Supporting Information

Construction of unique 2D/0D NiO/ZnCdS p-n heterojunction photocatalyst with highly improved photocatalytic H_2 generation

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Characterization of the materials

The X-ray diffraction (XRD) patterns were measured on a D/MAX 2500V diffractometer (Rigaku). UV-Visible (UV-Vis) absorption spectra were acquired using a Shimadzu 3600 UV-vis spectrophotometer. Scanning electron microscopy (SEM) images were obtained using a Zeiss Sigma 300. Transmission electron microscopy (TEM) images were carried out on a TECNAI F-30 at an accelerating voltage of 300 kV. XPS measurements were performed with an ESCALAB 250Xi. Under 370 nm excitation, photoluminescence (PL) and time-resolved photoluminescence (TRPL) were collected on the OmniFluo990LSP fluorescence spectrophotometer and HORIBA FL3C-111 fluorescence lifetime spectrophotometer, respectively. The photocurrent responses, electrochemical impedance spectroscopy (EIS), and Mott-Schottky plots were performed using a Bio-Logic VSP-300 multichannel potentiostat with a three-electrode system. The platinum sheet, Ag/AgCl electrode, and Na_2SO_4 solution (0.1 M) serve as the counter electrode, reference electrode, and electrolyte, respectively. A working electrode was prepared by coating ITO glass (1.0 cm x 2.0 cm) with a catalyst slurry (5 mg of photocatalysts dispersed in 0.5 mL of ethanol and 10 μL of Nafion solution) and then dried in a vacuum drying oven.

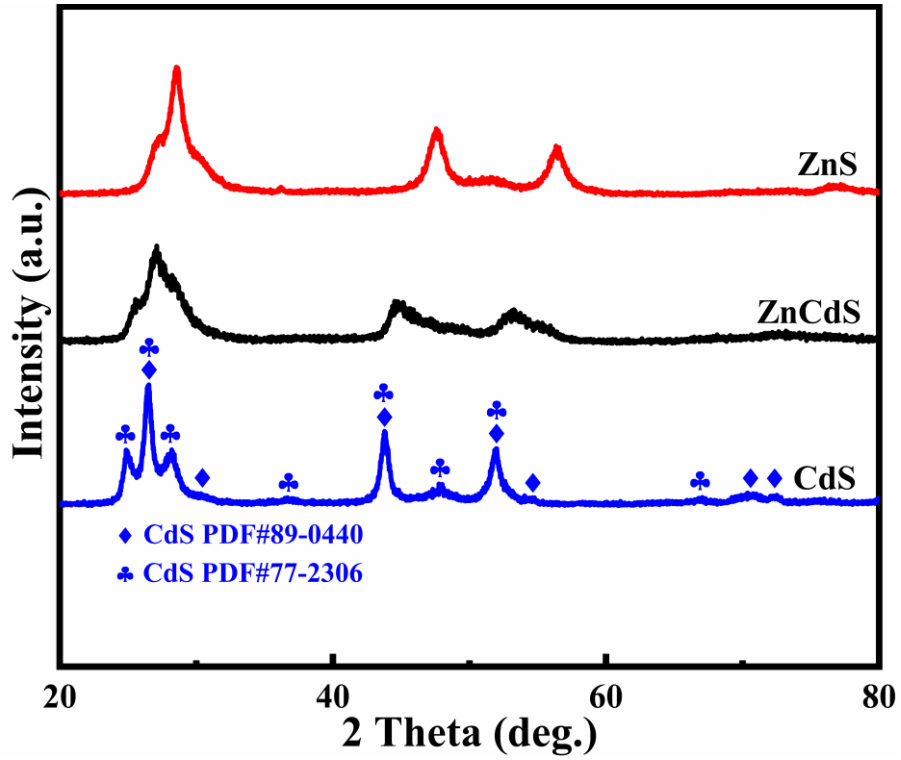

Fig. S1 XRD patterns of ZnS, CdS, and ZnCdS samples.

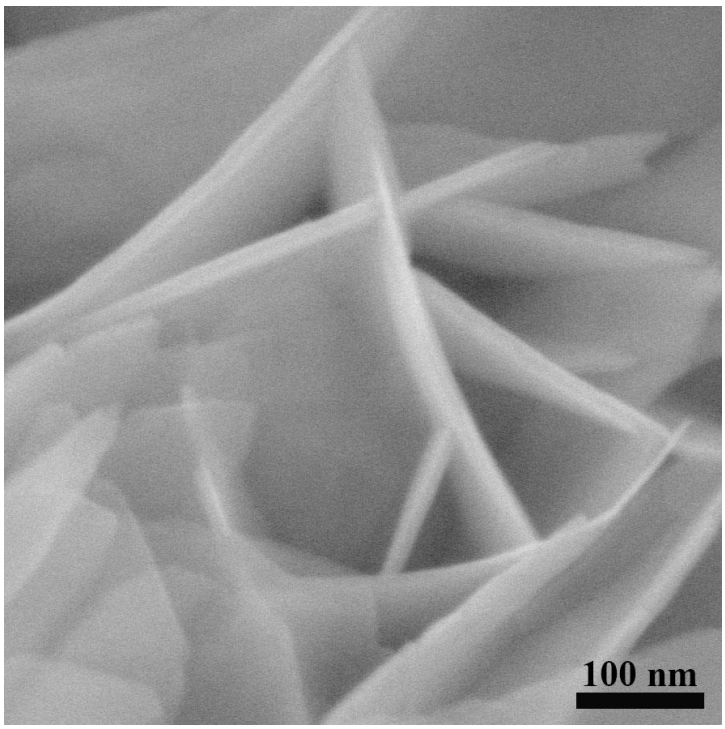

Fig. S2 SEM image of $Ni(OH)_2$ nanosheets.

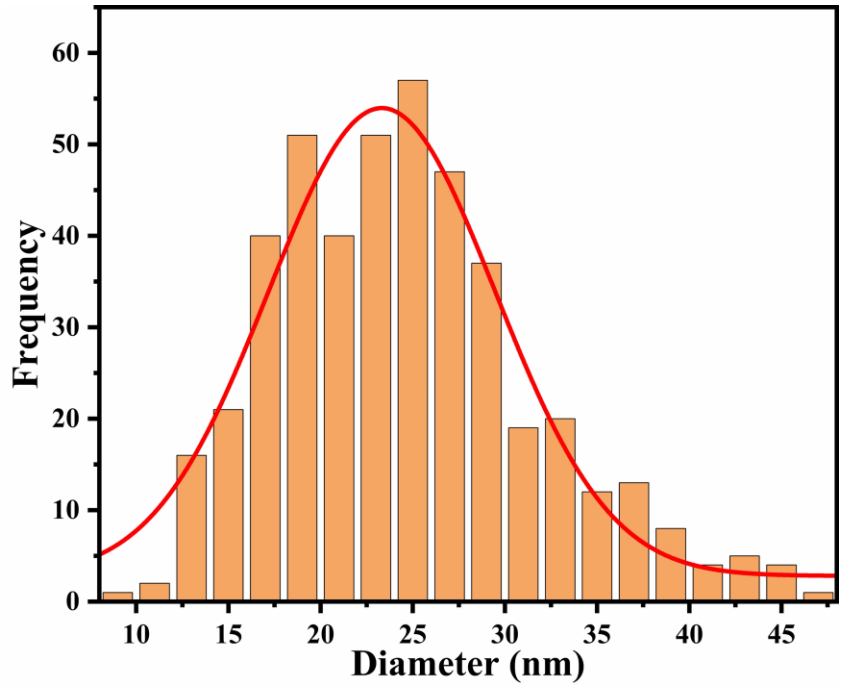

Fig. S3 Particle size distribution histogram of ZnCdS nanoparticles.

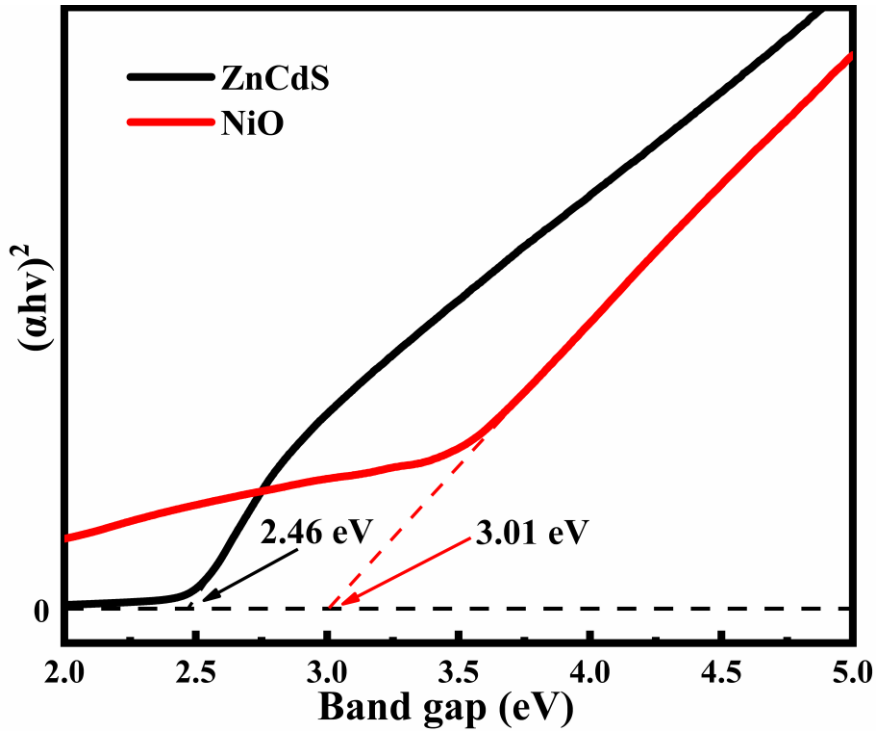

Fig. S4 Tauc plots of NiO nanosheets and ZnCdS nanoparticle.

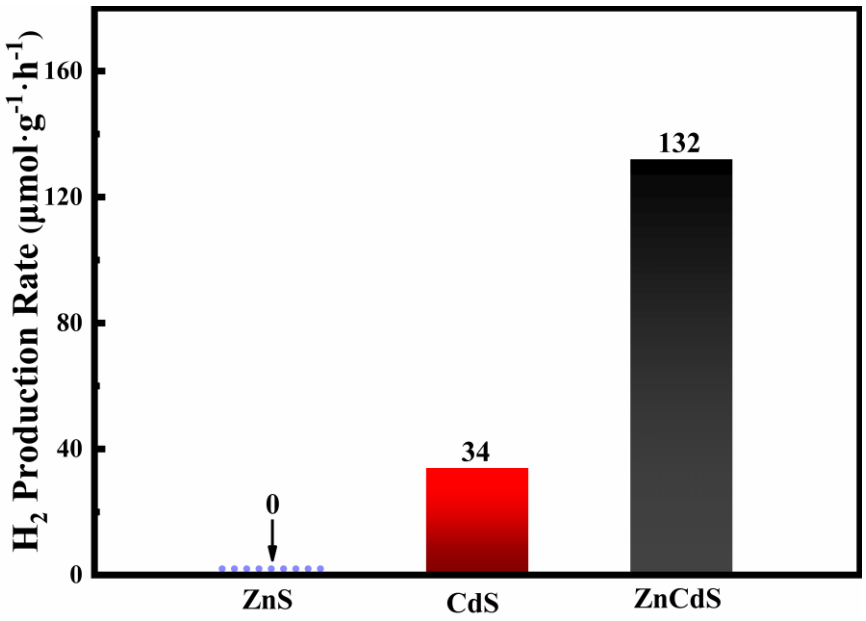

Fig. S5 Average H_2 production rates of ZnS, CdS, and ZnCdS samples under visible-light irradiation ($\lambda > 420$ nm).

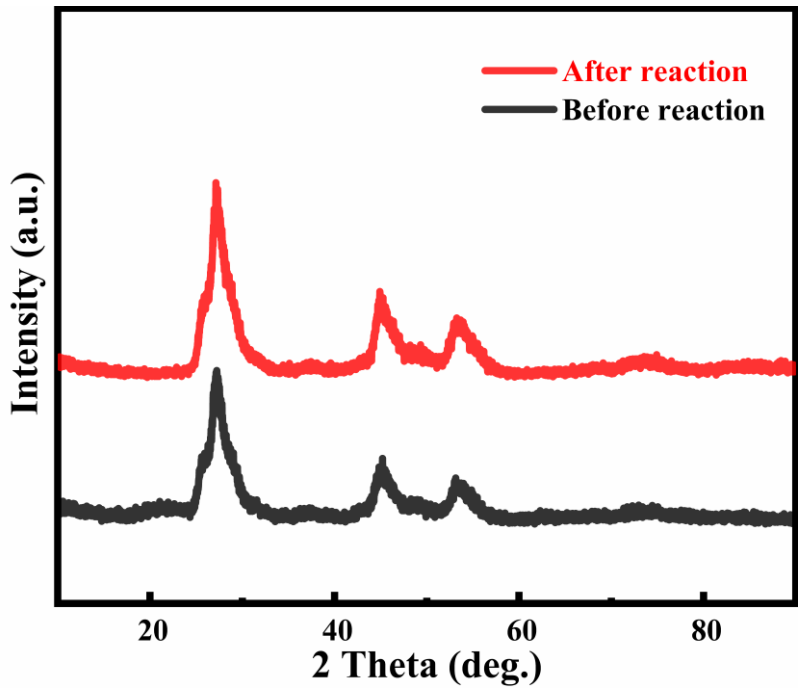

Fig. S6 XRD patterns of the 5% NiO/ZnCdS sample before and after cycling photocatalytic reactions.

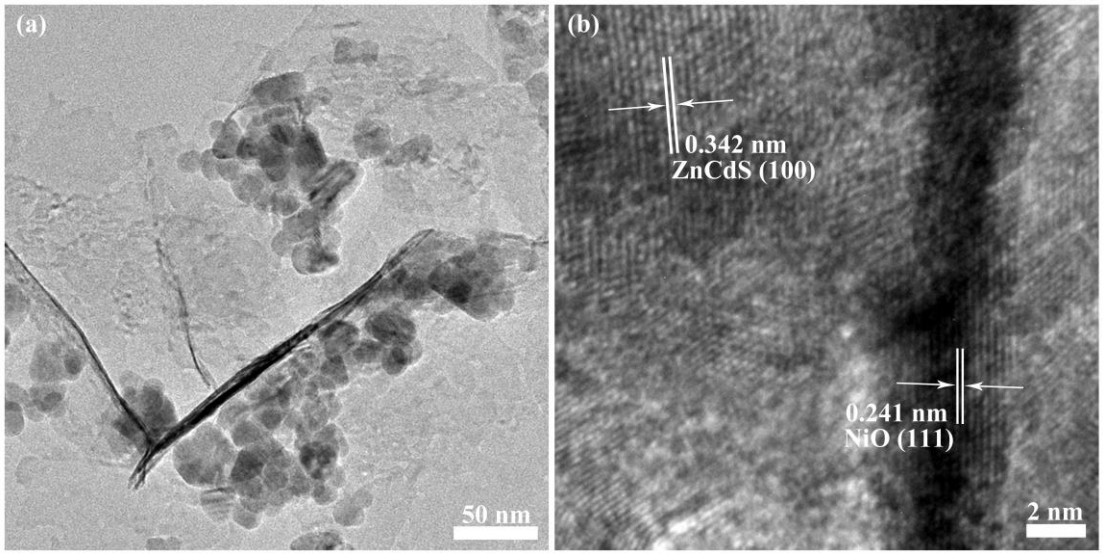

Fig. S7 TEM images of the 5% NiO/ZnCdS sample after cycling photocatalytic reactions.

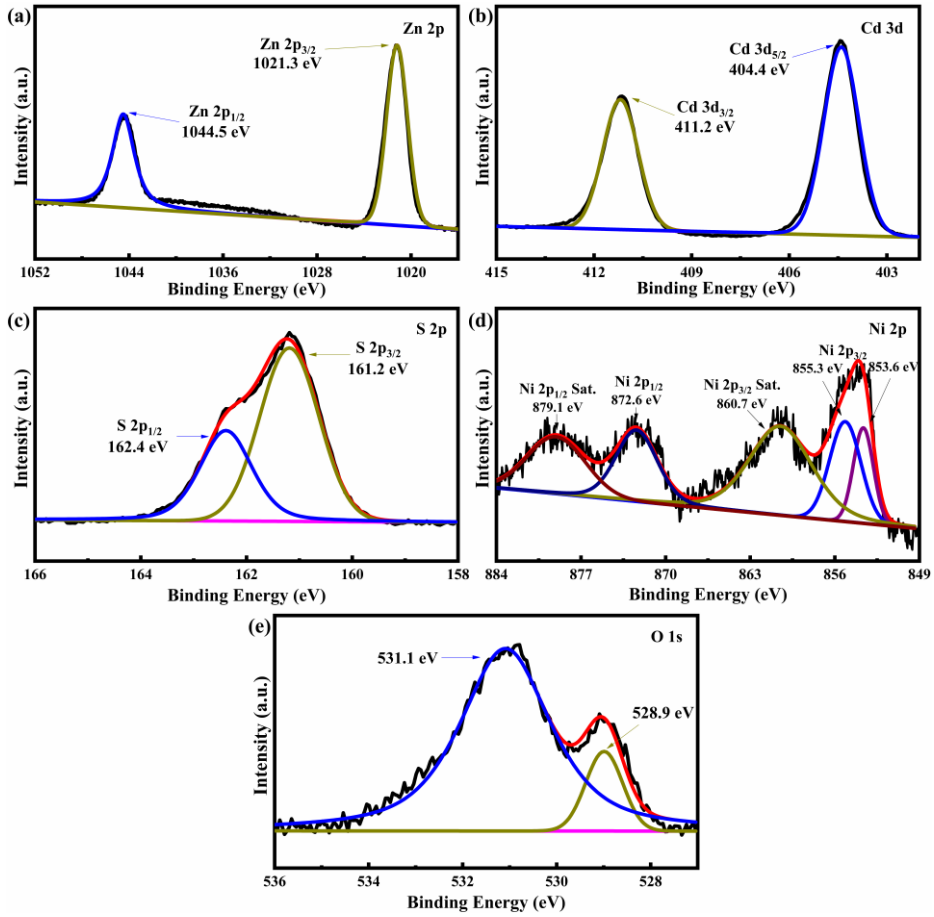

Fig. S8 XPS spectra of the 5% NiO/ZnCdS sample after cycling photocatalytic reactions.

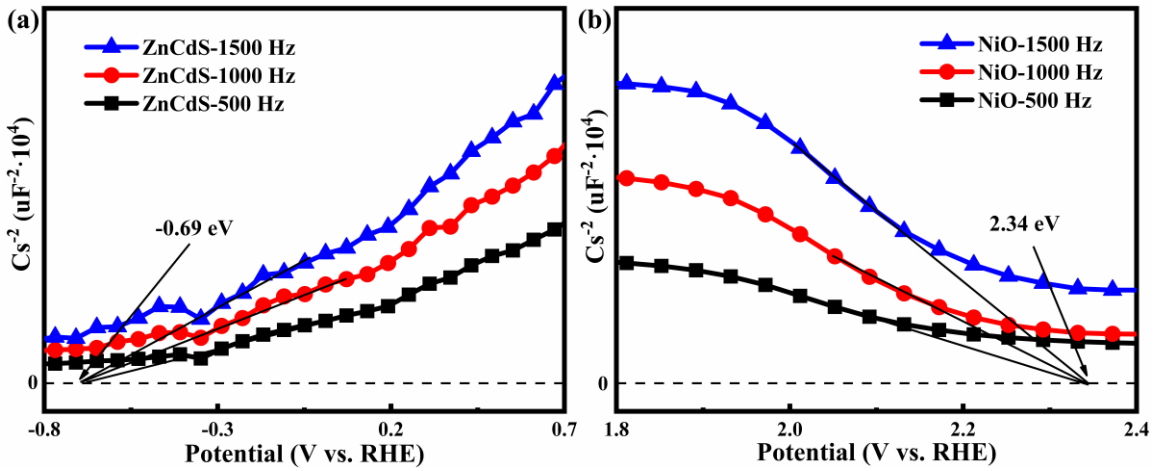

Fig. S9 Mott-Schottky plots of (a) ZnCdS nanoparticles and (b) NiO nanosheets.

Table S1. Photocatalytic H_2 evolution activity of ZnCdS-based photocatalysts.

	Photocatalyst	Light source	Scavenger	Activity (μmol h^{-1} g^{-1})	Enhancement factor* (Reference)	Refs
1	$MoS_2/Zn_{0.5}Cd_{0.5}S$ /g-C_3N_4	300 W Xe lamp	Na_2S /Na_2SO_3	4914	/	[1]
2	$Zn_{0.5}Cd_{0.5}S$ @MoS_2/RGO	300 W Xe lamp	Lactic aid	2310	9 ($Zn_{0.5}Cd_{0.5}S$)	[2]
3	$Zn_{0.5}Cd_{0.5}S$ @PAN	350 W Xe lamp	Na_2S /Na_2SO_3	475	27.4 ($Zn_{0.5}Cd_{0.5}S$)	[3]
4	$Zn_{0.5}Cd_{0.5}S$ @Ni-Glycerate	CEL-LED 100	Na_2S /Na_2SO_3	2800	/	[4]
5	$Zn_{0.7}Cd_{0.3}S$ /PDI	/	Na_2S /Na_2SO_3	5166	6.5 ($Zn_{0.7}Cd_{0.3}S$)	[5]
6	CdS @$Cd_xZn_{1-x}S$	300 W Xe lamp ($\lambda \geq 420$ nm)	Na_2S /Na_2SO_3	5170	12.3 ($Cd_xZn_{1-x}S$)	[6]
7	$Zn_{0.7}Cd_{0.3}S$ /NiWO4	5 W LED ($\lambda \geq 420$ nm)	Na_2S /Na_2SO_3	15,950	3.16 ($Zn_{0.7}Cd_{0.3}S$)	[7]
8	$Zn_{0.5}Cd_{0.5}S$ /C	300 W Xe lamp ($\lambda \geq 420$ nm)	Na_2S /Na_2SO_3	2018	/	[8]
9	Ni_2P /ZnCdS	300 W Xe lamp ($\lambda \geq 420$ nm)	Na_2S /Na_2SO_3	1040	5 (ZnCdS)	[9]
10	**NiO /ZnCdS**	**300 W Xe lamp (λ> 420 nm)**	**Na_2S /Na_2SO_3**	**5042**	**38.2 (ZnCdS)**	**This work**

Table S2. Fitting results of the Nyquist plots for ZnCdS, 5% NiO/ZnCdS, and NiO photocatalysts.

Photocatalyst	R_s (Ω)	R_{ct} (kΩ)	CPE ($F \cdot cm^{-2} \cdot S^{n-1}$)	n
ZnCdS	9.859	612	1.02E-4	0.89
5% NiO/ZnCdS	9.832	67.1	2.37E-4	0.84
NiO	9.804	8.03	2.73E-4	0.62

Table S3. Decay parameters of pure ZnCdS and 5% NiO/ZnCdS.

Samples	Lifetime, T (ns)	Rel (%)	T_{av} (ns)
ZnCdS	T_1= 2.04 T_2= 41.24	B_1= 64.82 B_2= 35.18	3.06
5% NiO/ZnCdS	T_1= 2.79 T_2= 110.21	B_1= 45.69 B_2= 54.31	5.92

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