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Supporting Information

Chainlike Mesoporous SnO₂ as a Well-Performing Catalyst for Electrochemical CO₂ Reduction

Katarzyna Bejtka^{,†}, Juqin Zeng^{*,†}, Adriano Sacco[†], Micaela Castellino[‡], Simelys Hernández[†], M. Amin Farkhondehfal[†], Umberto Savino^{†,‡}, Simone Ansaloni[‡], Candido F. Pirri^{†,‡} and Angelica Chiodoni[†]*

[†] Center for Sustainable Future Technologies @POLITO, Istituto Italiano di Tecnologia, Via Livorno 60, 10144 Turin, Italy

[‡] Department of Applied Science and Technology, Politecnico di Torino, Corso Duca degli Abruzzi 24, 10129 Turin, Italy

*E-mail: Katarzyna.Bejtka@iit.it, *E-mail: Juqin.Zeng@iit.it

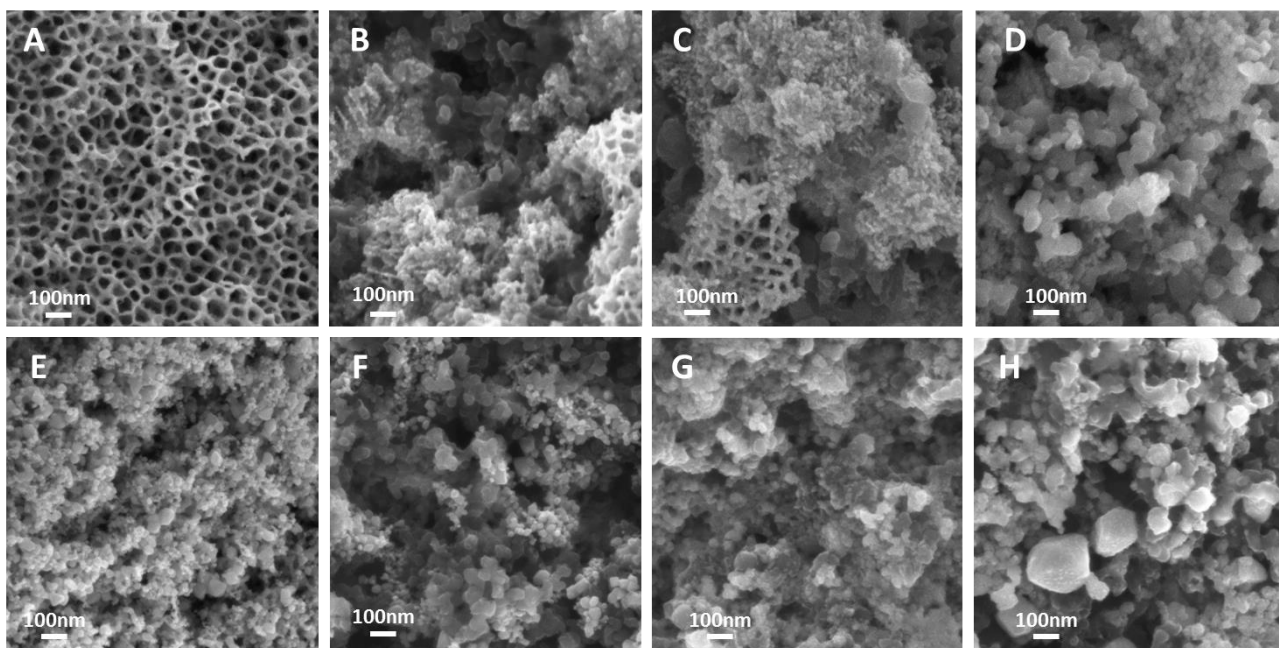


Figure S1 Top view FESEM images of the (a) as-grown SnO₂, (b) as-prepared electrode SnO₂-anod, (c) SnO₂-anod electrode reduced for 20min and (d) tested SnO₂-anod electrode, (e) commercial SnO₂, (f) as-prepared electrode SnO₂-comm, (g) SnO₂-comm electrode reduced for 20min and (h) tested SnO₂-comm electrode. All images are shown at the same magnification.

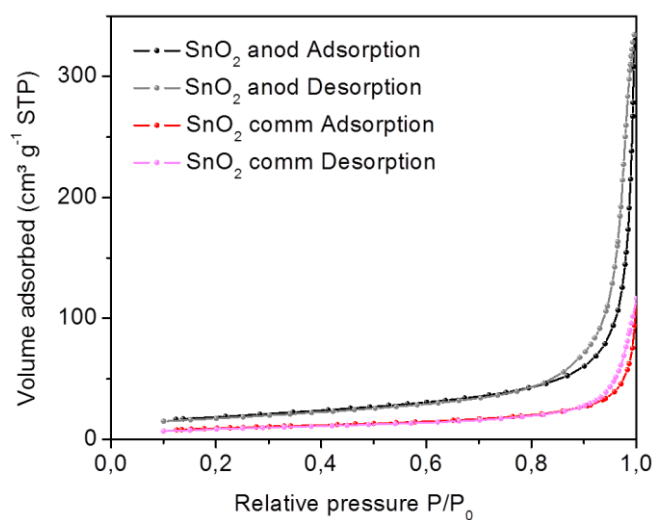


Figure S2 N₂ adsorption/desorption isotherms for SnO₂ prepared via anodic oxidation and commercial.

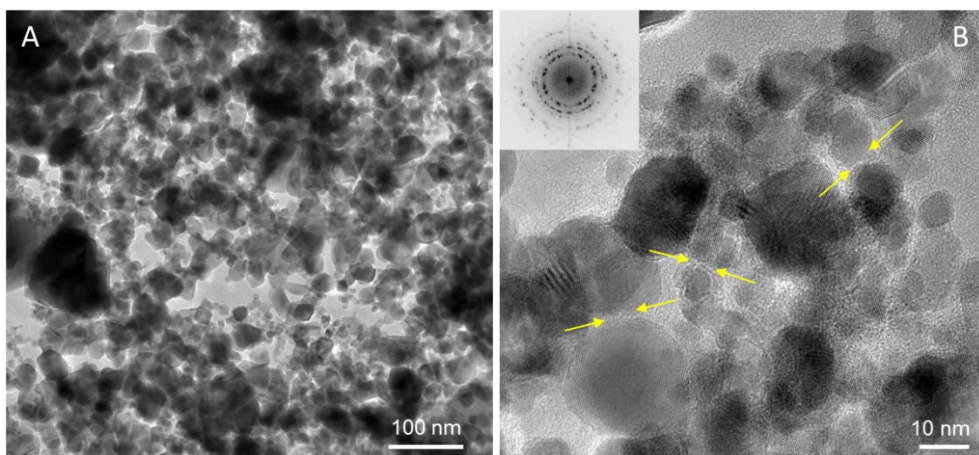


Figure S3 TEM image at two different magnification of the commercial SnO₂. In the inset the FFT of picture (b) is also reported.

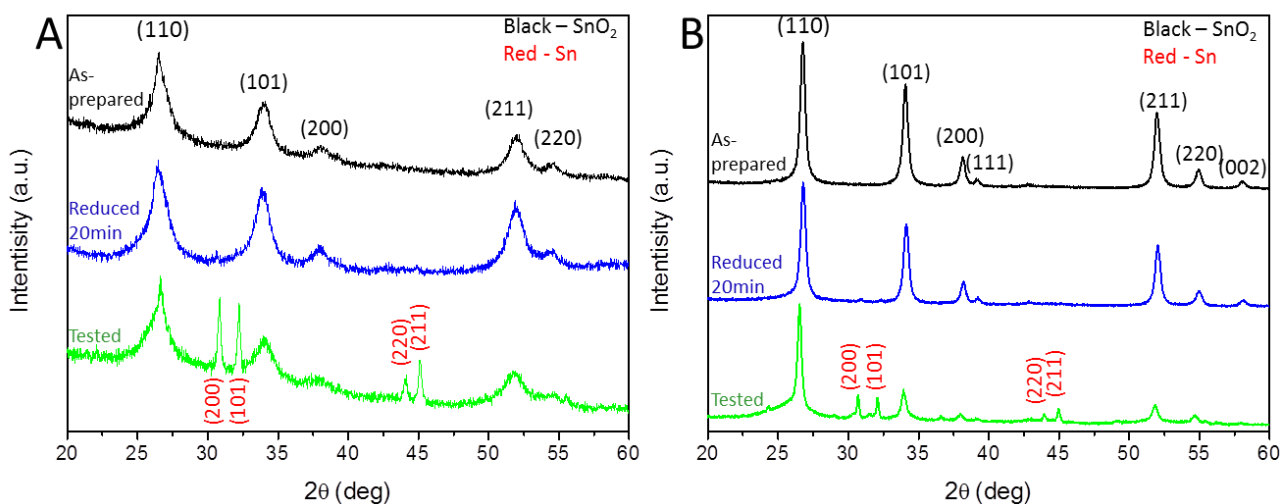


Figure S4 XRD patterns of (a) SnO₂-anod and (b) SnO₂-comm electrodes (as-prepared, reduced for 20min and tested).

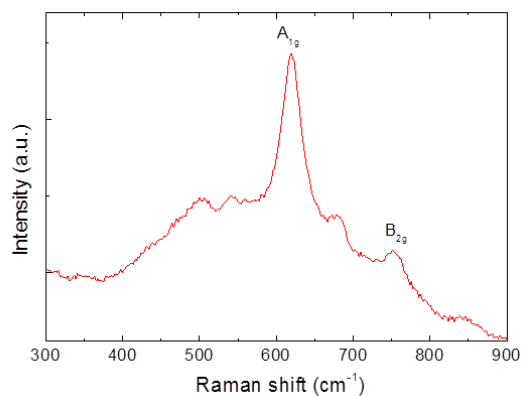


Figure S5 Raman spectrum of as-prepared SnO₂-anod electrode.

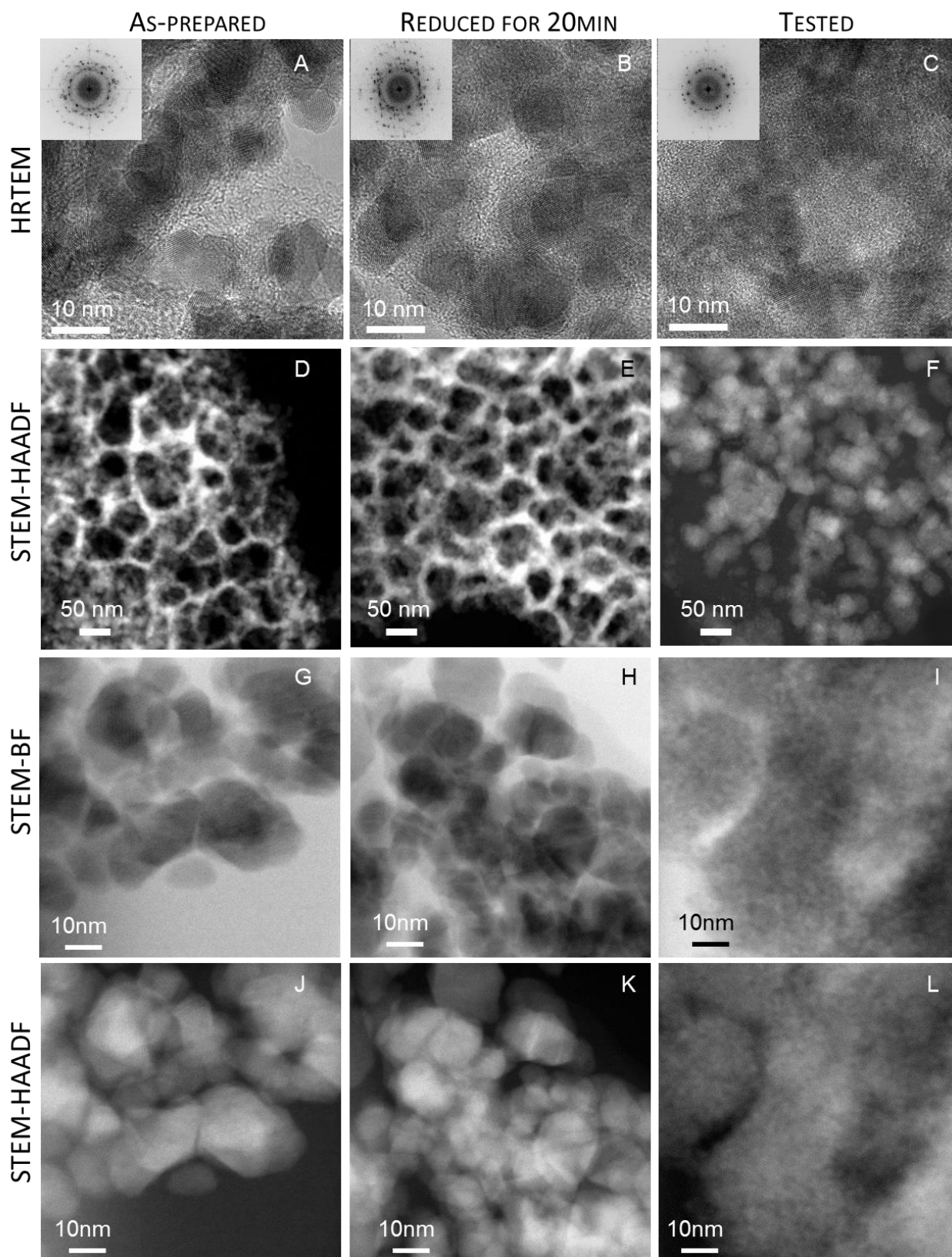


Figure S6 TEM study of the crystals evolution of the SnO₂-anod, including the as-prepared, reduced for 20 minutes and long term tested material. In the rows the following images are shown: HRTEM with FFT (of the shown area) in the inset, low magnification HAADF-STEM image, high magnification BF-STEM and HAADF-STEM.

The double-layer capacitance (C_{dl}) values of the SnO₂-comm, SnO₂-anod and Sn foil electrodes are evaluated by cyclic voltammetry (CV) at various scan rates in a potential range between -0.29 V and -0.39 V. The geometric current densities are plotted against the scan rates, and the slope of the linear fitting quantifies the double-layer capacitance C_{dl} .

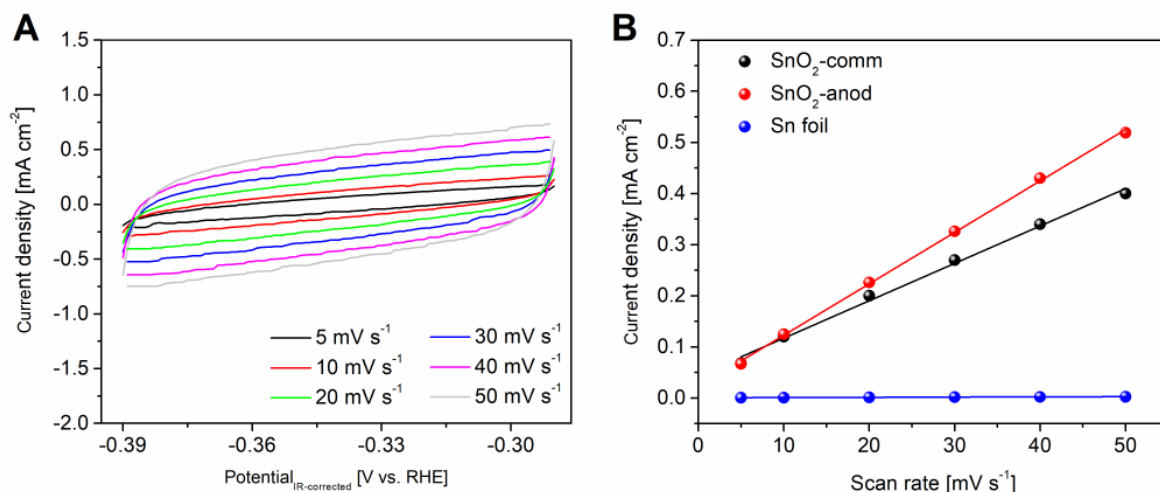


Figure S7 Determination of double-layer capacitance for various electrodes in CO₂-saturated 0.1 M KHCO₃: (a) representing CVs on SnO₂-anod electrode; (b) Capacitance values calculated from the slopes of current densities vs. scan rate.

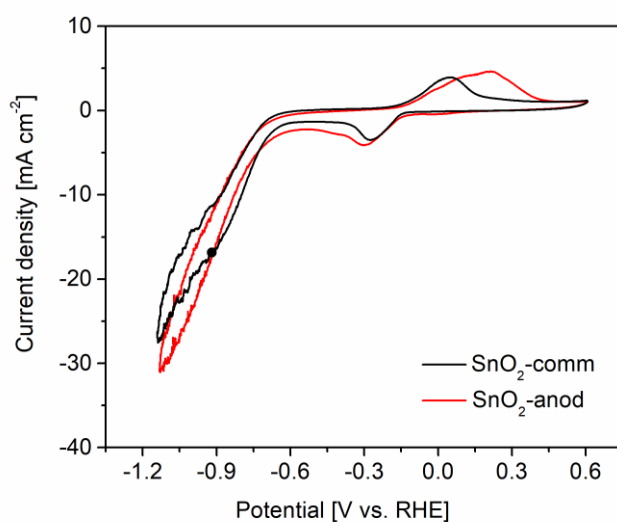


Figure S8 Comparison of the voltammograms of SnO₂-comm and SnO₂-anod in the CO₂-saturated electrolyte.

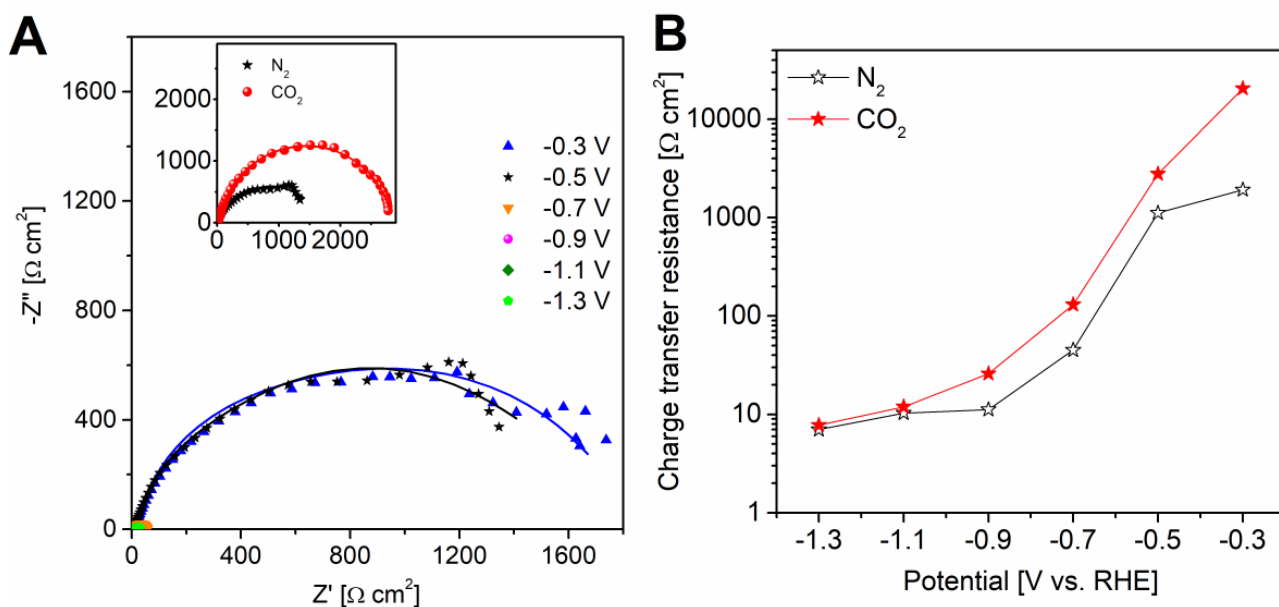


Figure S9 EIS analysis on a Sn foil electrode: (a) Nyquist plots obtained in N_2 -saturated electrolyte (the points are experimental data, the lines are the curves calculated through fitting). In the inset, the two spectra acquired at -0.5 V in N_2 - and CO_2 -saturated solutions are shown. (b) Charge transfer resistances reported as a function of the potential.

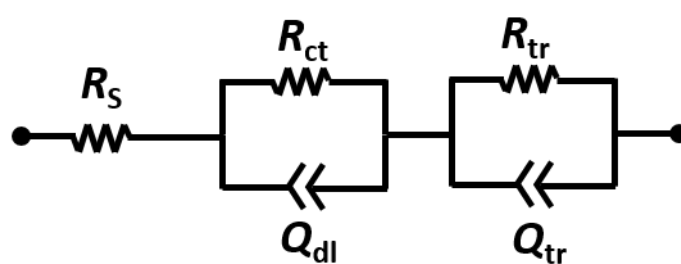


Figure S10 Equivalent circuit used for fitting of EIS data.

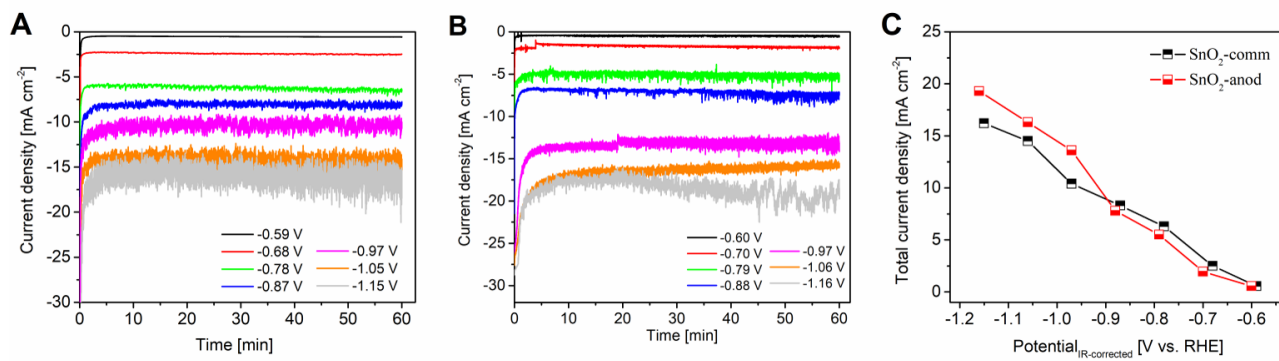


Figure S11 CA measurements carried out in CO₂-saturated 0.1 M KHCO₃ aqueous solution at different potentials: (a) SnO₂-comm; (b) SnO₂-anod; (c) Comparison of total current densities on SnO₂-comm and SnO₂-anod electrodes at various potentials.

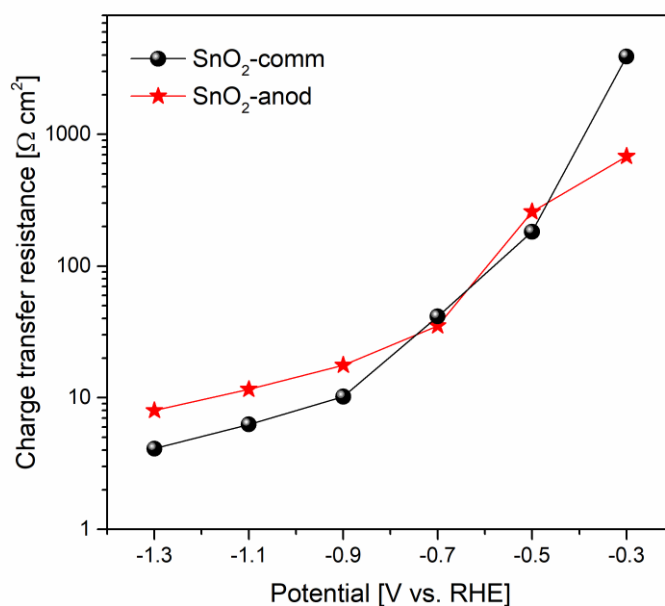


Figure S12 Comparison of charge transfer resistance obtained from EIS on SnO₂-comm and SnO₂-anod electrodes at various potentials.

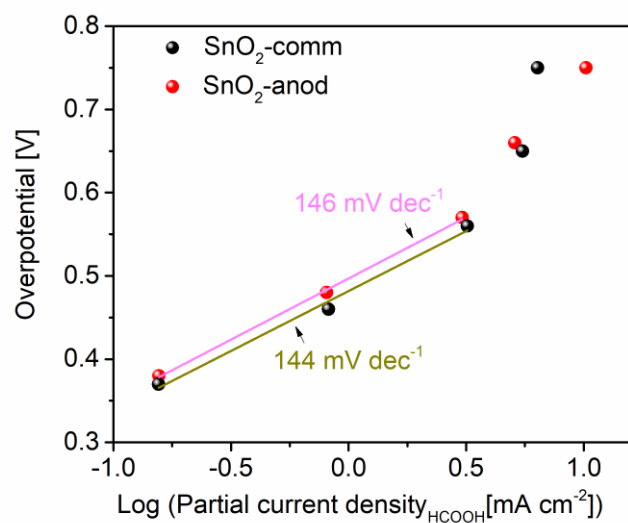


Figure S13 Tafel plot analysis for HCOOH production on SnO₂-comm and SnO₂-anod electrodes.

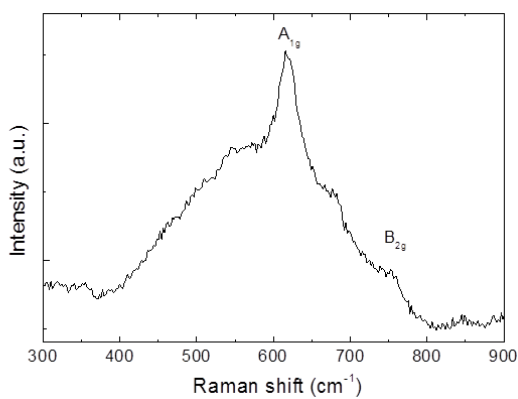


Figure S14 Raman spectrum of tested SnO₂-anod electrode.

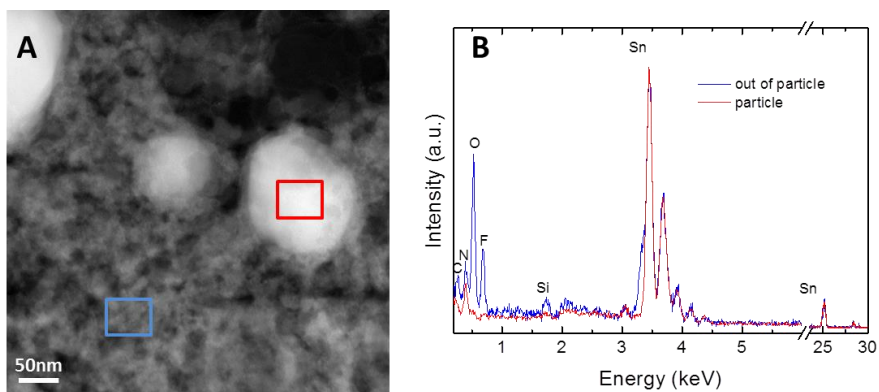


Figure S15 STEM image of the cross-section lamella of tested SnO₂-anod electrode (a) and EDX measurement performed locally in the particle and out of the particle (b).

Table S1 Comparison of electrocatalytic performance for reducing CO₂ to formic acid / formate on tin-based catalysts.

Electrode	Electrolyte	Maximum Faradic Efficiency [%]	Total current (mA cm ⁻²)	Ref
Sn/SnO ₂ porous hollow fiber	0.1 M KHCO ₃	82% @ -1.6 V (vs. SCE)	28,6	1
SnO ₂ nanosheets/Carbon cloth	0.5 M NaHCO ₃	87% @ -1.6 V (vs. Ag/AgCl)	48,6	2
SnO _x NPs	0.5 M KHCO ₃	87% @ -1.6 V (vs. SHE)	14,0	3
Electro deposited Sn	0.1 M KHCO ₃	91% @ -1.4 V (vs. SCE)	15,0	4
Sn particles	0.5 M KHCO ₃	73% @ -1.8 V (vs. Ag/AgCl)	13,5	5
SnO ₂ nanopowder	0.5 M NaOH	68% @ -0.6 V (vs. RHE)	3,5	6
SnO ₂ /graphene	0.1 M NaHCO ₃	94% @ -1.8 V (vs. SCE)	10,2	7
SnO ₂ /carbon black	0.1 M NaHCO ₃	86% @ -1.8 V (vs. SCE)	5,4	7
Sn dendrite	0.1 M KHCO ₃	72% @ -1.36 V (vs. RHE)	17,1	8
Sn - Nafion	0.5 M NaHCO ₃	70% @ -1.6 V (vs. NHE)	27,0	9
SnO ₂ /carbon aerogel	1.0 M KHCO ₃	76% @ -0.96 V (vs. RHE)	23,5*	10
SnO ₂ Porous NWs	0.1 M KHCO ₃	80% @ -0.8 V (vs. RHE)	6,0	11
SnO ₂ NPs	0.1 M KHCO ₃	58% @ -0.8 V (vs. RHE)	2,4	11
SnO ₂ at N-rGO	0.5 M NaHCO ₃	78% @ -0.8 V (vs. RHE)	21,3	12
SnO ₂ nanospheres	0.5 M KHCO ₃	56% @ -1.1 V (vs. RHE)	6,0*	13
Mmesoporous SnO ₂	0.1 M KHCO ₃	40% @ -0.8 V (vs. RHE)	5.0	14
		40% @ -1.4 V (vs. RHE)	21.3	14
Chain-like mesoporous SnO ₂	0.1 M KHCO ₃	82% @ -1.06 V (vs. RHE)	16,3	This work
		80% @ -1.15 V (vs. RHE)	19.3	This work
SnO ₂ nanopowder	0.1 M KHCO ₃	43% @ -1.15 V (vs. RHE)	16.2	This work
		67% @ -0.87 V (vs. RHE)	8.3	This work

* estimated on the basics of information given in the paper

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