

Electronic Supplementary Material (ESI) for Chemical Communications.

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Electronic Supporting Information

Laser activating gold catalyst for liquid-phase growth of cadmium selenide nanowires

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Experimental Section

Reagents: cadmium oxide (CdO,99%), selenium powder (Se,99%), oleic acid (OA,90%) and tri-n-octylphosphine (TOP, 97%) were purchased from Aladdin.

Preparation of Au catalyst: Silicon substrates with (100) exposed surface and an area of 1.5×1.5 cm² were ultrasonically cleaned in ethanol and deionized water, subsequently. Au thin film was deposited on the silicon substrates by magnetron sputtering with a sputtering current of 20 mA for 75 s. Then the substrate with Au film was annealed at 450 °C for 1 hr to form Au nanoparticles.

Preparation of precursors: for the preparation of Cd precursor, 25.7 mg CdO powder and 20 mL OA were added into a 50-mL reagent bottle and then heated in an oil bath with magnetic stirring for 3 hrs. The mixture turned light yellow at around 200 °C. Then the solution was cooled down to room temperature. For the preparation of Se precursor, 15.8 mg Se powder and 4 mL TOP were added into a 20-mL reagent bottle and ultrasonically stirred for 1 hr at room temperature.

Characterization: SEM images were recorded with a Hitach S4800 electron microscope. TEM, SAED and EDS mapping were obtained by a JEOL-2100F TEM with an acceleration voltage of 200 kV. The resultant products on the substrate were directly used for SEM observation, while the nanowires were scraped from substrate, dispersed in ethanol, and the dipped onto a copper grid with carbon film for TEM characterization. Transmission spectra were recorded with a Hitachi UV4100 UV-vis near-infrared spectrophotometer.

Supporting Calculation

The absorbed laser energy by the gold particles is directly measured by using a power meter. Since the precursor solution does not absorb any laser light at 1064 nm wavelength (see Figure S5), the energy loss is mainly due to the absorption of metal nanoparticles. The absorbed laser energy by the gold particles per unit mass and per laser pulse, Q (J g⁻¹ pulse⁻¹), is calculated by¹²

$$Q = E/fcV \quad (1)$$

E is the laser energy absorbed by the solution of the gold particle per unit time (J s⁻¹) measured by the power meter, f is the frequency of the pulsed laser (1 Hz), c is the mass concentration of gold (g m⁻³), and V is the irradiated volume of the solution (m³).

The heat loss of nanoparticles dispersed in a solvent proceeds by two ways, namely convection heat transfer

$$\Delta Q_1 = h(T - T_0)S(d_0)\tau \quad (2)$$

and radiation heat transfer

$$\Delta Q_2 = \varepsilon\delta T^4 S(d_0)\tau \quad (3)$$

h is the convection heat transfer coefficient ($50 < h < 1000$ in solution), T_0 the room temperature (302 K), $S(d_0)$

the surface area of nanoparticle $S(d_0) = \pi d_0^2$, τ the pulsed laser width, ε the emissivity of nanoparticle

($0 < \varepsilon < 1$), δ the Stefan-Boltzmann constant (5.67×10^{-8} W m⁻² K⁻⁴).

The energy for temperature rise can be calculated by

$$\Delta Q = c_p (T - T_0) = Q - N\Delta Q_1 - N\Delta Q_2 \quad (4)$$

and final temperature is determined as

$$T = (Q - N\Delta Q_1 - N\Delta Q_2) / C_p + T_0 \quad (5)$$

C_p is the specific heat of Au (0.131 Jg⁻¹K⁻¹), $N = \frac{1}{\rho V(d_0)}$ the number of nanoparticles in 1 g gold, ρ the

density of gold.

Supporting Figures

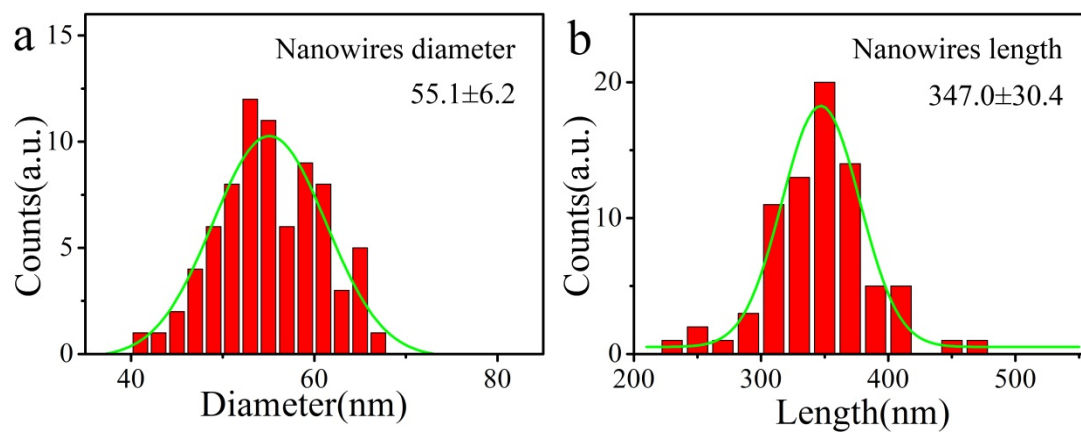


Figure S1. (a) Diameter and (b) length histograms of as-grown CdSe nanowires shown in Figure 2a.

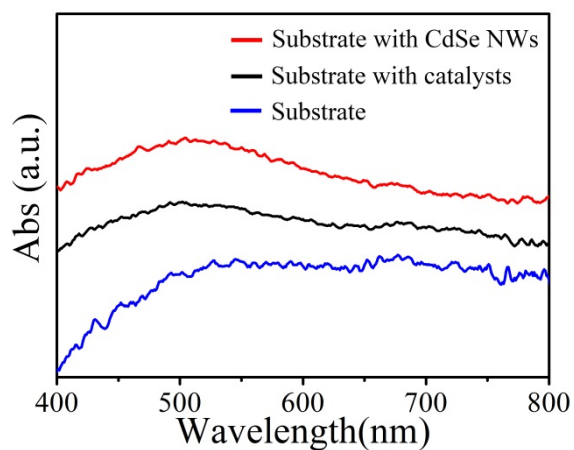


Figure S2. Absorption spectra of Si substrate (blue), Si substrate with Au catalysts (black), and Si substrate with CdSe nanowires (red).

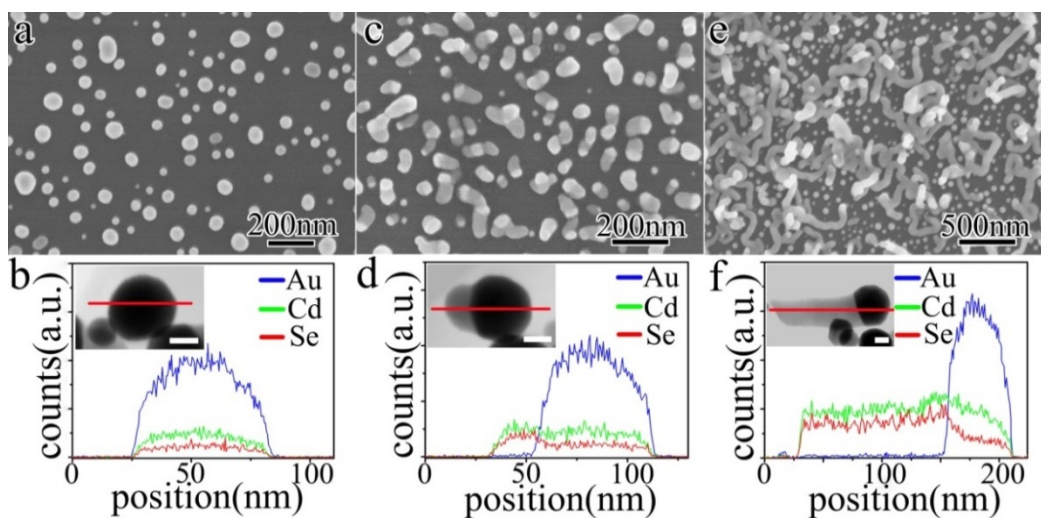


Figure S3. Characterizations on the CdSe nanowires prepared with Se:Cd molar ratio of 1:1 at different times. SEM images of products at (a) 1 min, (c) 3 min, (e) 5 min. (b), (d), (f) are EDS line scanning profiles of the products in (a), (c), (e), respectively. The insets are TEM images of the corresponding CdSe nanowires. Scale bar, 20 nm.

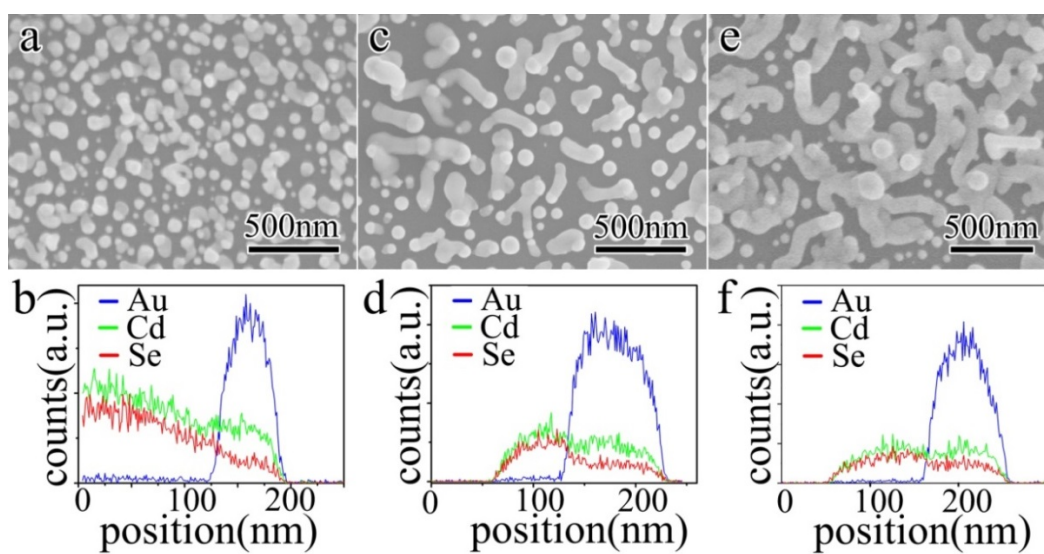


Figure S4. Characterizations on the CdSe nanowires prepared at different Se:Cd molar ratios. SEM images of CdSe nanowires prepared at the Se:Cd ratio of (a) 1:2, (c) 1:1, (e) 2:1. (b), (d), (f) show EDS line scanning profiles of the products in (a), (c), (e), respectively.

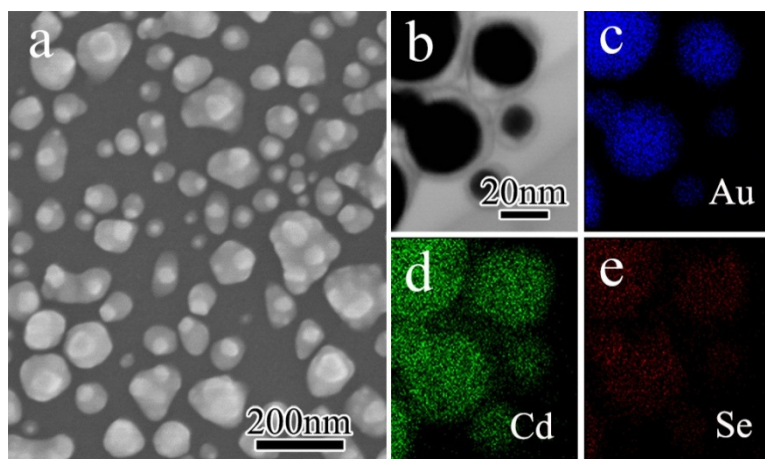


Figure S5. Characterizations of Au-CdSe core-shell nanostructure obtained under high-intensity laser irradiation for 5 min. (a) SEM image, (b) TEM image, (c) Au mapping, (d) Cd mapping, (e) Se mapping.

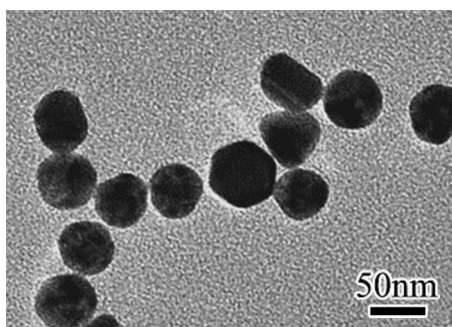


Figure S6. TEM image of Au nanoparticles irradiated by low-intensity laser for 5 min.

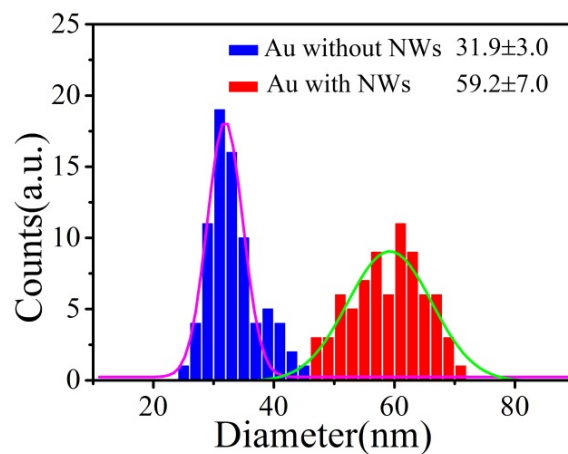


Figure S7. Diameter distributions of Au nanoparticles with or without nanowires shown in Figure 2a

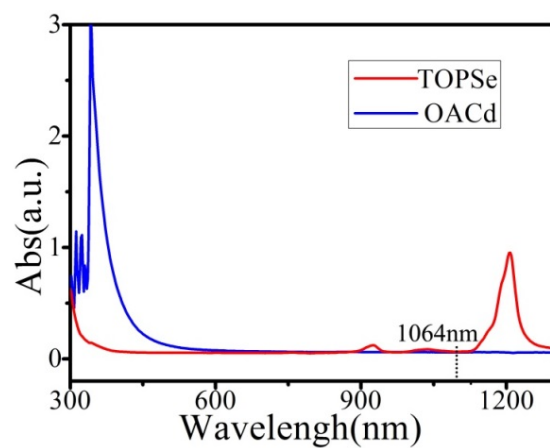


Figure S8. Absorption spectra of OA-Cd and TOP-Se precursors. No absorption is found at the 1064 nm laser wavelength, indicating that the solution does not absorb the pulsed laser energy.

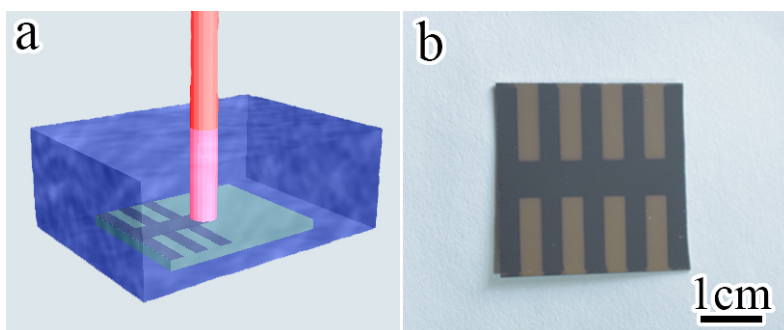


Figure S9. Patterned growth of CdSe nanowires on substrate. (a) Schematic illustration of the pulsed laser patterning process. (b) CdSe nanowires pattern grown on the Si substrate.

Supporting Tables

Table S1. Experimental parameters for the preparation of CdSe nanowires

Sample No.	molar ratio (Se:Cd)	OA-Cd (uL)	TOP-Se (uL)	OA (uL)	laser intensity (J/mm ²)	irradiation time (s)
1	1:1	2000	400	1600	0.20	300
2	1:1	2000	400	1600	0.20	180
3	1:1	2000	400	1600	0.20	60
4	1:2	2000	200	1800	0.20	300
5	2:1	2000	800	1200	0.20	300
6	1:1	2000	400	1600	0.40	300
7	1:1	2000	400	1600	0.05	300

Table S2. Quantitative EDS results of as-prepared nanowires.

precursor ratio Se:Cd	The atomic percentage in Au catalysts			Cd:Au	Se:Cd
	Au	Se	Cd		
1:2	52.96	18.51	28.53	0.5387	0.6488
1:1	50.89	21.61	27.50	0.5404	0.7858
2:1	49.64	23.59	26.77	0.5393	0.8812

Supporting Reference

- 1 (a) Akinori Takami, Hideaki Kurita, and Seiichiro Koda. *J. Phys. Chem. B*, 1999, **103**, 1226–1232. (b) Michael Strasser, Kenji Setoura, Uwe Langbein, and Shuichi Hashimoto. *J. Phys. Chem. C*, 2014, **118**, 25748–25755

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