Supporting Information to

High temperature stable plasmonic and cavity resonances in metal nanoparticle decorated silicon nanopillars for strong broadband absorption in photothermal applications

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Section 1 *SEM characterizations of Au/Si NPs*

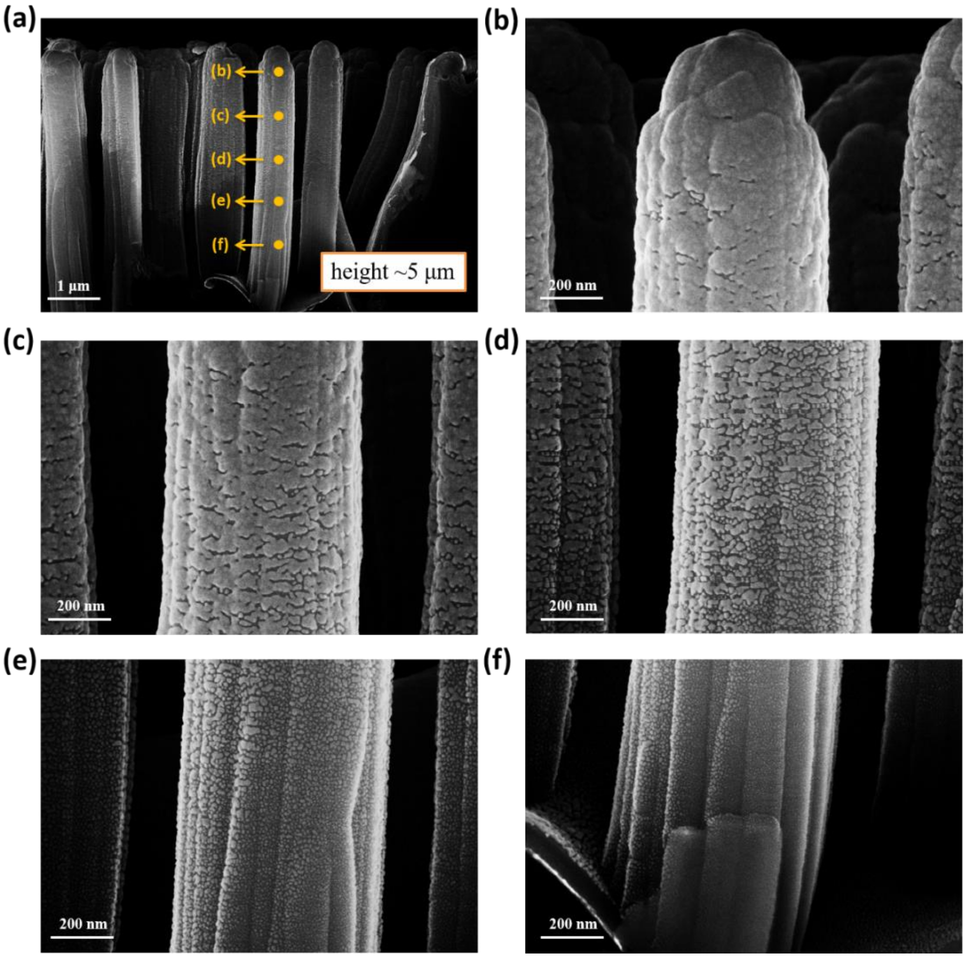

Fig. S1 (a) Side-view SEM characterizations of the Au nanoparticles (a nominal Au thickness of ~50 nm) sputtered on the sidewalls of Si nanopillars (NPs) with a height of 5 μm, while (b-f) show more details of the Au particles found on different places from top to bottom, with labels indicating roughly their corresponding positions in (a).

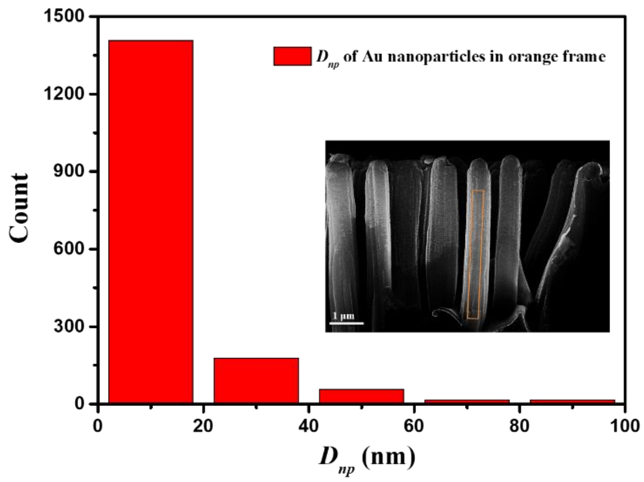

Fig. S2 Statistics of Au nanoparticle size distribution in the region marked by an orange rectangle in the SEM image on the sidewalls of a Si NP of 5 μm height.

Section 2 *FDTD simulation of Au/Si NP structure*

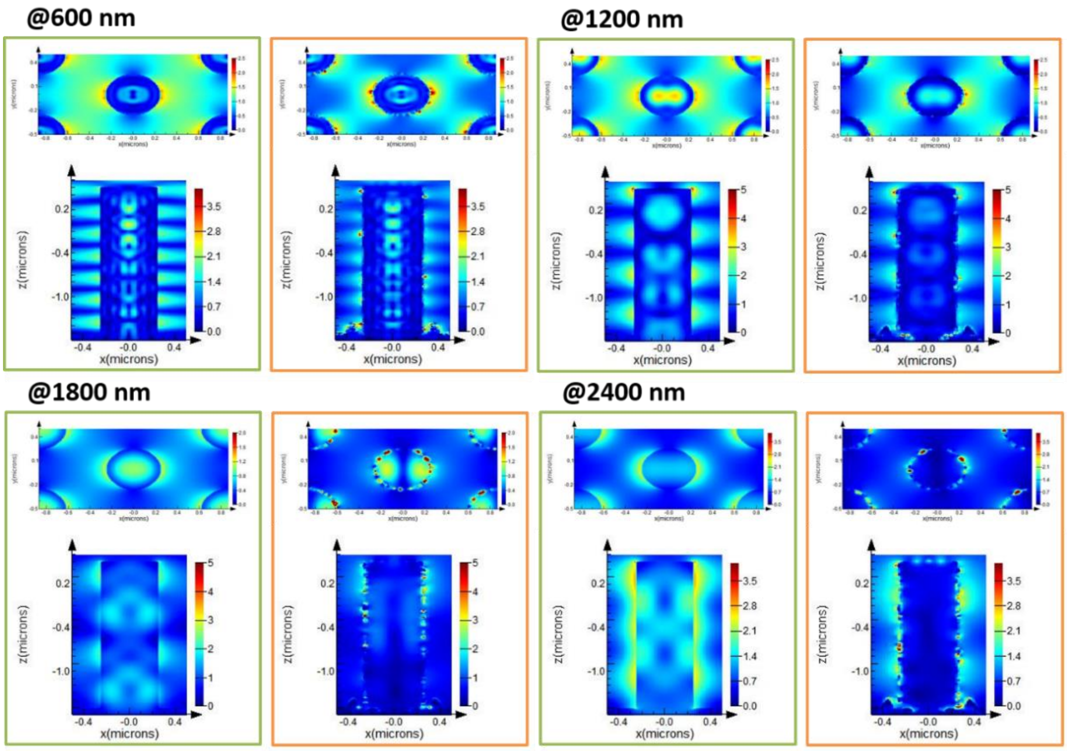

Fig. S3 Electric field distributions of 2D XY/XZ cross section at 600 nm, 1200 nm, 1800 nm and 2400 nm, respectively. Green frame: Si NP, Orange frame: Au/Si NP.

Also, to distinguish the absorption in nanopillar and underlying wafer, we performed the FDTD simulation containing different positions of transmission monitor. The light absorption realized only in the Au-coated Si NPs, or with the wafer together, are calculated from 200 nm to 2500 nm and shown in Fig. S4. It is shown that the top Au/Si NPs structure can absorb most of the incident light, >93%.

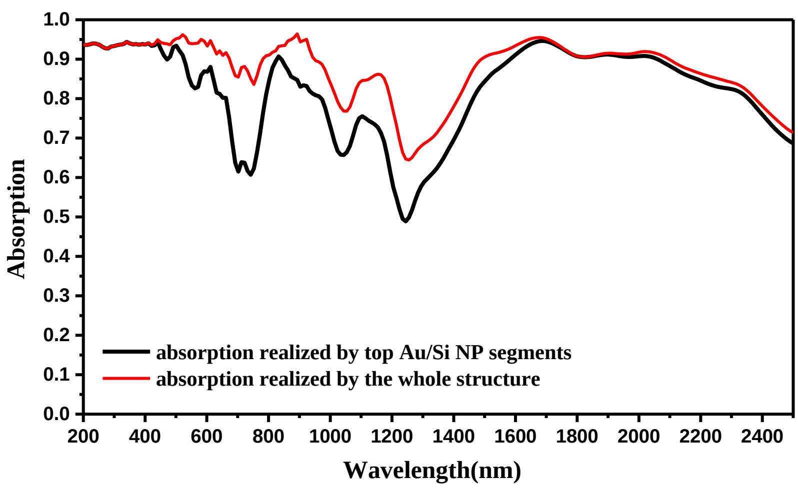

Fig. S4 The simulated absorption spectrum with different position of transmission (T) monitor. Black line: T monitor is at the bottom of nanopillar (z-axis is -2 μm). Red line: T monitor is inside the wafer (z-axis is -10 μm).

Section 3 *SEM characterizations of Cu/Si NPs*

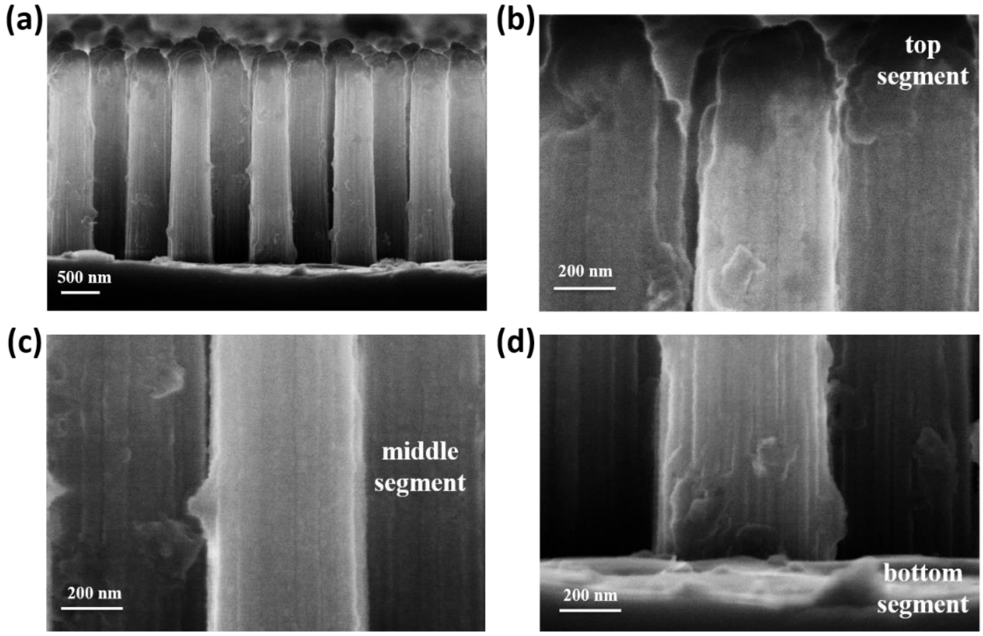

Fig. S5 (a) and (b) The top and bottom SEM characterizations of Cu/Si NPs coated with Al_2O_3 after annealing, respectively.

Section 4 *Calculations of thermal evaporation system*

It takes about 2382 J heat to evaporate one-gram water, containing 126 J of heating water (assuming to 50 °C) and 2256 J of gasification latent heat. Although the electro-thermal efficiency can be up to 95%, the electrical energy consumption is 2507 J. Correspondingly, the consumed energy in our circulation comes mainly from the pump that carry the water to a certain height (set as 1 m) for the rapid thermal evaporation cycle. The efficiency from electrical energy to potential energy of centrifugal pump (ACm37) is about 38.4%. So the energy needed to evaporate 1g water can transport ~100kg water to thermal evaporation circulation.

The formula is shown below.

(1)

$Q_{absorb}=C*m*(T_2-T_1)$

Q_{absorb} means the heating energy absorbed; C means specific heat capacity of liquid; m means quality of liquid; T_1 means initial temperature; T_2 means final temperature.

$Q_{total}=Q_{absorb}+Q_{liquid\ to\ gas}$

$Q_{liquid\ to\ gas}$ means the gasification latent heat.

(2)

$P_e=\rho*g*Q*H$

P_e means effective power of pump; ρ means density of liquid; g means acceleration of gravity; Q means quantity of flow; H means lift of pump.

$\eta_{pump}=P_e/P_s*\eta_m$

P_s means shaft power of pump. η_m means efficiency from motor to shaft.

When salt water (concentration of 0.5%) drops are drippled to the surface, as seen in the snapshots in Fig. 6c, the water drops were quickly splashed on the heated surface and bounced off, and during this course roughly a portion of the water drop (estimated to be ~25%) will be evaporated in a single touch, meanwhile the high temperature can be quickly recovered after 5~6 seconds. After that, the vapor generation rate is calculated as ~42.3 mg/min. To calculated the photothermal conversion efficiency, we use the following formula:

$$\eta=m*h_{LV}/P$$

where m means rate of mass change, h_{LV} means gasification latent heat and P means energy density of light radiation. And a photothermal conversion efficiency about 80% can be achieved in this no salt circulative evaporation way.