

Supplementary Information (SI)

Tab. S1. The textural properties of different catalysts were calculated from N₂ adsorption-desorption isotherms.

Catalyst	BET surface area (m ² g ⁻¹)	Pore diameter (nm)	Pore volume (cm ³ g ⁻¹)
RuP	1.82	5.33	0.02
Cu	29.71	21.80	0.16
4% RuP/Cu	19.83	13.59	0.07

Tab. S2. The CO productivity of different reaction conditions of 4% RuP/Cu.

Reaction conditions	CO productivity (mmol/g/h)
H ₂ atmosphere	1.65
CO ₂ atmosphere	Trace
Ar atmosphere	Trace
Quarta sand, without catalyst	Trace

(Unless otherwise stated, the reaction condition was fixed: 20 mg catalyst, 300°C reaction temperature, 500 mW/cm² light intensity, 50 mL/min flow rate, the stoichiometric ratio of CO₂:H₂ is 4:1, and 1 h reaction period.)

Tab. S3 the ICP-OES results of different catalysts.

Catalyst	Concentration of Ru (mg/L)	Concentration of Cu (mg/L)	Theoretical mass ratio	Actual mass ratio
2%RuP/Cu	0.93	48.95	0.02	0.019
4%RuP/Cu	1.77	47.84	0.04	0.037
6%RuP/Cu	2.81	51.09	0.06	0.055
8%RuP/Cu	3.96	53.50	0.08	0.074

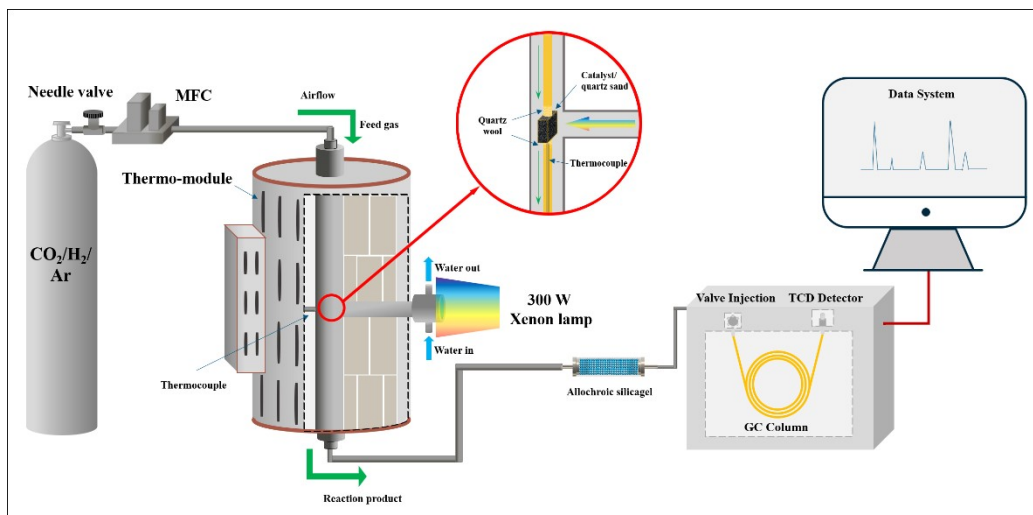


Fig. S1 Schematic diagram of the photothermal device.

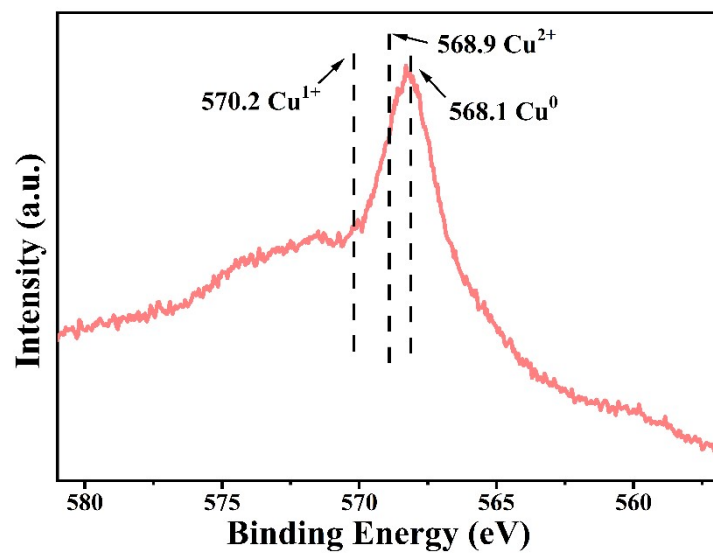


Fig. S2 XPS spectra of the Cu LMM of 4% RuP/Cu.

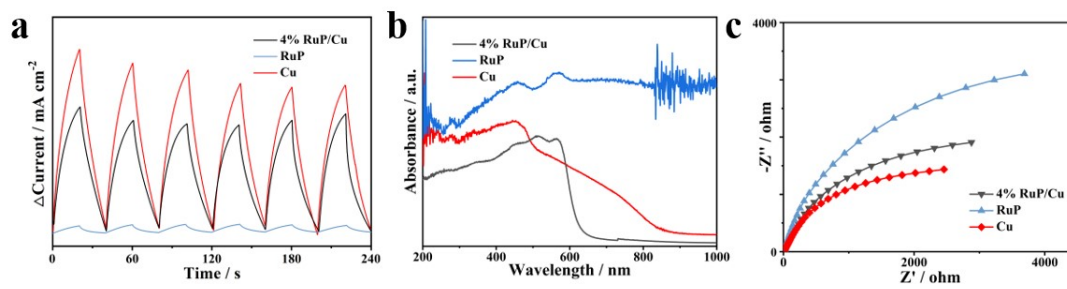


Fig. S3 (a) Transient photocurrent responses. (b) UV-Vis diffuse reflectance spectra. (c) Electrochemical impedance spectroscopy (EIS) analysis.

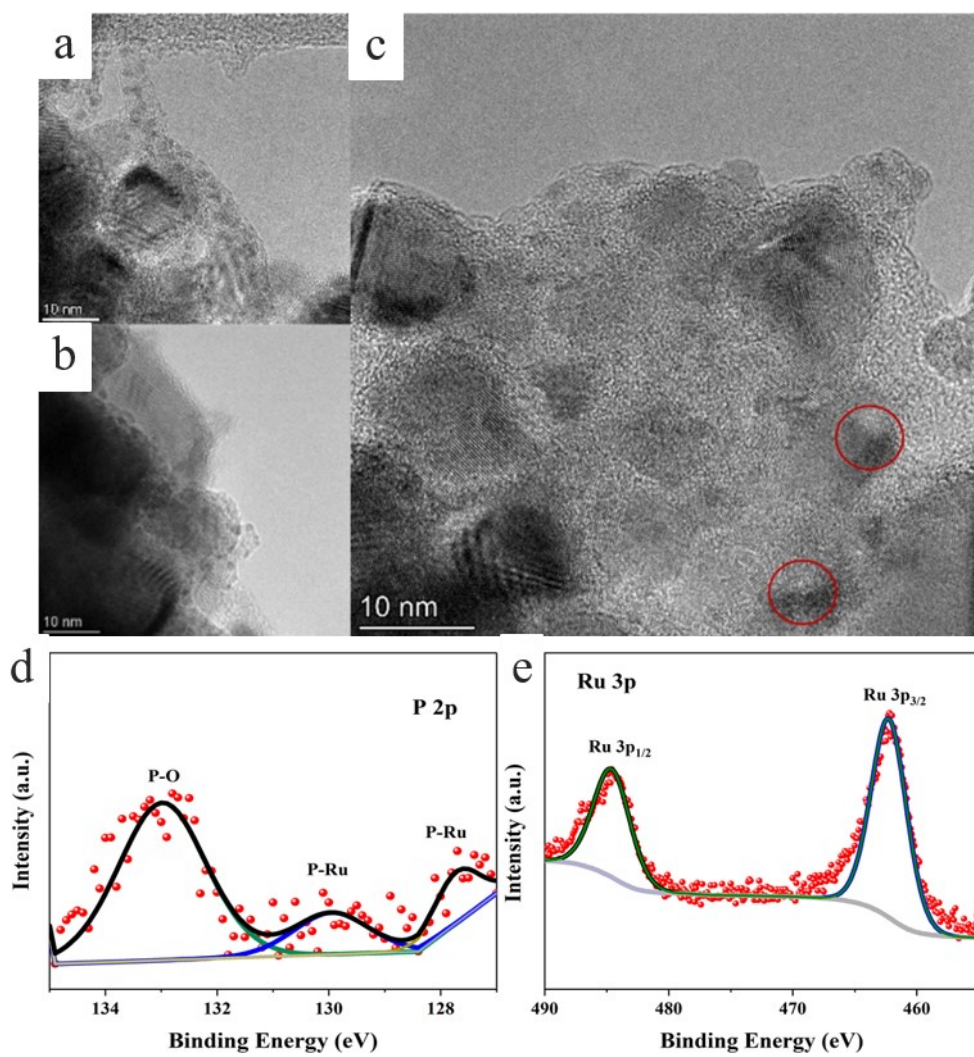


Fig. S4. TEM of 4%RuP/Cu after reaction (a-c), and XPS of 4% RuP/Cu after reaction (d) P 2p and (e) Ru 3p.