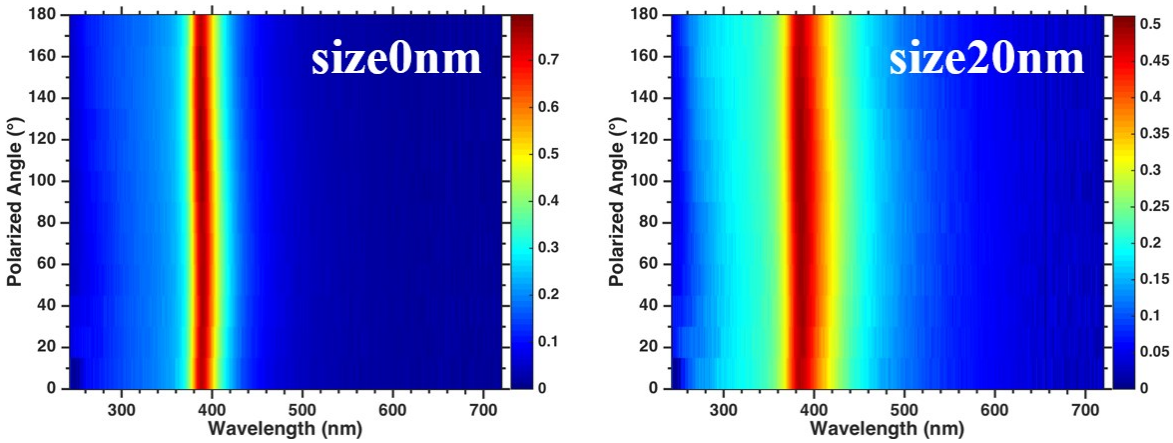

Fig. S5. The experimental polarization-dependent extinction spectra for size0nm and size20nm.

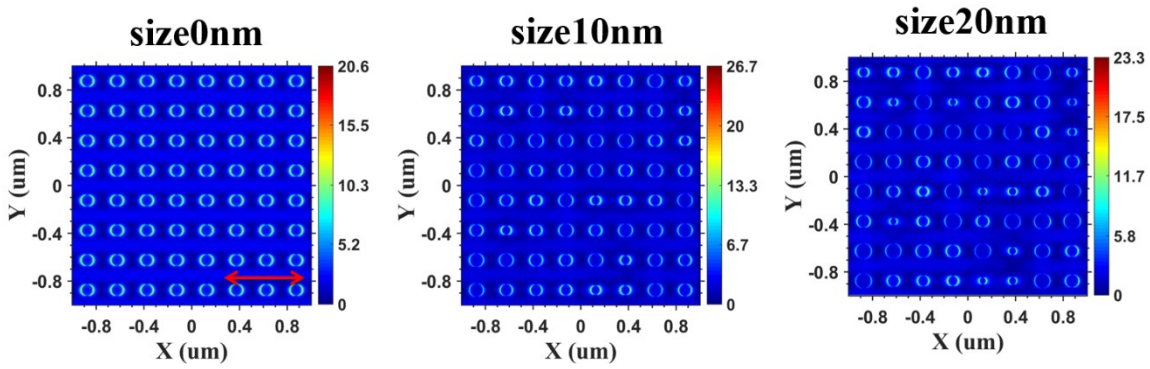

Fig. S6. Calculated electric field at 378 nm for nanodisk array with different size disorder. Polarization direction is along the x axis indicated by the red arrow.

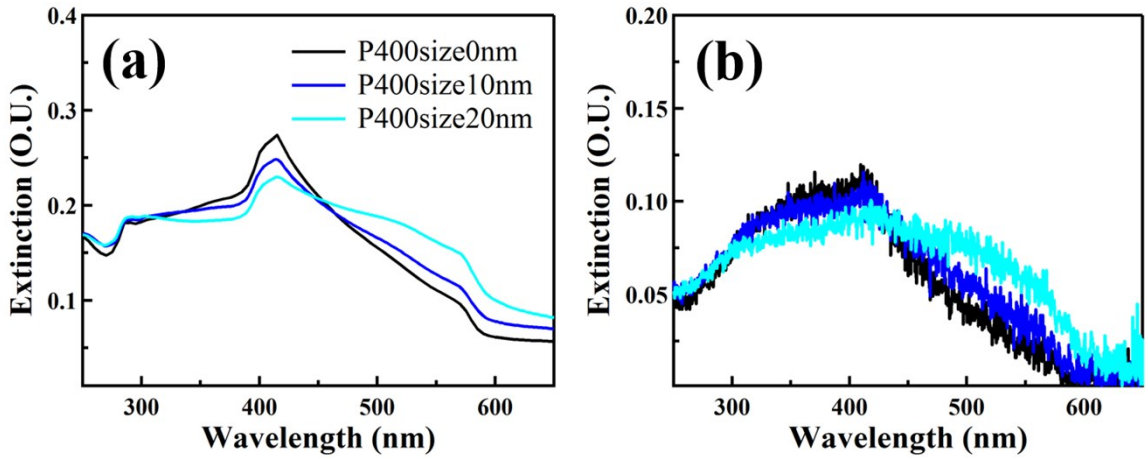

Fig. S7. Calculated (a) and experimental (b) extinction spectra for nanodisk arrays for pitch 400 nm as a function of size disorder.

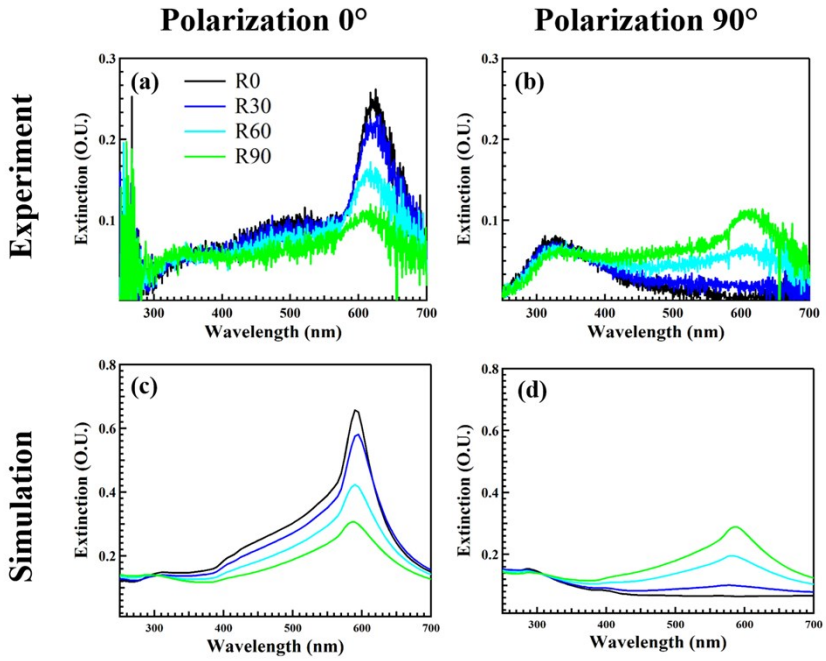

Fig. S8. Extinction spectra from both experiments (first row) and FDTD calculations (second row) of corresponding Al plasmonic metasurfaces with different rotation disorder (R0, R30, R60, and R90) at polarized angle 0° (left column) and 90° (right column).