Electronic Supplementary Material (ESI) for Materials Advances.

Supplementary Information

Amorphous NiS_x film as a robust cocatalyst for boosting photocatalytic hydrogen generation over ultrafine ZnCdS nanoparticles

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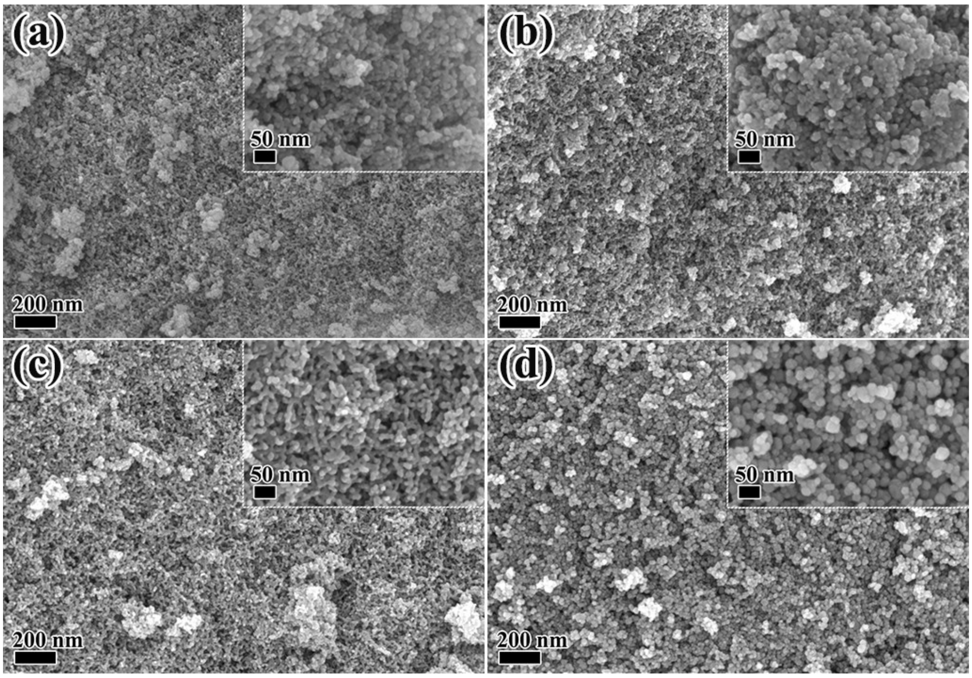

Fig. S1 SEM images: (a) ZCS, (b) ZCS-NS2, (c) CS-NS, and (d) ZS-NS nanocomposites.

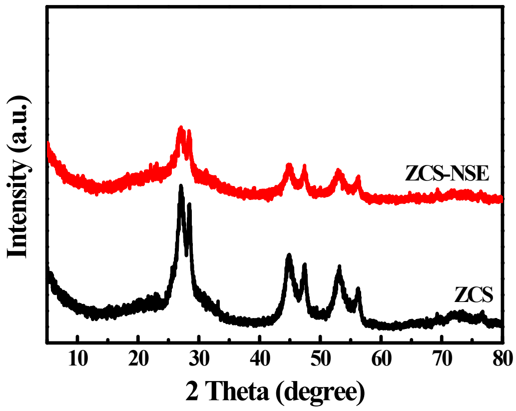

Fig. S2 The XRD patterns of ZCS and ZCS-NSE.

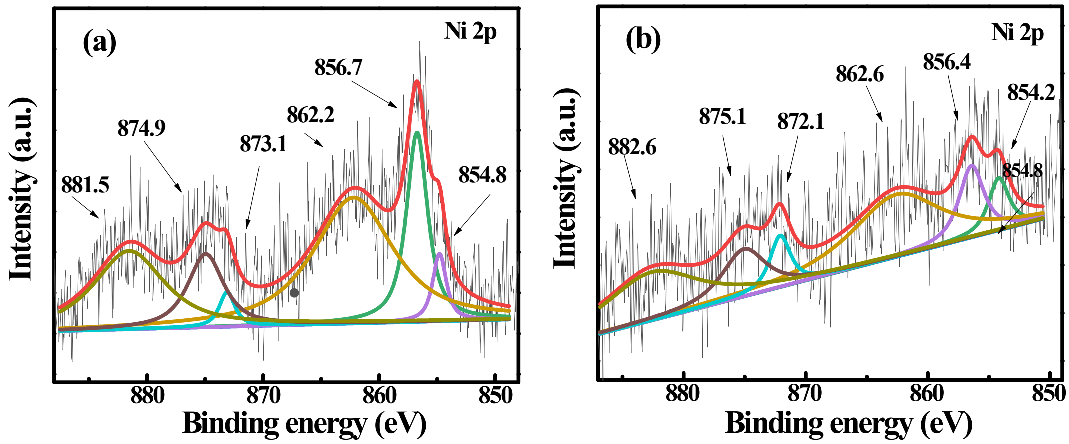

Fig. S3 High-resolution XPS spectra of Ni 2p of (a) CdS and (b) ZnS.

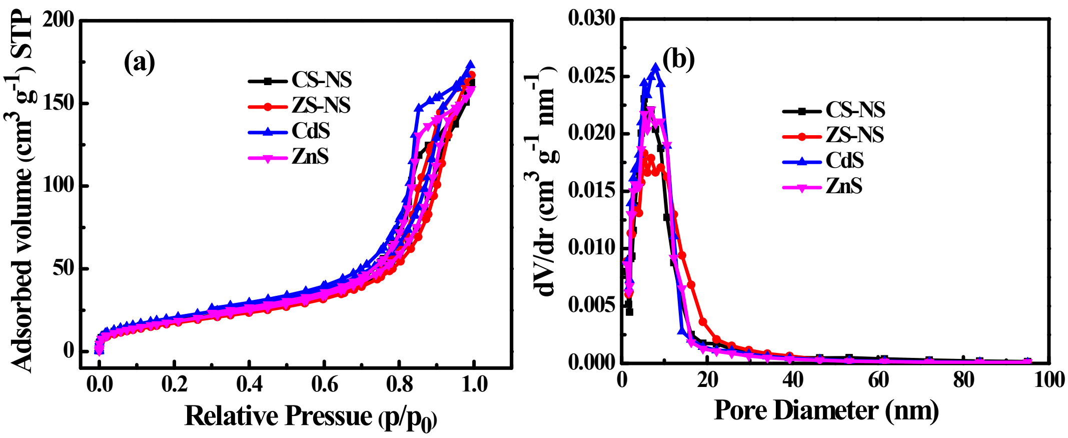

Fig. S4 Nitrogen adsorption/desorption isotherms and the corresponding pore-size distribution curves of the CS-NS, ZS-NS, CdS and ZnS.

As shown in Fig. S4 and Table S1, the present synthetic method can be extended to synthesize CS-NS, ZS-NS, CdS and ZnS with large specific surface areas, which is benefit to improve the photocatalytic performance.

Table S1 The corresponding textural properties of prepared samples.

Sample	S_{BET} ($m^2\ g^{-1}$)	Mean pore diameter (nm)	Pore volume ($cm^3\ g^{-1}$)
ZCS	102.23	11.75	0.30
ZCS-NS1	89.01	12.60	0.28
ZCS-NS2	96.30	11.90	0.29
ZCS-NS3	95.14	11.82	0.28
ZnS	70.66	13.77	0.247
ZS-NS	67.11	15.31	0.26
CdS	78.57	13.61	0.27
CS-NS	70.63	14.02	0.25

Table S2 Comparison of some nickel sulfide cocatalysts for photocatalytic hydrogen evolution.

Photocatalyst	Light source	Sacrificial agent	Activity mmol $h^{-1}\ g^{-1}$	Ref.
NiS/CdS	300 W Xe-lamp λ>420 nm	Na_2S, Na_2SO_3	1.131	1[1]
NiS/$Zn_{0.5}Cd_{0.5}S$	300 W Xe-lamp λ>420 nm	Na_2S, Na_2SO_3	16.780	2[2]
NiS/$Zn_{0.5}Cd_{0.5}S$/ RGO	solar simulator AM 1.5, 100 mW cm^{-2}	Na_2S, Na_2SO_3	7.514	3[3]
NiS/$Cd_{0.4}Zn_{0.6}S$	300 W Xe-lamp λ>420 nm	Na_2S, Na_2SO_3	1.2	4[4]
CdS/NiS/RGO	300 W Xe-lamp λ>420 nm	lactic acid	14.960	5[5]
NiS/$ZnIn_2S_4$	320 W Xe-lamp λ>420 nm	lactic acid	3.333	6[6]
C_3N_4- $Zn_{0.5}Cd_{0.5}S$ -NiS	300 W Xe-lamp λ>420 nm	Na_2S, Na_2SO_3	53.19	7[7]
$Zn_{0.2}Cd_{0.8}S$/MoS2/NiS	300 W Xe-lamp solar light irradiation	Na_2S, Na_2SO_3	41.29	8[8]
NiSx/$Cd_{0.8}Zn_{0.2}S$/rGO	300 W Xe-lamp λ>420 nm	lactic acid	7.84	9[9]
$Cd_{0.5}Zn_{0.5}S$(en)/NiS	300 W Xe-lamp λ>420 nm	Na_2S, Na_2SO_3	38.187	10[10]
CdS/La_2Ti_2O7/NiS_2	300 W Xe-lamp λ>400 nm	lactic acid	12.77	11[11]
NiS/g-C_3N_4	300 W Xe lamp an AM 1.5 G filter	triethanolamine	16. 4	12[12]
NiS/CdS	300 W Xe-lamp λ>420 nm	lactic acid	30.1	13[13]
NiSx/CdZnS	300 W Xe-lamp λ>420 nm	lactic acid	67.75	This Work

Table S3 The photocatalytic hydrogen evolution rates under single-wavelength light and the corresponding AQE of ZCS and ZCS-NS2.

Sample	420 nm		500 nm		520 nm	
	H_2 evolution (μmol $g^{-1}h^{-1}$)	AQE	H_2 evolution (μmol $g^{-1}h^{-1}$)	AQE	H_2 evolution (μmol $g^{-1}h^{-1}$)	AQE
ZCS	216.3	0.155%	23.7	0.015%	5.7	0.003%
ZCS-NS2	23991.0	17.073%	3286.8	1.965%	92.3	0.053%

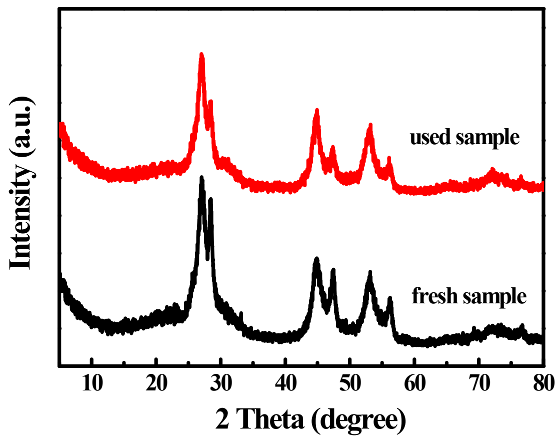

Fig. S5 The XRD patterns of the fresh and used ZCS-NS2 photocatalyst

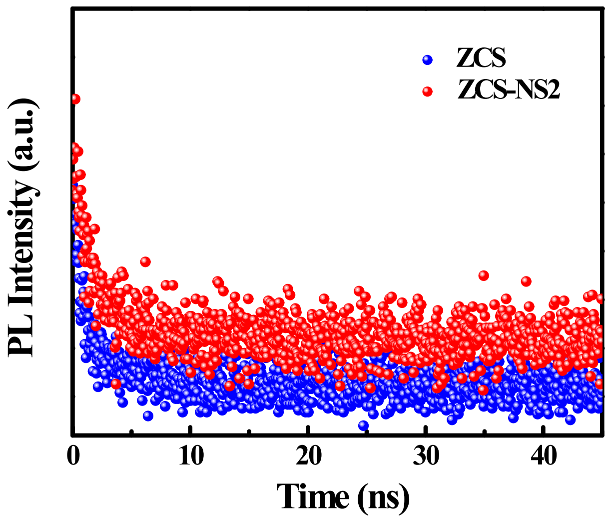

Fig. S6 Time-resolved PL decay under the excitation of 420 nm for ZCS and ZCS-NS2 samples.

Table S4 The radiative fluorescence lifetimes and relative percentages of the photoinduced charge carriers in the ZCS and ZCS-NS2

Sample	τ_1(ns)	Rel. (%)	τ_2(ns)	Rel. (%)	τ(ns)

ZCS	1.02	43.27	4.82	56.73	3.18
ZCS-NS2	1.42	57.54	8.06	42.46	4.24

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