Supporting Information for

Anti-ultrasonic-stripping effect in confined micro/nanoscale cavities and its applications for efficient multiscale metallic patterning

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Figure S1. **An array of 10,000 gold disks with 500 nm diameter.**

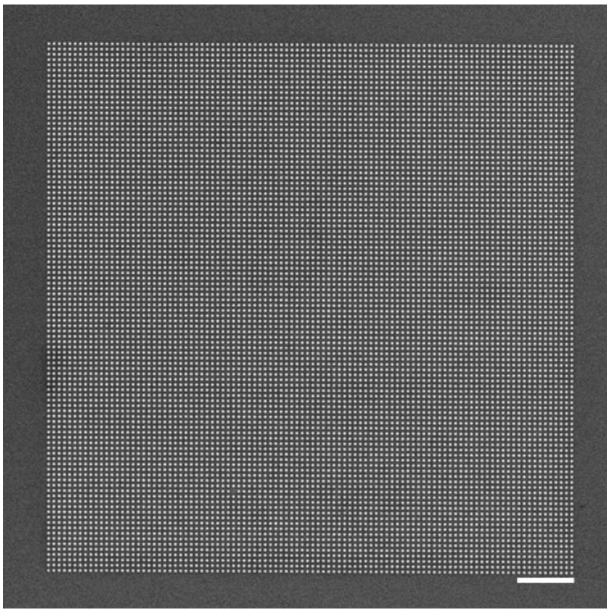

Figure S1. The SEM image of an array of 10,000 gold disks with 500-nm diameter and 1-µm pitch, indicating the 100% yield of the fabrication process based on AUS effect. Scale bar: 10 µm.

Figure S2. More representative metallic structures fabricated by ultrasonic stripping based on AUS effect.

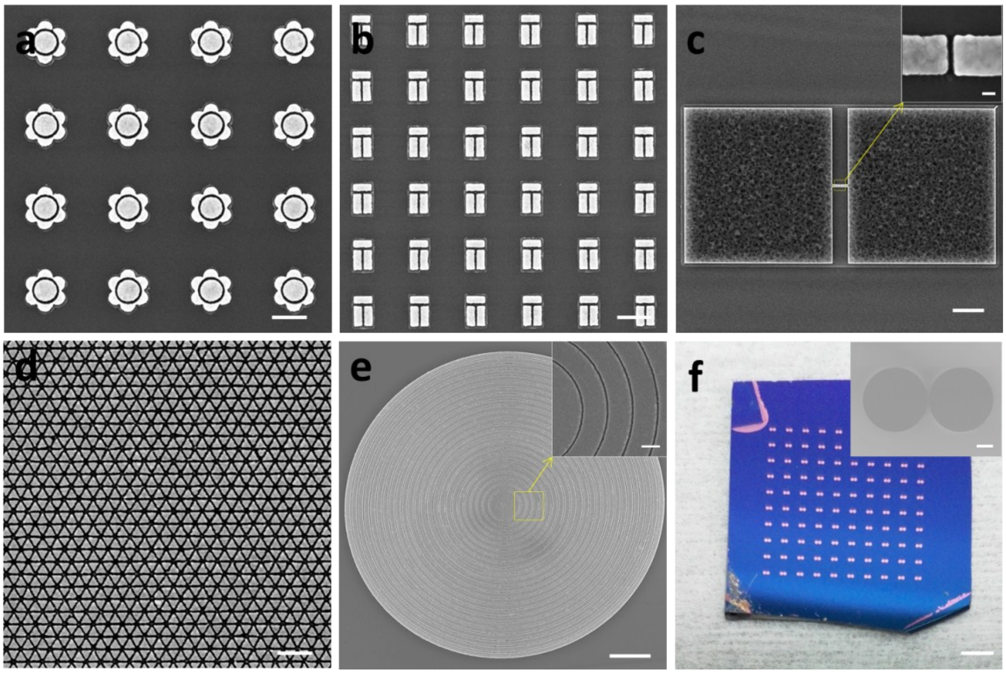

Figure S2. SEM images of more representative periodic gold structures fabricated by ultrasonic stripping based on AUS effect. (a) Flower-like structures array with a pitch of 1 μm, in which gold disk with 250 nm diameter was designed in the center. (b) Rectangle trimer array with a pitch of 1 μm, in which the length and width of each gold rectangle was 150 nm and 50 nm, respectively. (c) Electrode pair with ~20 nm gap size. (d) Densely-packed gold triangles with identical gap of ~20 nm and uniform edge length of ~150 nm. (e) A zone plate with maximum diameter of 20 μm, and all gaps inside were ~20 nm. (f) An array of 100-μm dimer with ~25 nm gap. Scale bars: (a-b) 500 nm; (c) 1 μm; (d) 500 nm; (e) 2 μm; (f) 1 mm. Scale bars of insets: (c) 50 nm; (e) 100 nm; (f) 25 μm.

Figure S3. Gold disk arrays with different sizes defined by the AUS-effect-based EBDW process.

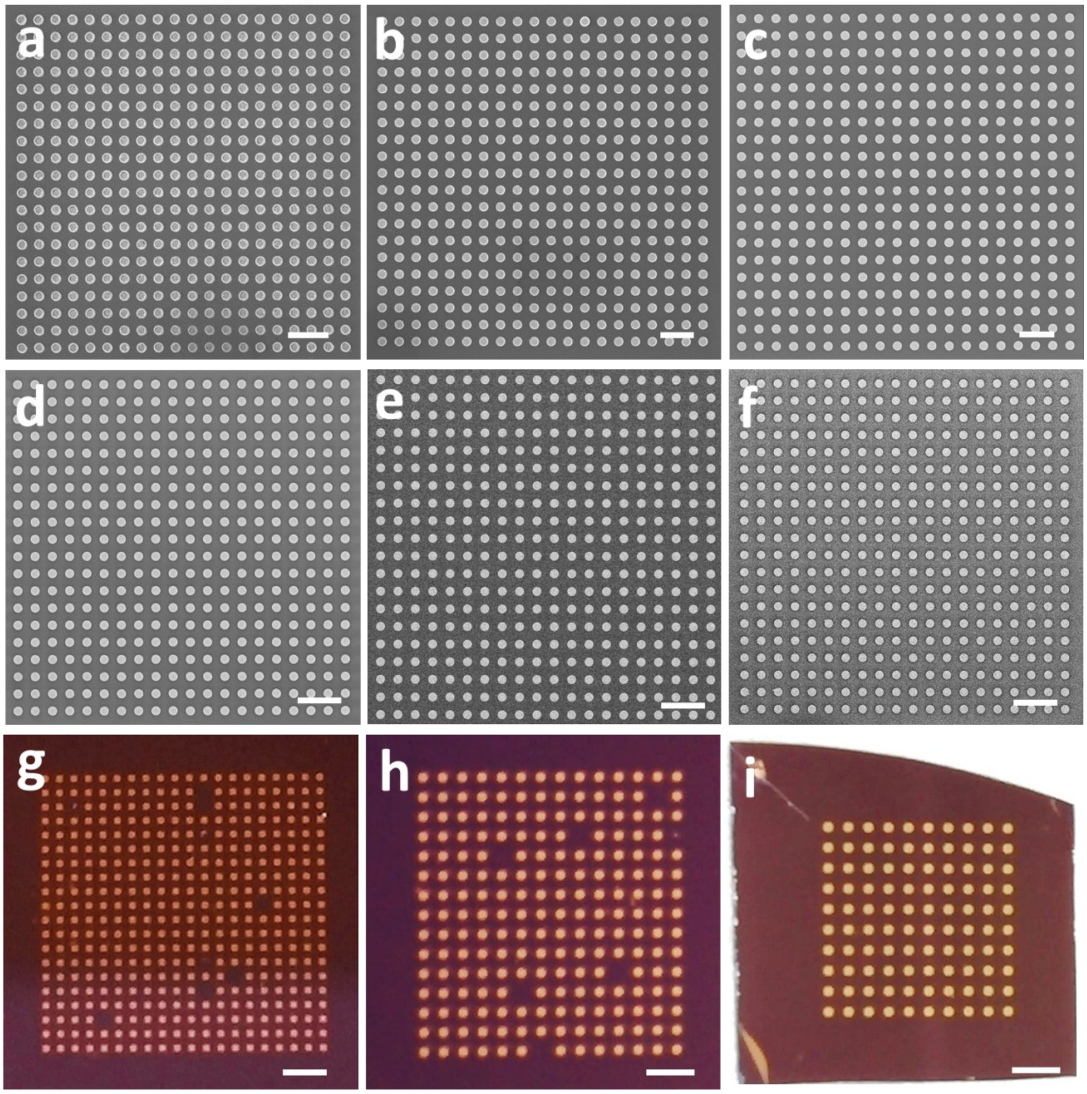

Figure S3. The SEM images and photographs of periodic gold disks with different sizes from 100 nm to 500 μm. Due to the patterning areas of the 100-μm, 200-μm and 500-μm samples were larger than the maximum scanning field in SEM, their photographs were taken by digital camera of a smartphone. Scale bar: (a) 500 nm; (b) 1 μm; (c) 2 μm; (d) 5 μm; (e) 50 μm; (f) 250 μm; (g) 500 μm; (h) 1000 μm; (i) 1500 μm.

Figure S4. Gold disk with 50-µm diameter removed by ultrasonic stripping when the HSQ ring was unclosed.

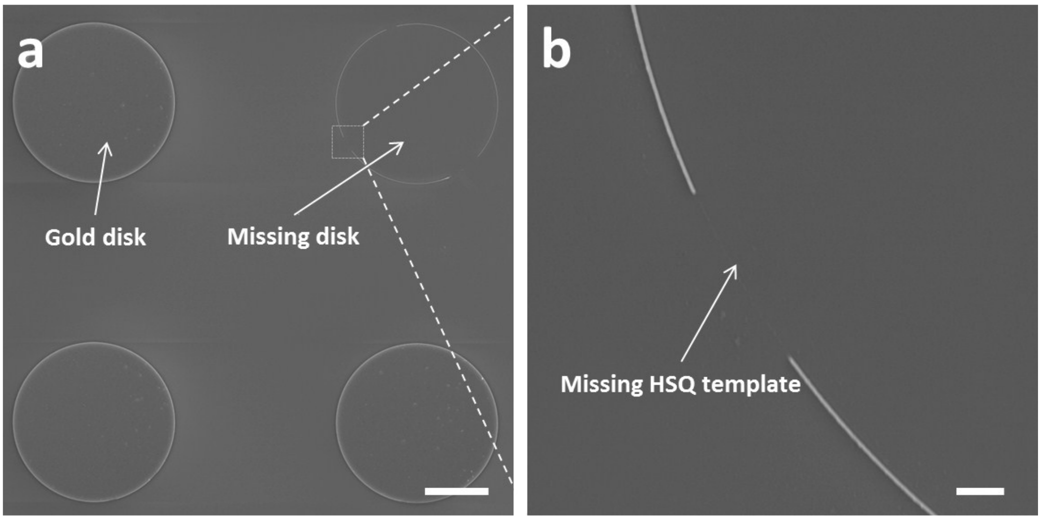

Figure S4. The SEM images of gold disk with 50-µm diameter removed by AUS process when the HSQ ring was unclosed. (a) The gold disk with unclosed HSQ ring was removed by AUS process while the other three with closed HSQ ring were preserved; (b) the unclosed area of HSQ ring in (a) was enlarged, which result from the dirty particle exactly right on the exposure area of HSQ ring. Scale bars: (a) 20 µm, (b) 2 µm.

Figure S5. The reliability of AUS-effect-based process as a function of opening angle of the outline.

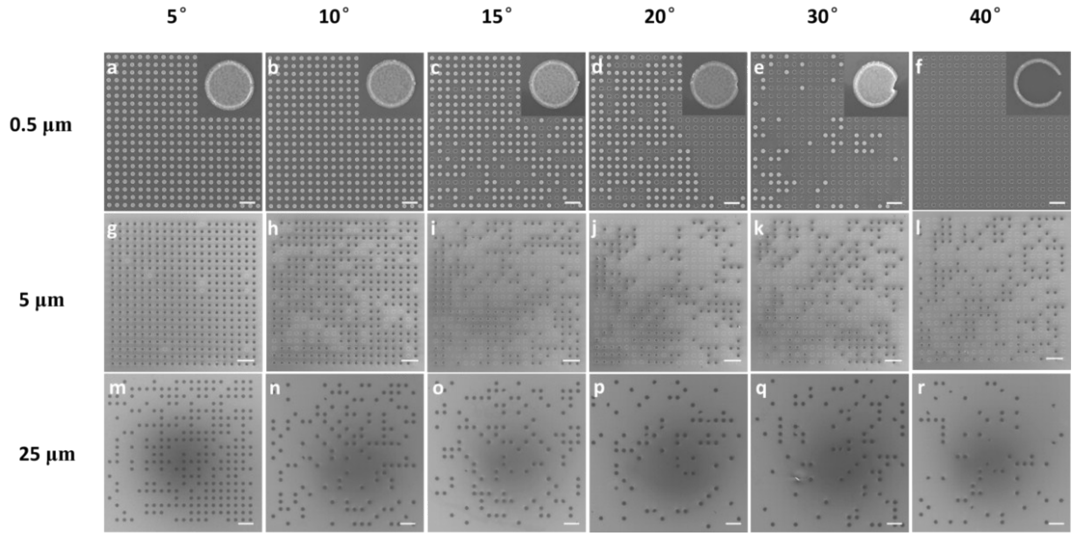

Figure S5. SEM images of three different diameter gold disk arrays with different opening angle on the HSQ outlines. (a-f) The opening angle of 0.5-μm HSQ ring is: (a) 5°; (b) 10°; (c) 15°; (d) 20°; (e) 30°; (f) 40°. The scale bar: 2 μm. (g-i) The opening angle of 5-μm HSQ ring is the same as the parameter mentioned in panel (a-f). The scale bar: 20 μm. (m-r) The opening angle of 25-μm HSQ ring is the same as the set value in (a-f). The scale bar: 100 μm.

Figure S6. The reliability of AUS-effect-based process as a function of the inter-disk spacing size.

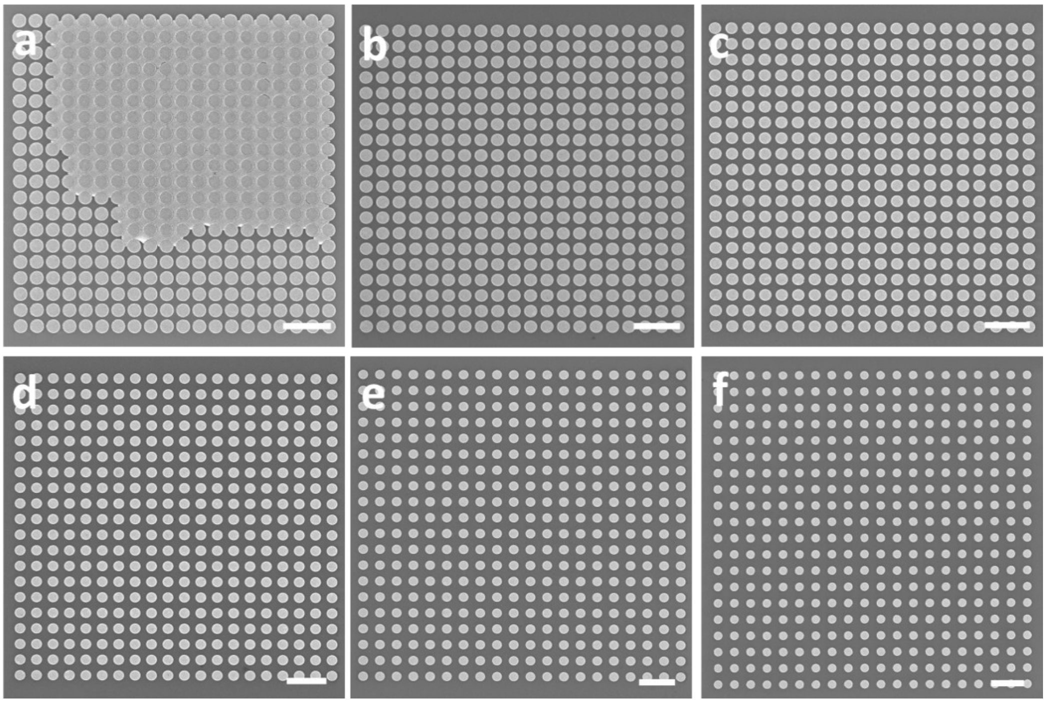

Figure S6. SEM images of 500-nm gold disks with varied inter-disk spacing size. (a-f) The serial images directly show the change of yield as a function of the spacing size in array. 100 nm (a); 150 nm (b); 200 nm (c); 300 nm (d); 400 nm (e); 500 nm (f). Scale bar: 2 μm.

Figure S7. AUS-effect-based EBDW process on PMMA resist.

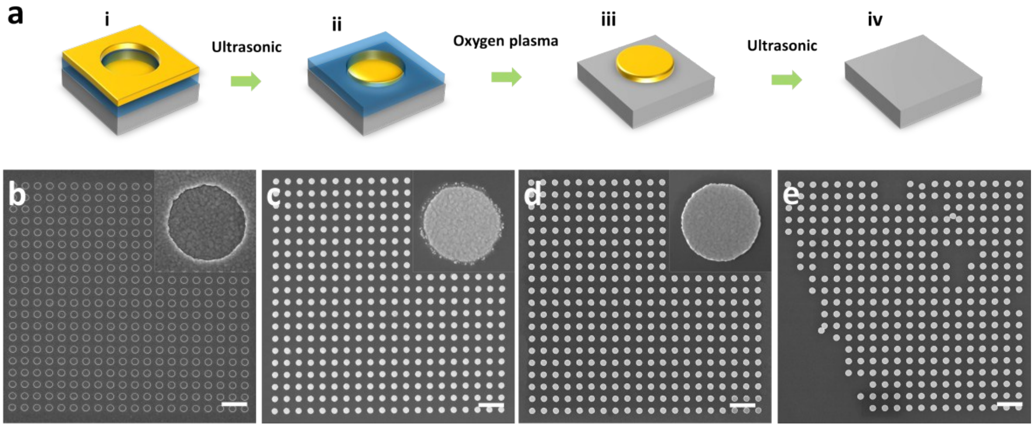

Figure S7. AUS-effect-based EBDW process on PMMA resist. (a) The schematic of gold disk fabricated by AUS-effect-based EBDW process with PMMA resist followed oxygen plasma and ultrasonic. (b-e) The four SEM images successively present the corresponding result of gold-coated 500-nm hole templates, gold disk array after ultrasonic, pure gold disk array after oxygen, gold disk array with some missing structures after the second ultrasonic with only 2 minutes.

Table S1. The statistic result of an opening part affecting the yield of AUS-

effect-based process.

Diameter of HSQ template (μm)	Missing length (nm) / Yield (%)					
0.5	22 / 100	44 / 100	65 / 68	87 / 26	131 / 17.5	174 / 0
5	220 / 96.25	440 / 65.5	650 / 48.25	870 / 40	1310 / 31.25	1740 / 26.25
25	1090 / 57	2180 / 30.75	3271 / 27.5	4361 / 14.25	6542 / 12.25	8722 / 10