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Electronic Supplementary Information for:

Merging individual metal nanostructures into a superstructure for plasmon mode hybridization and electric-field nanofocusing

Zhihao Zhao[a,b,†] , Guoheng Xu[a,b,c,†], Jiaming Zhang[a,c,†], Yongliang Zhang[d], Jie Liu[a,c], Shuangbao Lyu[a,b,c], Hongwei Cheng[a,c], Dangyuan Lei[e,*], Jinglai Duan[a,c,f,*]

[a] *Materials Research Center, Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou 730000, China.*

[b] *School of Physical Science and Technology, Lanzhou University, Lanzhou 730000, China.*

[c] *School of Nuclear Science and Technology, University of Chinese Academy of Sciences, Beijing 100049, China.*

[d] *Department of Applied Physics, The Hong Kong Polytechnic University, Hong Kong, China.*

[e] *Department of Materials Science and Engineering, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong, China.*

[f] *Huizhou Research Center of Ion Sciences, Huizhou 516000, Guangdong, China.*

† *These authors contributed equally.*

* *Corresponding authors.*

Email: j.duan@impcas.ac.cn (JD) ; dangylei@cityu.edu.hk (DL)

Supplementary Note 1: Mesh grid for the nanocone tip

In our COMSOL Multiphysics simulations, a self-adaptive meshing scheme was applied to keep simulation requirements within our computational resource while providing reliable accuracy. As an example, the mesh at the tip of the nanocone is fine enough as shown in Figure S1.

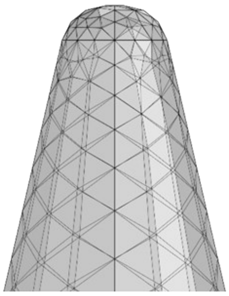
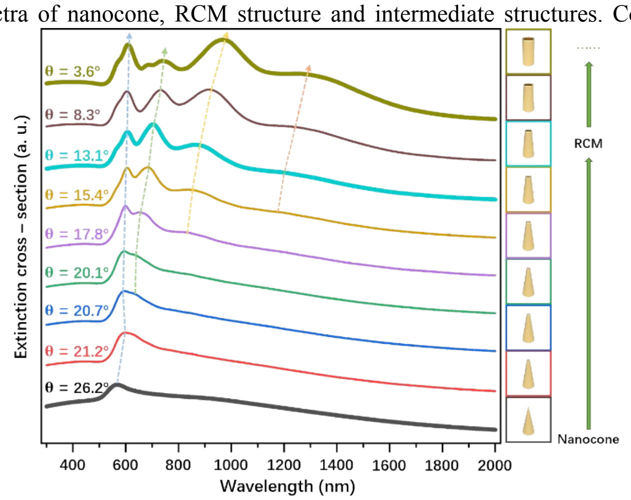


Figure S1. Mesh at tip region used in a nanocone simulation with FEA method.

Supplementary Note 2: Extinction spectra of nanocone, RCM structure, and intermediate structures

It is found that, as the cone angle decreases, several new resonant peaks emerge gradually due to the changes of the coupling, indicating the excitation of new plasmon modes in the RCM superstructure. The emergences and spectral evolutions of these resonances are highlighted with the dashed lines. Hence one can breezily understand the inheritance and merging interpretation by following the dashed lines in the spectra and contrasting modes of elementary structures, i.e. nanocone and nanoring presented in Figure 2. To be specific, the orange line indicates the symmetric mode ω_- of nanoring and its red-shift characteristic due to increased diameter of the top opening. Emergence of new peaks in the process of structure evolution proves that the RCM structure could bring forward plasmon mode hybridization via modes inheritance and evolution of nanocone and nanoring.

Figure S2. Extinction spectra of nanocone, RCM structure and intermediate structures. Cone angle θ is varied



gradually from 26.2° to 3.6°, exhibiting the structural evolution from a sharp nanocone to a hollow cone structure with a smaller cone angle (θ=3.6°) via the RCM structure presented in Figure 2. Four dashed lines with arrows coloured by baby blue, grass green, light yellow, and orange, mark the positions and evolution directions of the peaks.

Supplementary Note 3: TEM examination of the uniformity of wall thickness

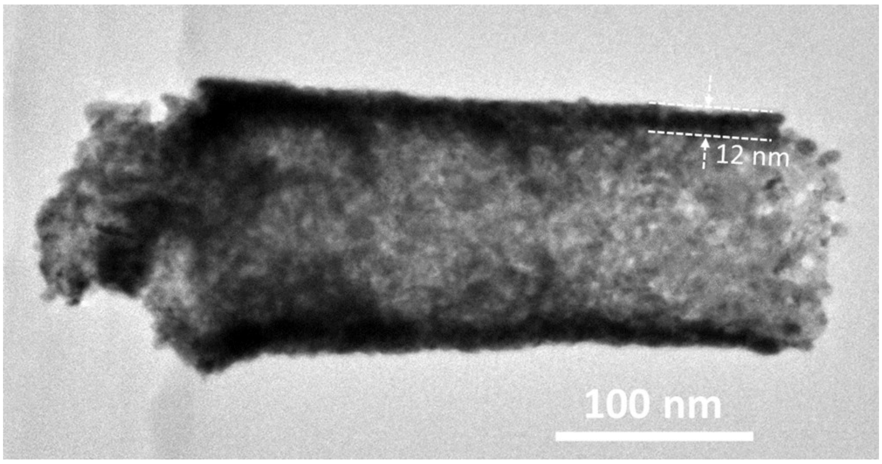


Figure S3. TEM image of a conical hollow structure with smaller cone angle (5.2°) and thinner thickness (12 nm).

Supplementary Note 4: Hollow cylinders created by sputter coating of gold on a template containing cylindrical pores

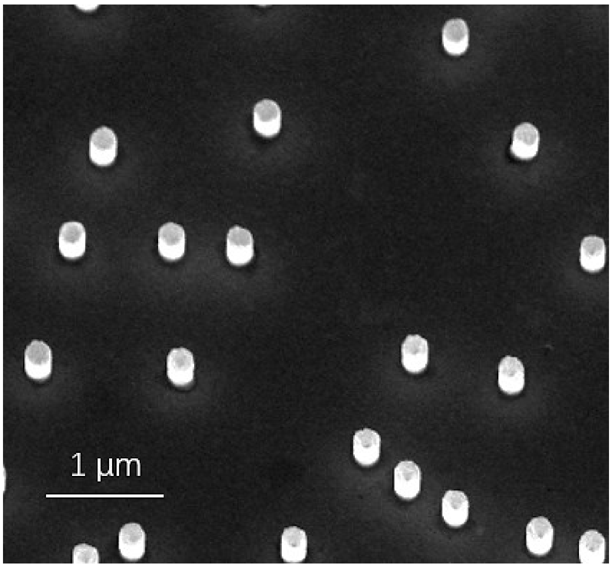


Figure S4. SEM image of vertically aligned gold hollow cylinders obtained recently.

Supplementary Note 5: Additional simulations of size tuned RCM superstructures

In our present work, the inherited electric-field distribution profiles at wavelength of 705 nm (module of electric near-field intensity, normalized) and extinction spectra of fabricated samples have also been simulated. Taking Figure 2c6 as a comparison, Figure S5 illustrates that fabricated samples obtained with different etching time possess the similar electric-field distribution. One can reasonably conjecture according to the electrodynamics nature emphasized here that, as long as the main geometric feature (i.e. nanoring-nanocone merged superstructure) of RCM remain, the electric-field distribution profiles stay alike. Figure S6 proves exactly the same fact from a point of view of the extinction spectra. The calculated extinction cross-sections of different samples exhibit that all samples have the same optical extinction peculiarity like Figure 1 has clarified.

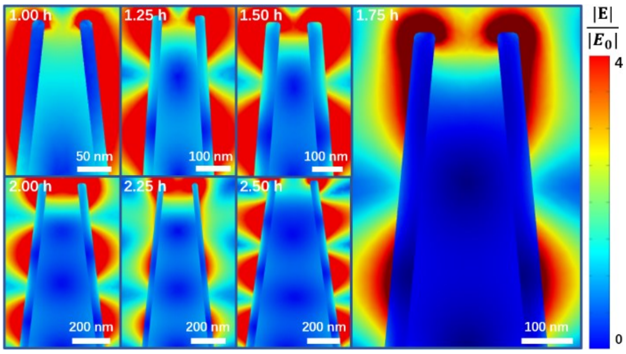


Figure S5. Electrodynamics simulations. The fabricated samples which have different etching time hold the similar inherited electric-field distribution profiles as the model demonstration addressed in Figure 2.

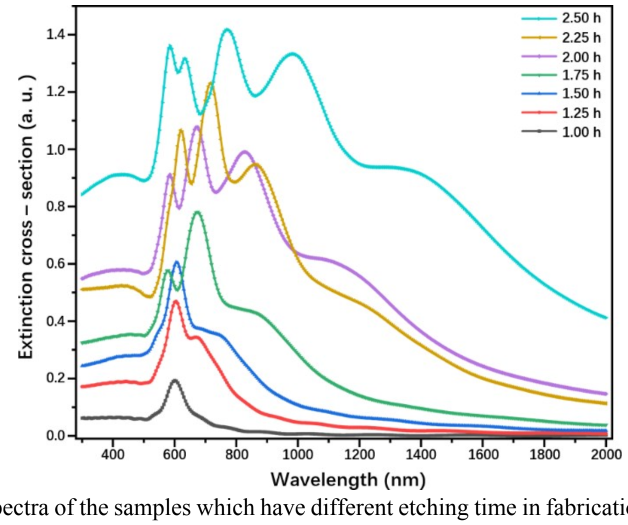


Figure S6. Extinction spectra of the samples which have different etching time in fabrication procedures. Additional plasmon modes and broadband response could be realized especially when size of RCM is relatively large, suggesting potential optical applications, e.g. nonlinear optics, hot-carrier studies, SERS and light harvesting.