Supporting Information:

Efficient flower-like ZnSe/$Cu_{0.08}Zn_{0.92}S$ photocatalyst for hydrogen production application

Ying Wang[1#], Yue Han [1#], Ruiyang Zhao[3]*, Jishu Han[1]*, Lei Wang[1,2]

1 Key Laboratory of Eco-chemical Engineering, Ministry of Education, International Science and Technology Cooperation Base of Eco-chemical Engineering and Green Manufacturing, College of Chemistry and Molecular Engineering, Qingdao University of Science and Technology, Qingdao 266042, China.

2 Shandong Engineering Research Center for Marine Environment Corrosion and Safety Protection, College of Environment and Safety Engineering, Qingdao University of Science and Technology, Qingdao 266042, China.

3 College of Chemical Engineering, Qingdao University of Science and Technology, Qingdao 266042, China.

[#]These authors contributed equally.

Calculation of apparent quantum efficiency (AQE)

The AQE for H_2 evolution is measured under the same photocatalytic hydrogen production reaction condition. The xenon lamp is equipped with a 420 mn band-pass filter to measure the photocatalytic hydrogen production of the material (Microsolar 300 Xenon lamp, Beijing Perfectlight). The intensity and number of photons of the light source at 420 nm are measured by an irradiate-meter. The distance from light source to catalyst surface is 14 cm. The AQE is calculated by the following equation:

$$AQE(\%) = \frac{\text{number of reacted electrons}}{\text{number of incident photons}} \times 100$$
$$= \frac{2 \times \text{number of evolved } H_2 \text{ molecules}}{\text{number of incident photons}} \times 100$$
$$n_{photons} = \frac{I \cdot S \cdot \lambda}{hc} \times t$$

Where I is the light intensity at 420 nm, S is the illuminate area, λ means the wavelength of incident light (420 nm), h is Planck's constant, c represents the velocity of light, and t is the illumination time.

Kubelka-Munk equation:

$$\alpha\ (h\nu) = A\ (h\nu - E_g)^n$$

where α, ν, h, n, A represents optical absorption coefficient, frequency of the incident photon, Planck constant, the nature of transition and a constant, respectively.

Fig. S1 TEM image of ZnSe/$Cu_{0.08}Zn_{0.92}S$ microflowers.

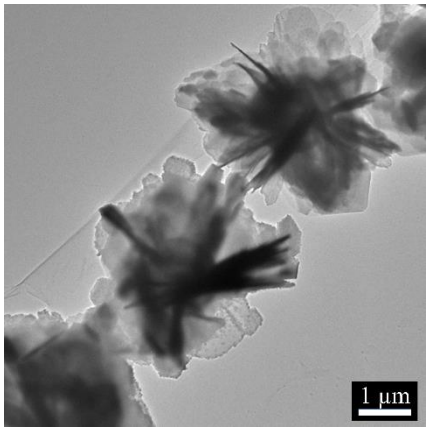

Fig. S2 XPS survey spectrum of ZnSe/$Cu_{0.08}Zn_{0.92}S$ microflowers.

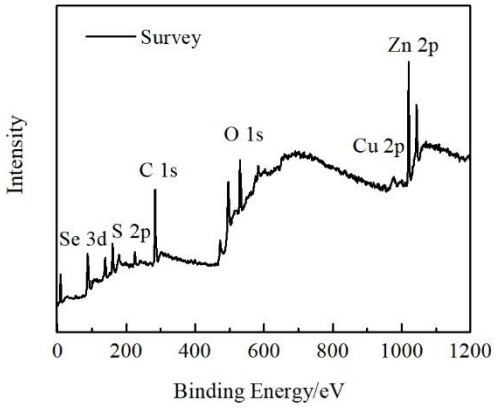

Fig. S3 High-resolution Cu 2p (a), Zn 2p (b) and S 2p (c) XPS spectra for $Cu_{0.08}Zn_{0.92}S$ microflowers.

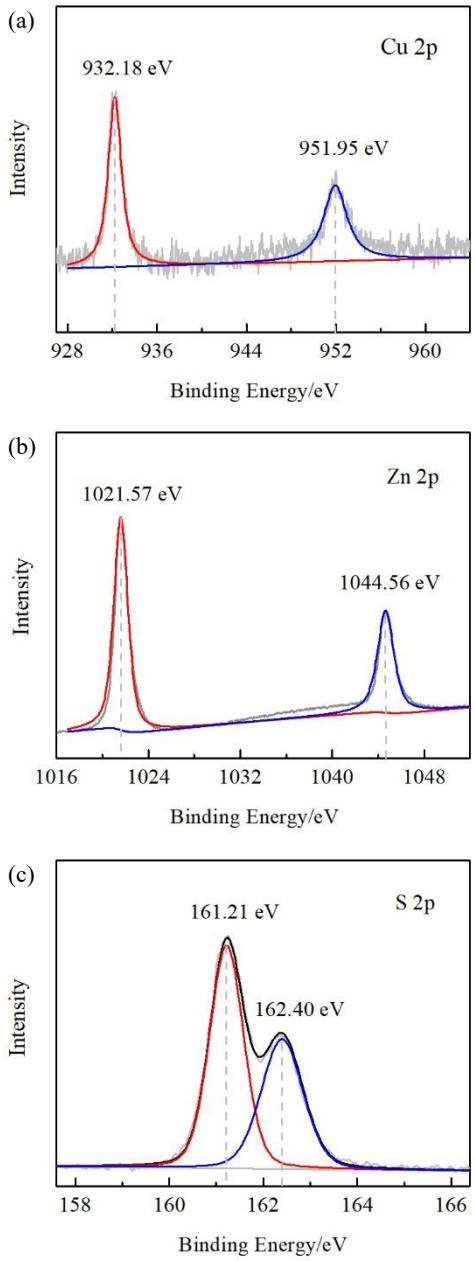

Table S1 The element content of ZnSe/$Cu_{0.08}Zn_{0.92}S$ through the ICP-AES analysis.

Element	Content ratio
Zn	1.00
Cu	0.13
S	0.73
Se	0.06

Fig. S4 Photocatalytic hydrogen production levels of $Cu_{0.05}Zn_{0.95}S$, $Cu_{0.08}Zn_{0.92}S$ and $Cu_{0.12}Zn_{0.88}S$.

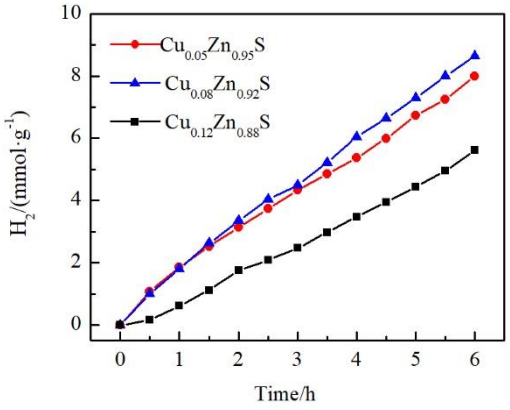

Fig. S5 Photocatalytic hydrogen production level of ZnSe.

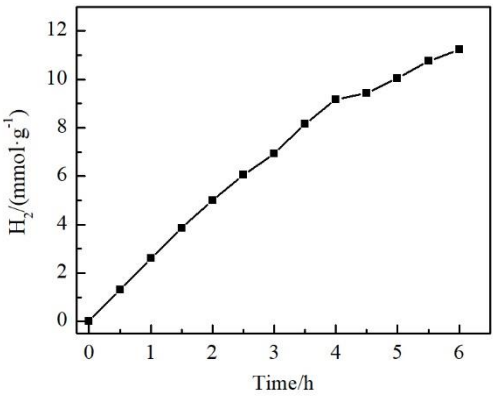

Fig. S6 Photocatalytic hydrogen production levels of ZnS and ZnSe/ZnS.

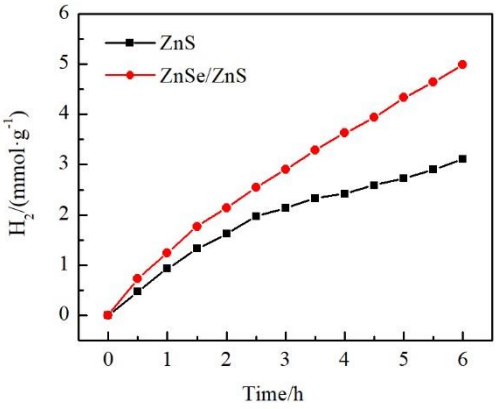

Table S2. Comparison of photocatalytic hydrogen production performance of different catalysts.

Photocatalyst	Light source	Sacrificial reagent	Activity/ ($\mu mol\ g^{-1}\ h^{-1}$)	Ref.
8% Ni_2P/ZnSe	300 W Xe lamp (λ>420 nm)	0.2 M Na_2S, 0.35M Na_2SO_3	4336	1
ZnSe/$FeSe_2$	300 W Xe lamp	10 vol% methanol	1228	2
ZnSe/ZnS	300 W Xe lamp (λ>420 nm)	Ascorbic acid	1810	3
ZnSe	300 W Xe lamp (λ>420 nm)	0.35 M Na_2S, 0.25 M Na_2SO_3	595.66	4
$Cu_{0.02}Zn_{0.98}S$/zeolite	300 W Xe lamp (λ>250 nm)	0.1 M Na_2S, 0.1 M Na_2SO_3	1200	5
$Cu_{0.05}Zn_{0.95}S$	150 W Xe lamp with an AM 1.5G filter	0.35 M Na_2S, 0.25 M Na_2SO_3	595	6
1% Cu-ZnS nanoframe	300 W Xe lamp	0.75 M Na_2S, 1.05 M Na_2SO_3	8229.1	7
ZnSe/$Cu_{0.08}Zn_{0.92}S$	300 W Xe lamp (λ>420 nm)	0.35 M Na_2S, 0.25 M Na_2SO_3	3586.67	This work

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Fig. S7 Steady-state PL spectra of $Cu_{0.08}Zn_{0.92}S$, ZnSe and ZnSe/$Cu_{0.08}Zn_{0.92}S$ microflowers.

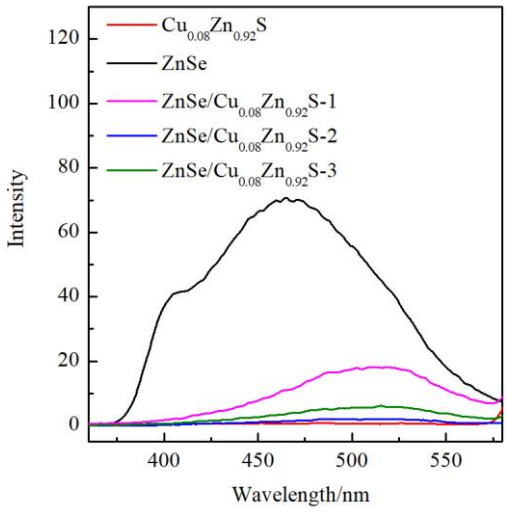

Table S3. The data of $Cu_{0.08}Zn_{0.92}S$, ZnSe and ZnSe/$Cu_{0.08}Zn_{0.92}S$ obtained from N_2 adsorption-desorption measurements.

Sample	$S_{BET}/(m^2\ g^{-1})$	Pore volume/$(cm^3\ g^{-1})$	Average pore size/Å
$Cu_{0.08}Zn_{0.92}S$	8.38	0.014	68.66
ZnSe	9.88	0.011	45.36
ZnSe/$Cu_{0.08}Zn_{0.92}S$-2	15.11	0.029	78.07