Electronic Supplementary Material (ESI) for Materials Advances.

Supporting Information

Silver Modified Copper Foam Electrodes for Enhanced Reduction of CO_2 to C_{2+} products

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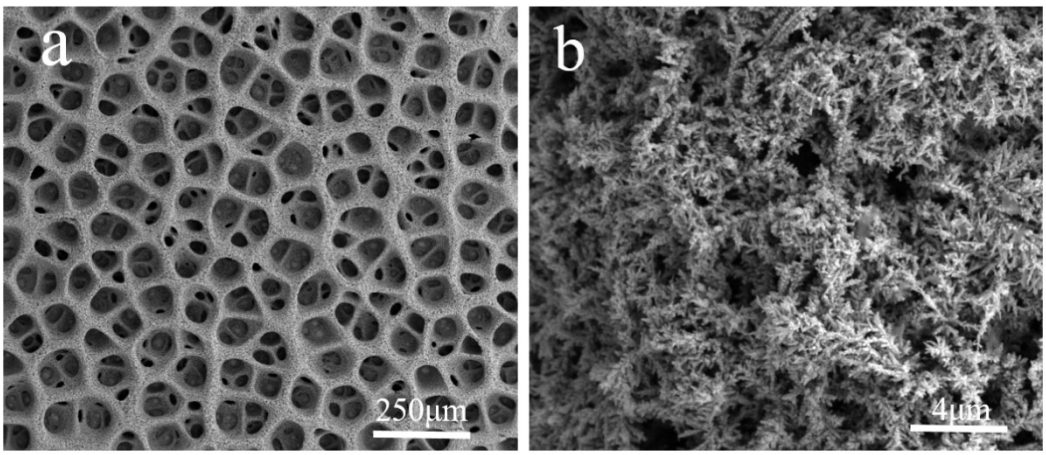

Figure S1 (a) and (b) SEM images of Cu porous.

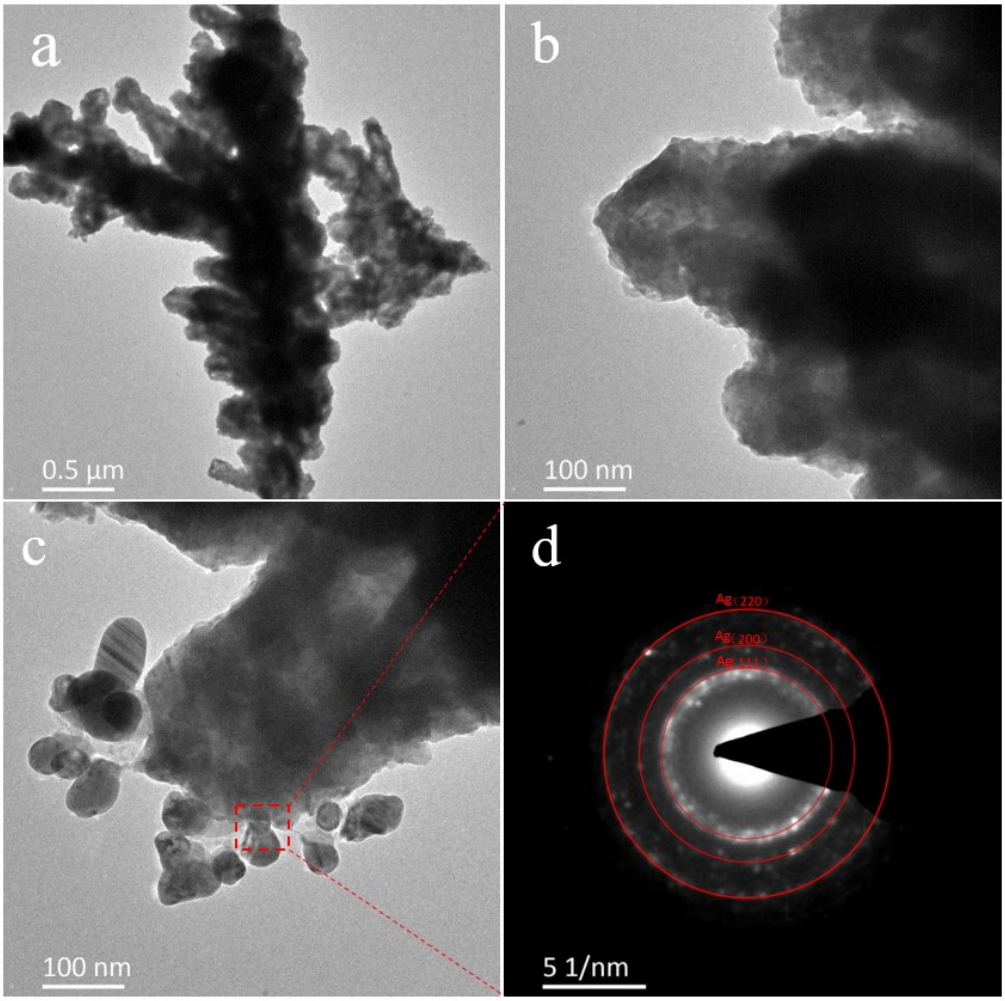

Figure S2 TEM characterizations of Cu/CuO at different magnifications(a) (b), Cu/CuO-Ag (c) and SAED pattern (d).

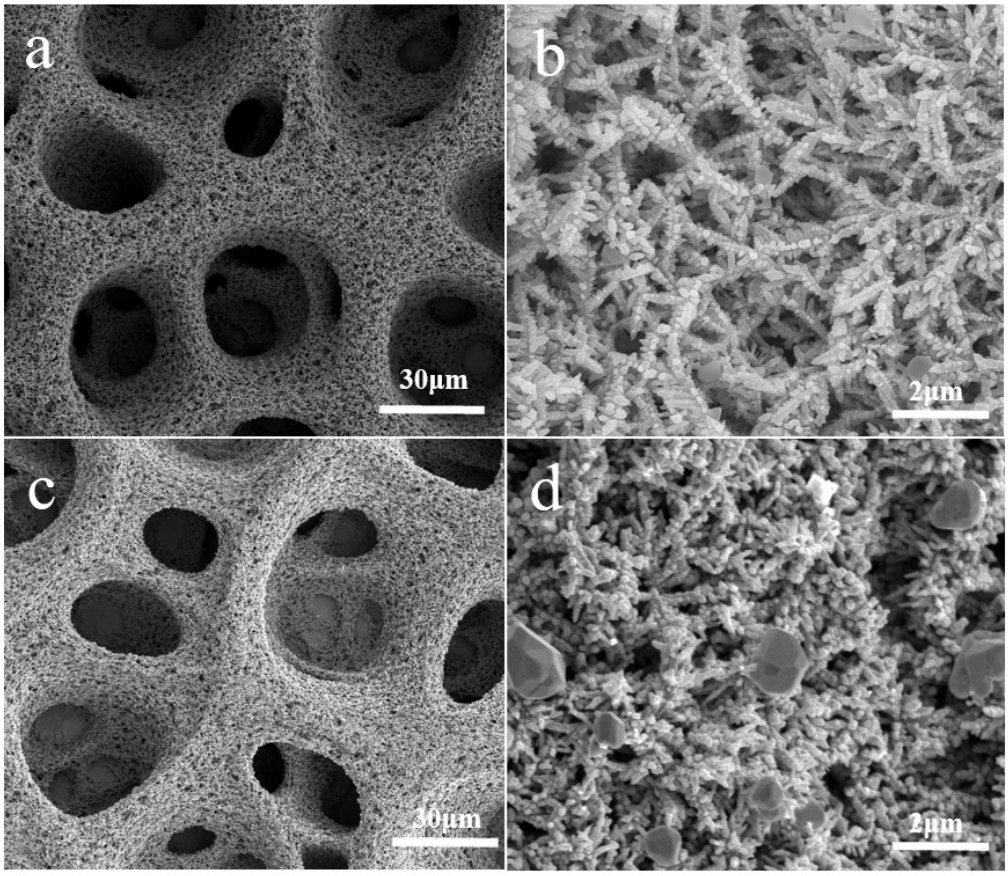

Figure S3 SEM images of (a) (b) Cu/CuO-Ag1 and (c) (d) Cu/CuO-Ag5.

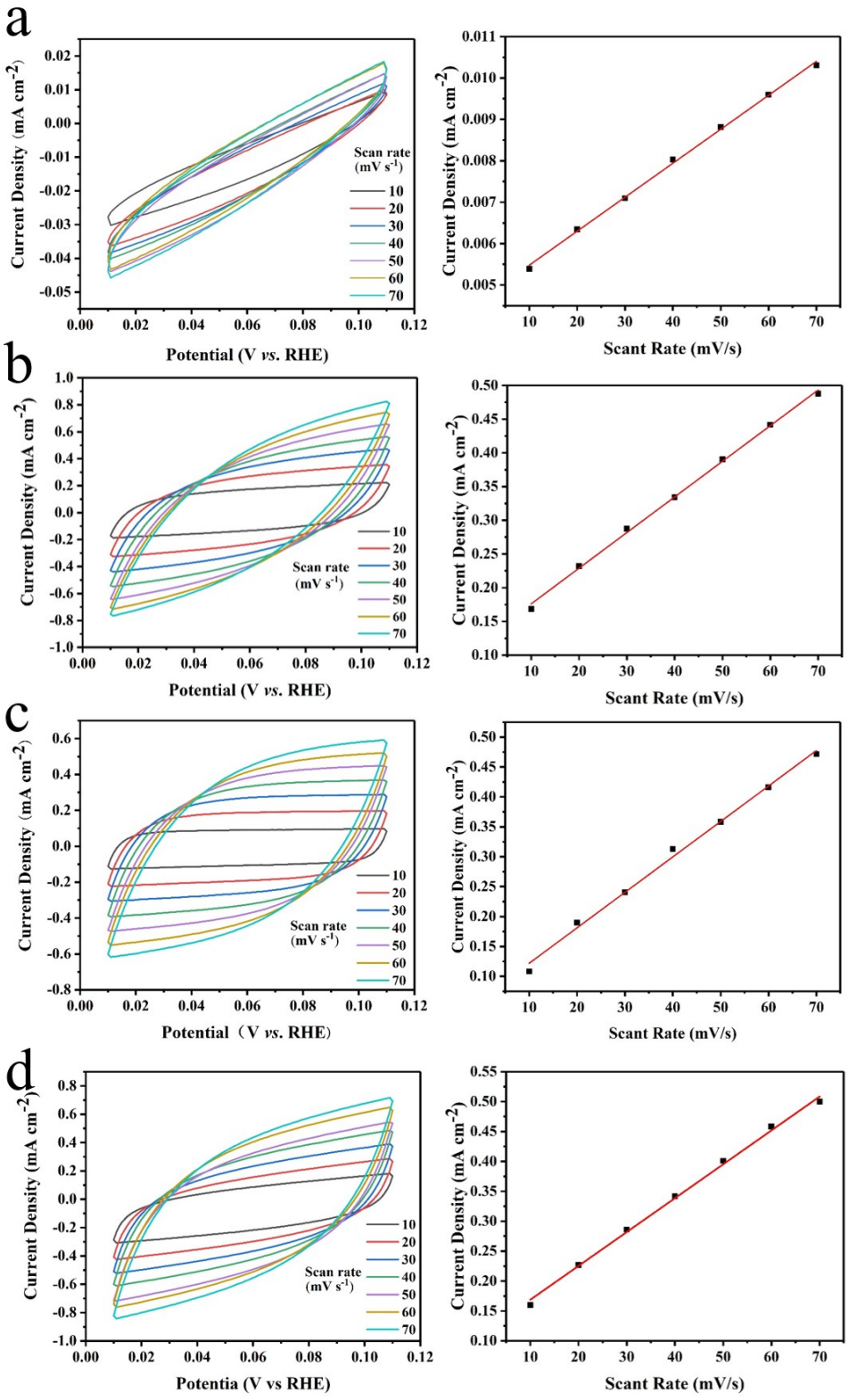

Figure S4 Presentative cyclic voltammograms within a non-faradaic potential range of (a) Cu foil，(b) Cu foam (c) Cu/CuO and(d)Cu/CuO-Ag at different scant rates from 10 to 70 mV s^{-1} in Ar-saturated 0.1 M $KHCO_3$.

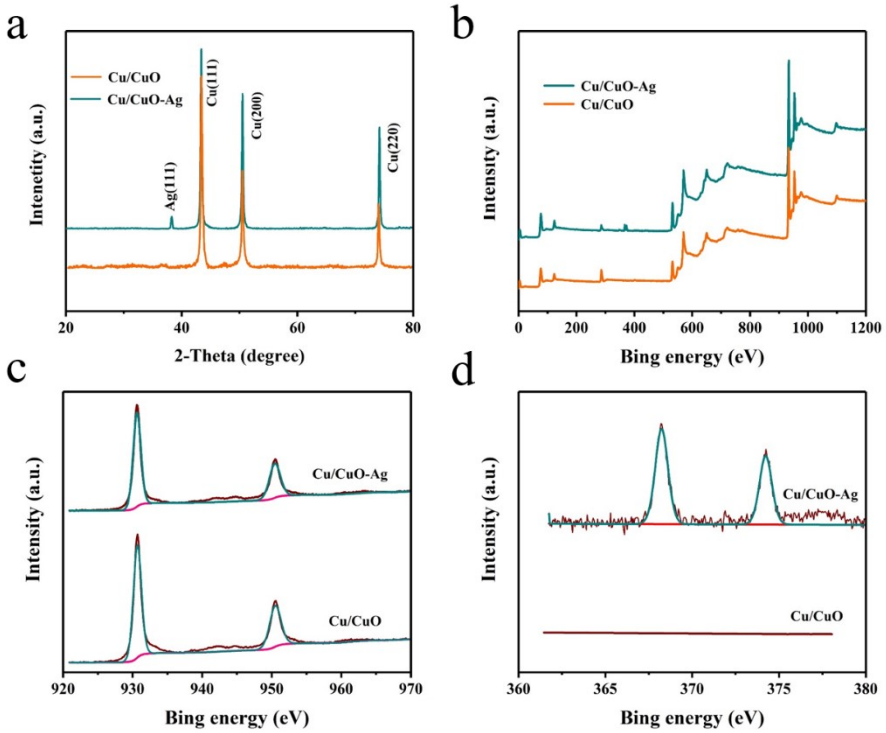

Figure S5 Chemical characterizations of Cu/CuO and Cu/CuO-Ag after 60-min electrolysis. (a) XRD patterns (b) XPS survey spectra, and (c) (d)high-resolution XPS spectra of Cu2p and Ag3d after 60-min CO_2 electroreduction at -2.0 V (vs. Ag/AgCl).

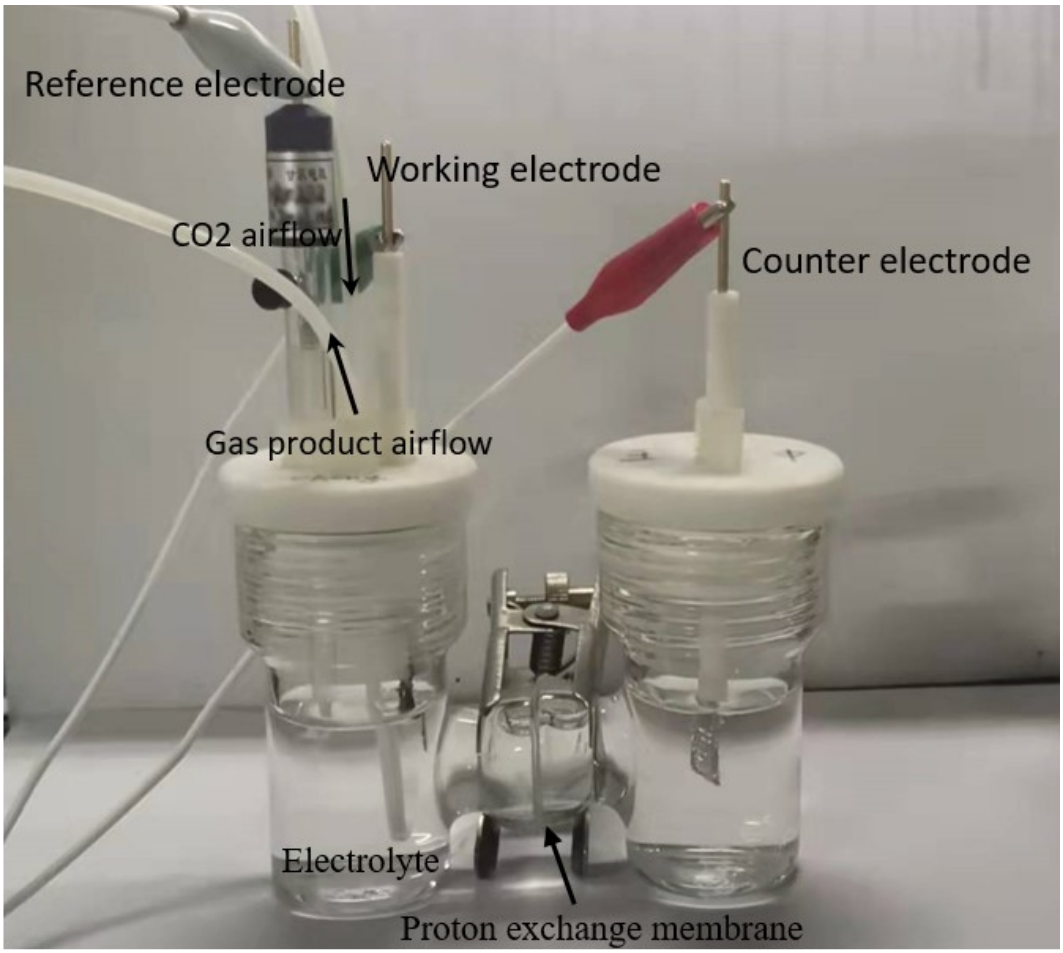

Figure S6 A photograph of the electrochemical peek cell used for CO_2 reduction experiments in this work. The custom-built cell is separated into two compartments by an anion exchange membrane. The working electrode (WE) is held in the airtight cathodic compartment, with the reference electrode (RE) placed nearby.

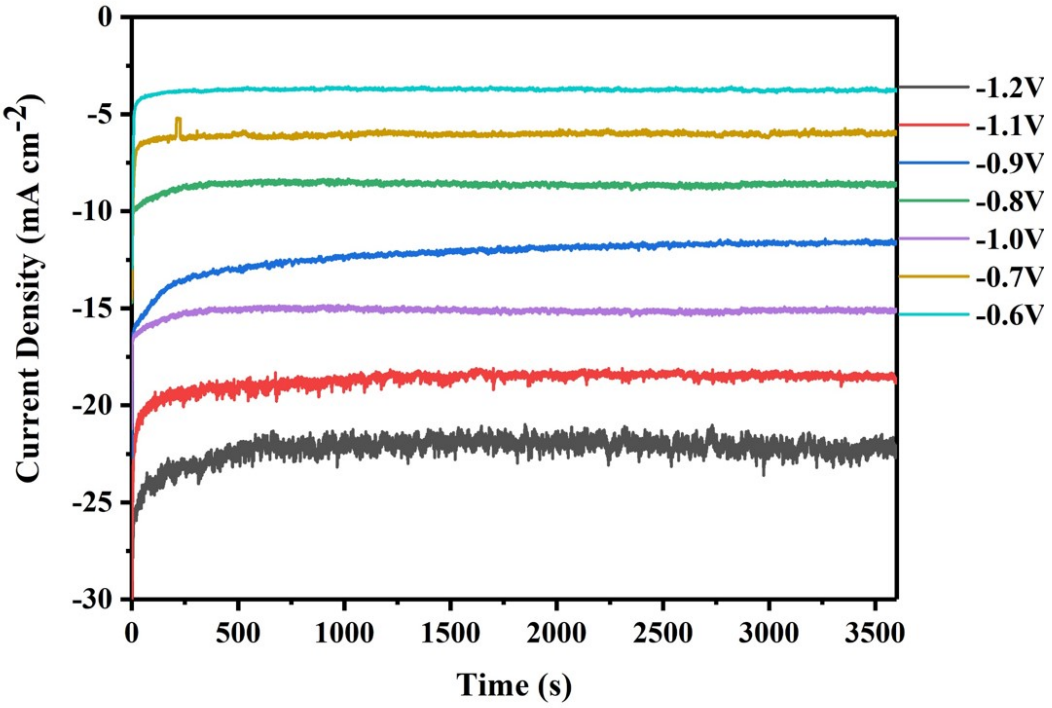

Figure S7 Representative chronoamperograms Cu/CuO-Ag cathodes over 60-min electrolysis at different potentials.

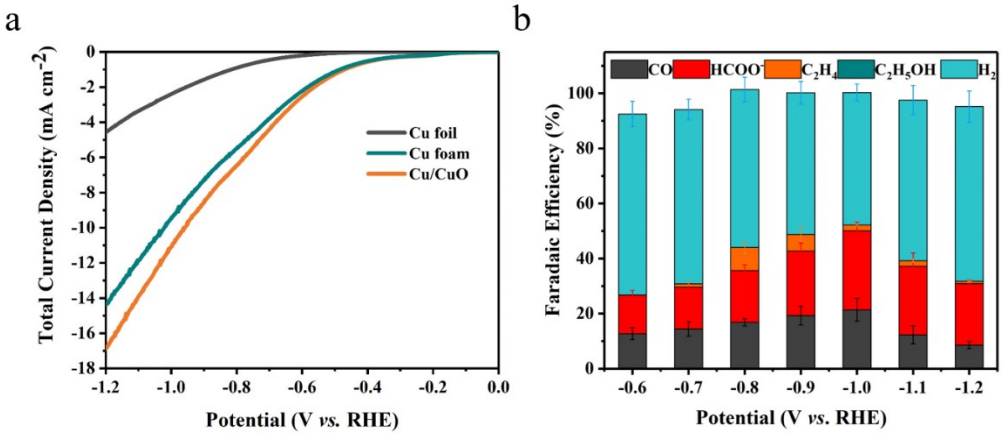

Figure S8 (a) LSV curves of Cu foil,Cu Porous and Cu/CuO-Ag. (b)FEs for each gaseous product (H_2, CO, C_2H_4) and for the main liquid product ($HCOO^-$) over Cu foam in the potential range from -0.8 to -1.2 V (vs. RHE).

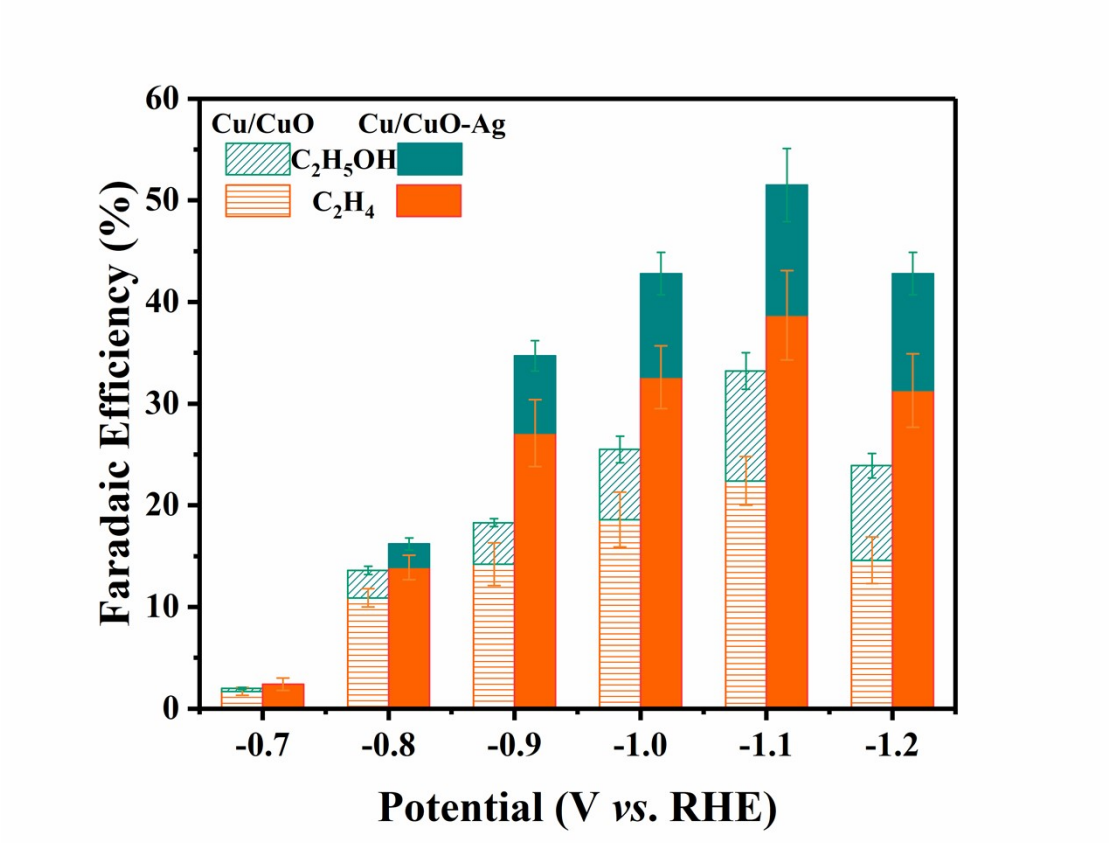

Figure S9 FEs for C_{2+} product of Cu/CuO-Ag1 Cu/CuO-Ag and Cu/CuO-Ag5 in the potential range from -0.7 to -1.2 V (vs. RHE).

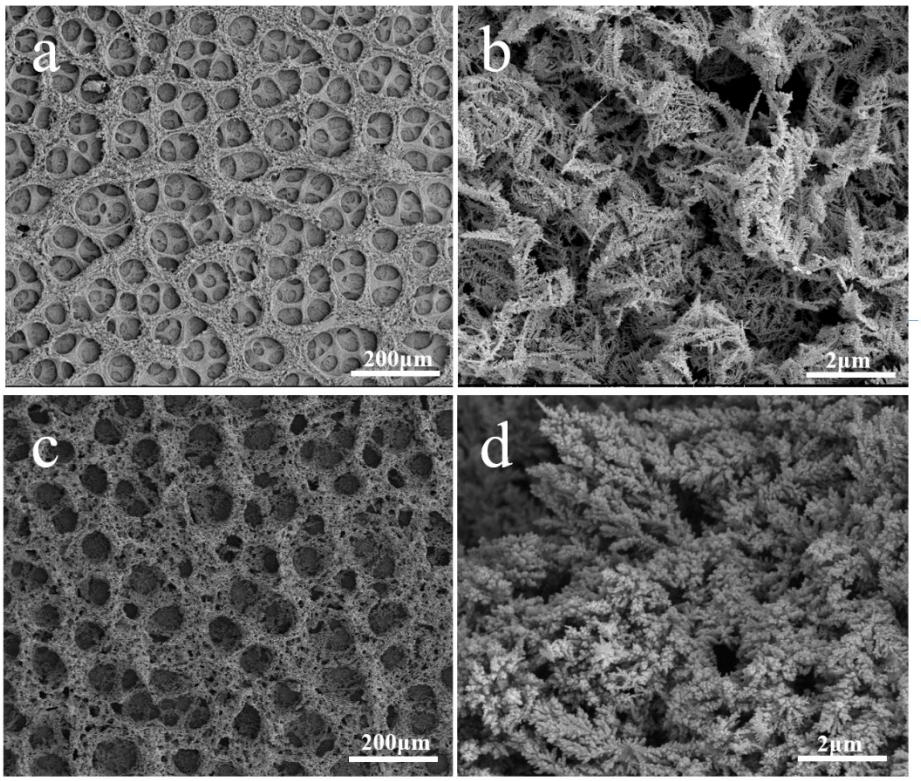

Figure S10 (a), (b) SEM images of Ag foam. (c), (d) SEM images of Cu-Ag.

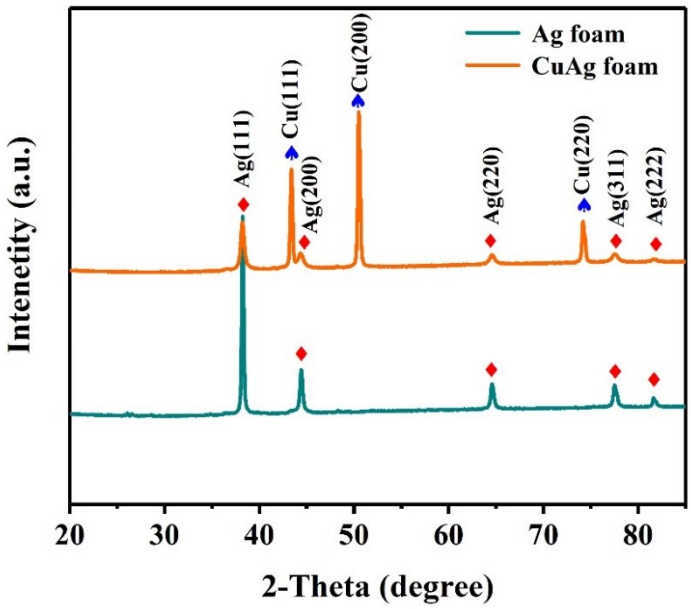

Figure S11 XRD patterns of Cu/CuO and Cu/CuO-Ag.

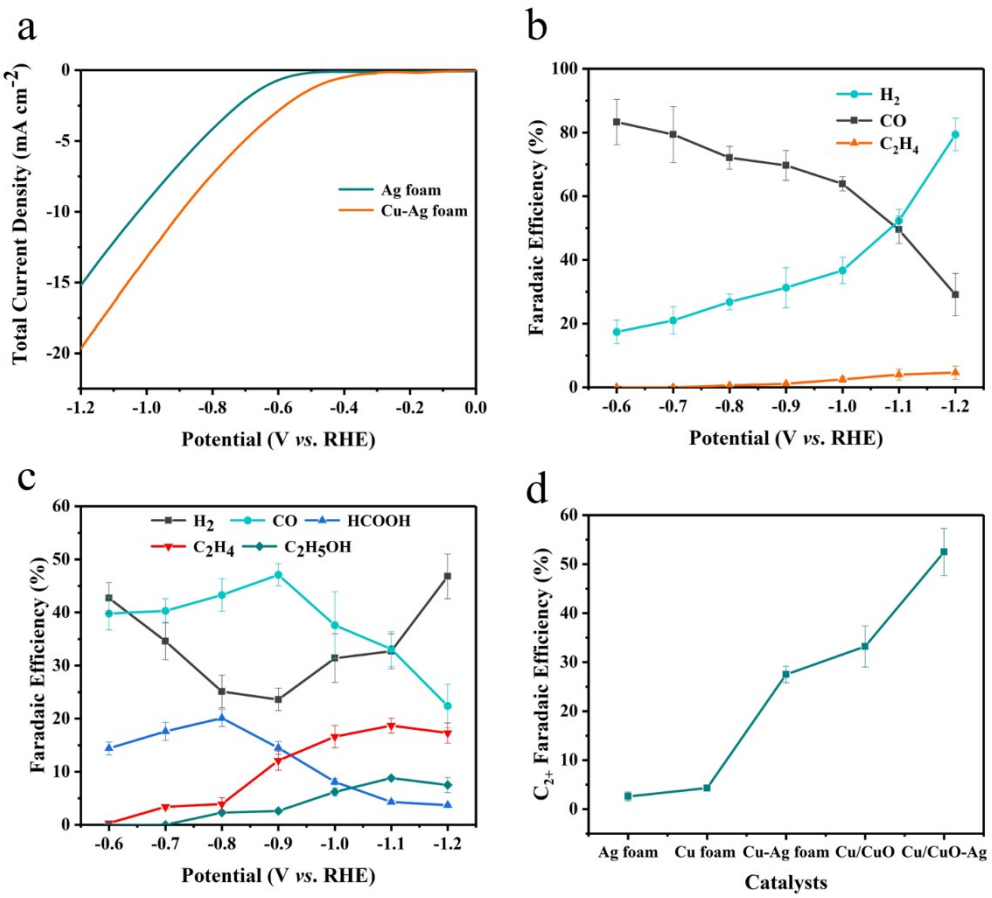

Figure S12 (a) LSV curves of Ag foam and Cu-Ag foam. FEs for representative products over (b) Ag foam, (c) Cu-Ag foam in the potential range of -0.8 to -1.2 V (vs. RHE). (d) FEs for C_{2+} product of Ag foam, Cu foam, Cu-Ag foam, Cu/CuO and Cu/CuO-Ag at -1.1V (vs. RHE).

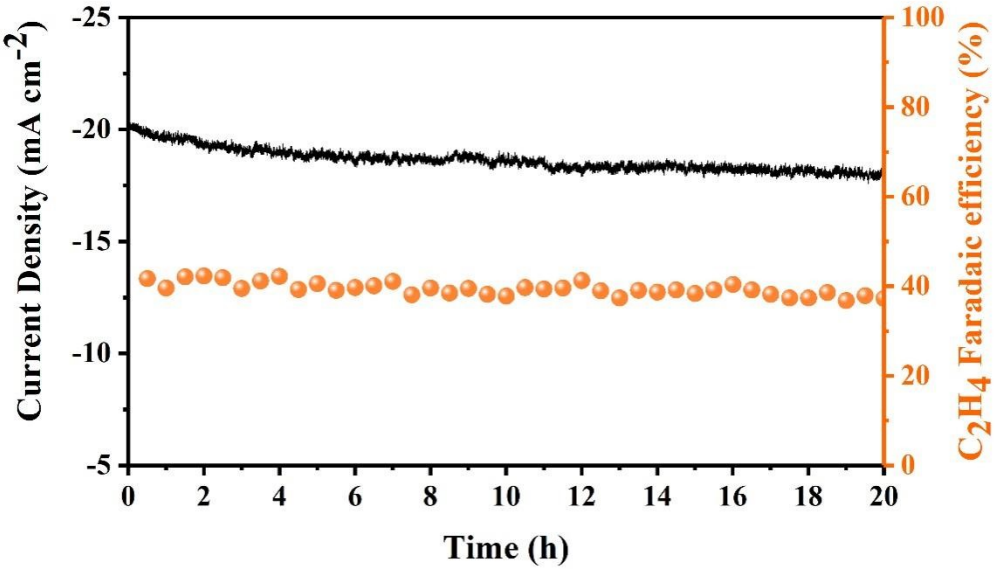

Figure S13 The FE of C_2H_4 and total current density of the Cu/CuO-Ag catalyst over 20 hours at -1.1V (vs. RHE).

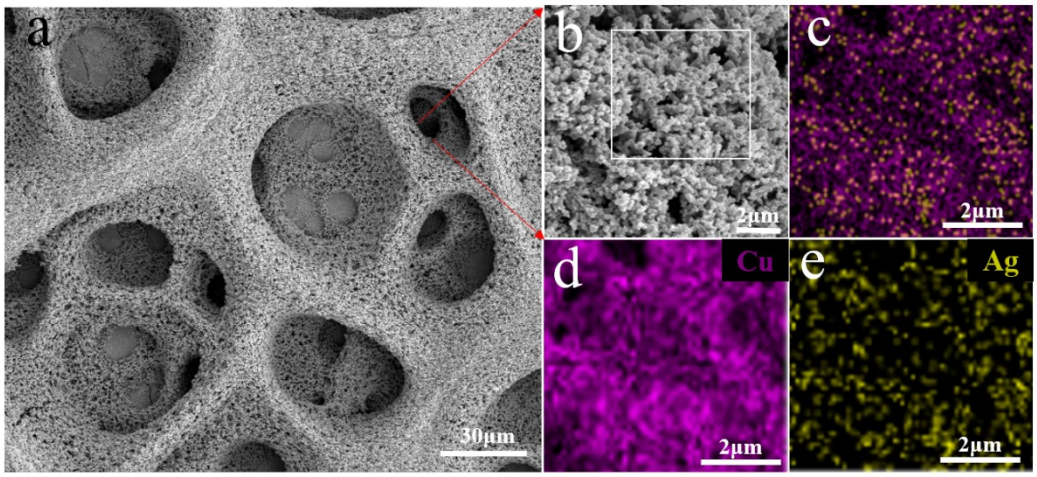

Figure S14 (a) (b) SEM images of Cu/CuO-Ag; (c-e) EDX images of overlap, Cu, and Ag of Cu/CuO-Ag.

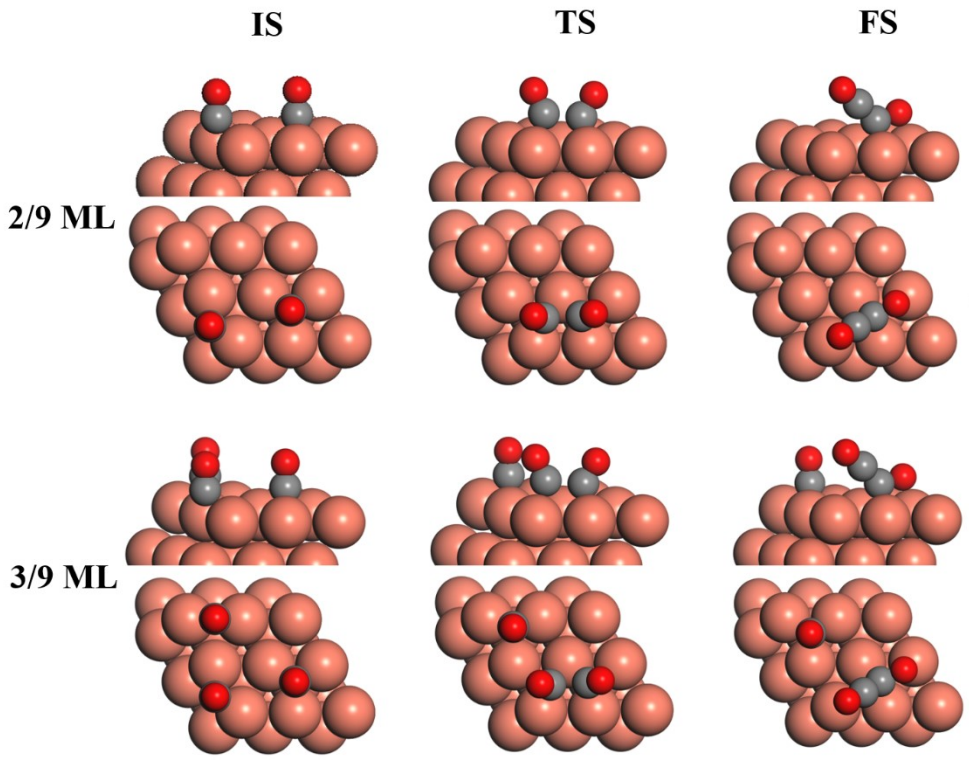

Figure S15 Corresponding configurations of initial, transition and final states on the CO coverage of 2/9 ML and 3/9 ML. The colors are Cu in orange, C in grey, and O in red; FS, initial state; TS, transition state; FS, final state.

Table S1 The roughness of Cu and CuAg catalysts estimated from double layer capacitance.

catalyst	Capacitance mF	Roughness factor
Cu foil	0.61±0.017	-
Cu porous	4.69±0.134	76.89±2.196
Cu/CuO	5.51±0.15	90.33±2.607
Cu/CuO-Ag	5.18±0.146	86.56±2393

Table S2 Adsorption energy of CO on Cu(111) surface with different coverage.

CO* coverage(ML)	1/9 ML	2/9 ML	3/9 ML
Eads (eV per adsorbed CO*)	-0.88255352	-0.818094105	-0.756631863

Table S3 Recently reported highly-active catalysts for CO_2 reduction in aqueous solution.

Catalysts	Electrolyte	Main C_{2+} Product	Potential (V_{RHE})	Electrolytic cell	FE (%)	Ref.
Cu/CuO-Ag	0.1M $KHCO_3$	C_2H_4	-1.1V	H-cell	38.7%	This work
CuAg alloy	1 M KOH	C_2H_5OH	-1.1V	Flow cell	~ 25%	S1
Cu(111)@Cu-THQ	0.1M $KHCO_3$	C_2H_4	-1.4V	H-cell	42%	S2
Ag1–Cu1.1 NDs	0.1M $KHCO_3$	C_2H_4	-1.1V	H-cell	~ 40%	S3
AuCu400	1MKOH	C_2H_4	-1.3V	Flow cell	~ 37%	S4
$Au_1Ag_1Cu_6$	0.1M $KHCO_3$	C_2H_5OH	-0.8V	H-cell	37.5%	S5
Cu@Ag0.1nm	1M KOH	C_2H_4	NA	Flow cell	27%	S6
Ag/Cu	0.1M $KHCO_3$	C_2H_4	NA	H-cell	42%	S7
Cu_4Zn	0.1 M $KHCO_3$	C_2H_5OH	-1.05V	H-cell	29.1%	S8
Porous Cu	1 M KOH	C_2H_4	-0.68V	Flow cell	29 %	S9
Cu–Ag bimetallic	0.1 M $KHCO_3$	C_2H_4 C_2H_6	-0.74V	H-cell	14%	S10
Au NBP–Cu JNC	0.1 M $KHCO_3$	C2H6	-1.0V	H-cell	~40%	S11
$Au0.02Cu_2O$	0.1 M $KHCO_3$	C_2H_4	-1.3V	H-cell	24.4%	S12
Ce-Cu NPs	1M KOH	C_2H_4	-0.68V	Flow cell	53%	S13

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