catCHy

EUROPEAN TRAINING NETWORK

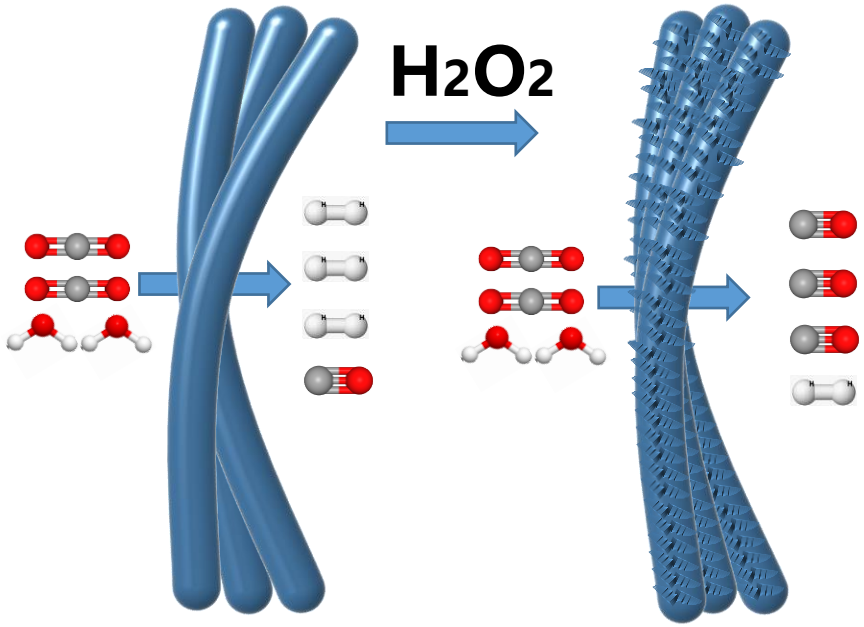
Novel catalysts for CO_2 Hydrogenation and Electro-reduction

Mid-Term Review

vito

KU LEUVEN

Clusters modified copper based catalysts for electrochemical CO_2 reduction



Supervisors: Deepak Pant (VITO)
Ewald Janssens (KUL)

Presenter: Wenjian Hu
(ESR 13, VITO/KUL)

Email: Wenjian.hu@vito.be

BME and FETI, Budapest, April 22, 2022

WP5-Catalysts Testing and Prototyping of a Model Gas Diffusion Electrode

- Fabrication of clusters/catalysts into Gas Diffusion Electrodes (GDEs)
- Electrochemical testing of catalysts in H-type cell and flow cells
- Synthesis of Nanoscale Catalysts by Wet Chemical Method

Copper selenides for electrochemical CO_2 reduction

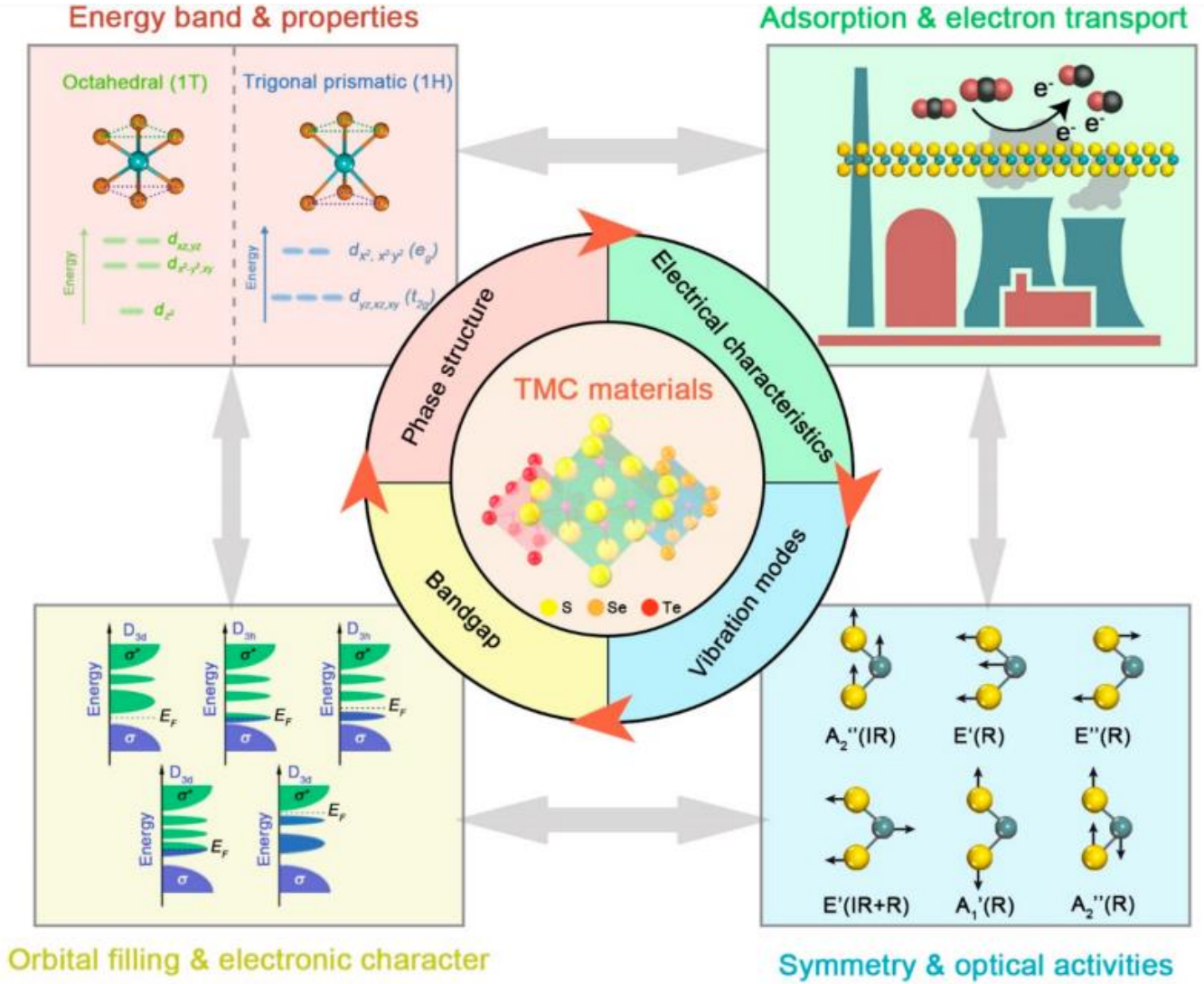


Figure 1. Schematic illustration of the characteristics of transition-metal chalcogenides including phase structure, electrical characteristics, bandgap, and vibration modes.

As transition metal chalcogenides (TMCs)

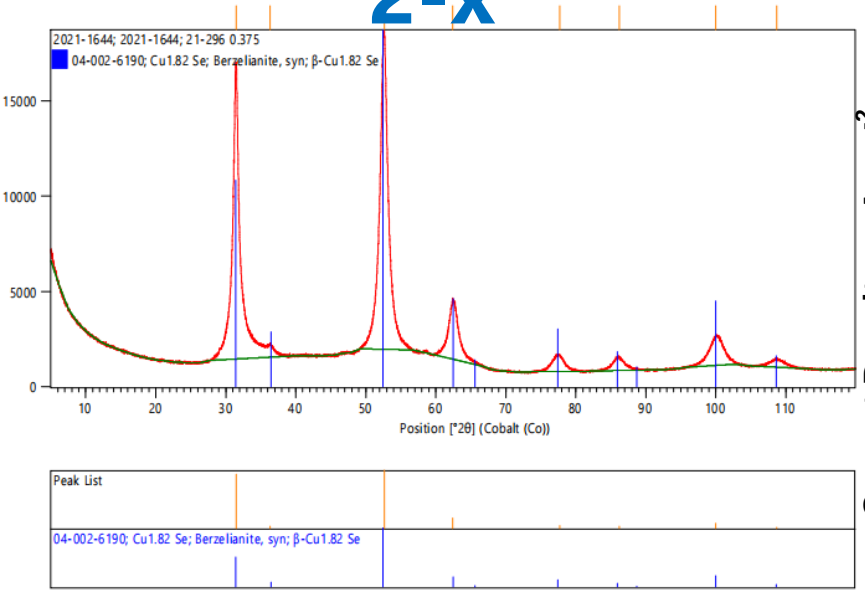
Low cost

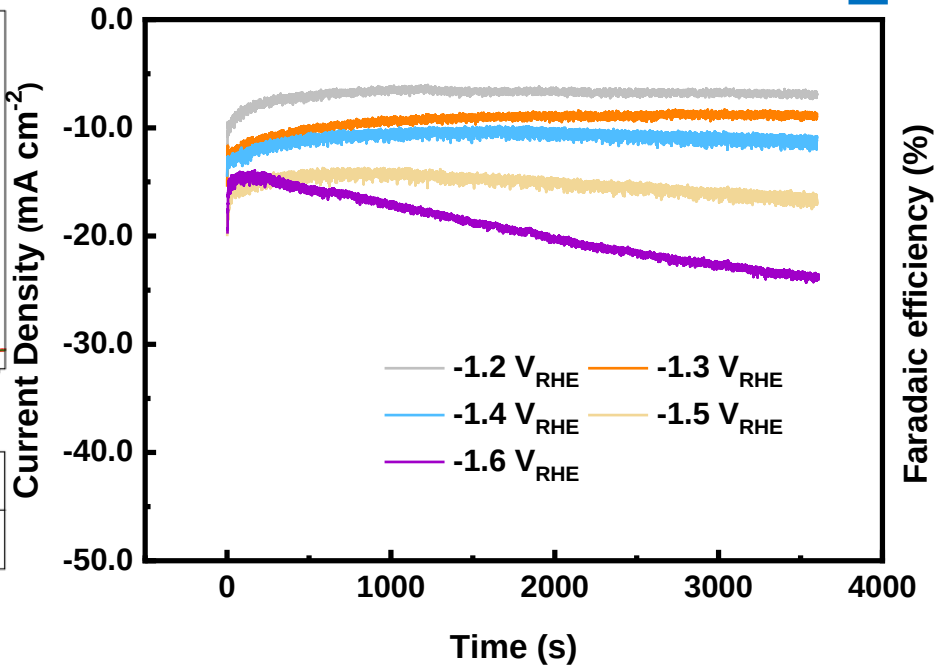
Structure stability

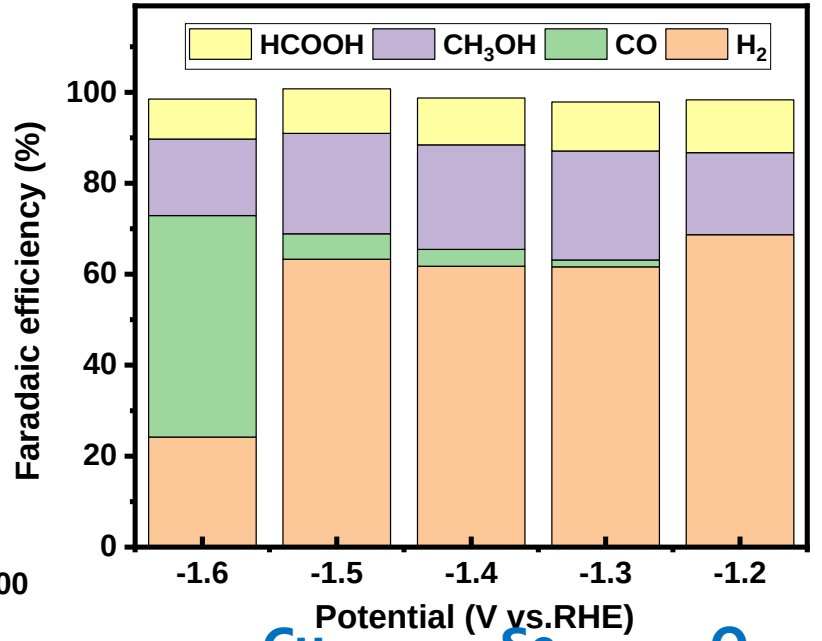
Composition dependent electrical properties

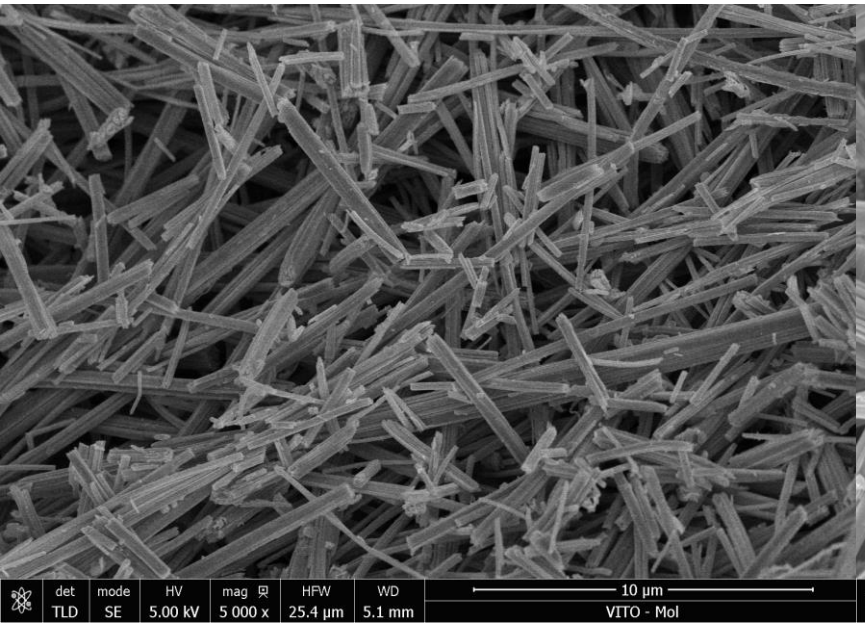
Min-Rui Gao* et al. Energy Fuels 2021, 35, 12869−12883

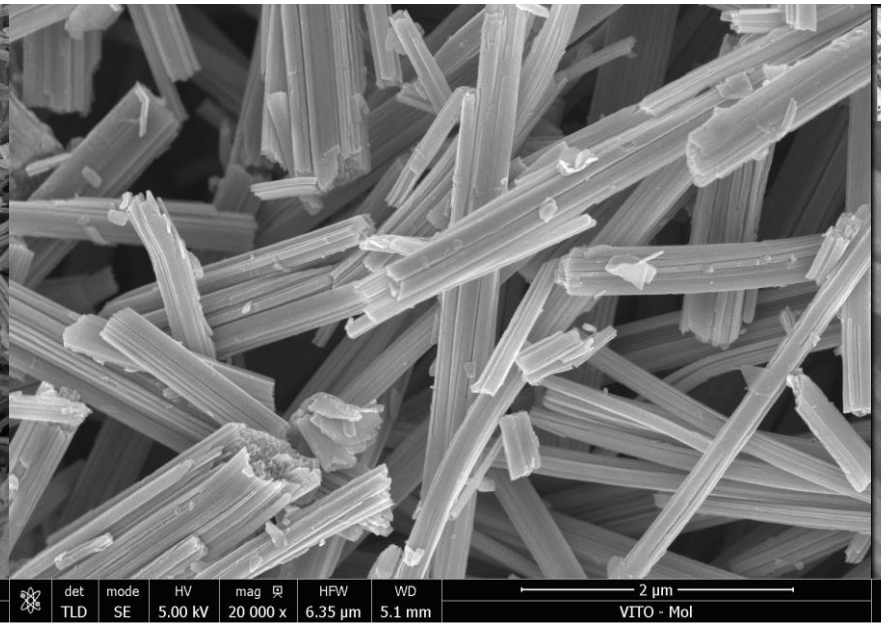
$Cu_{2-x}Se$ nanowires for CO_2 reduction

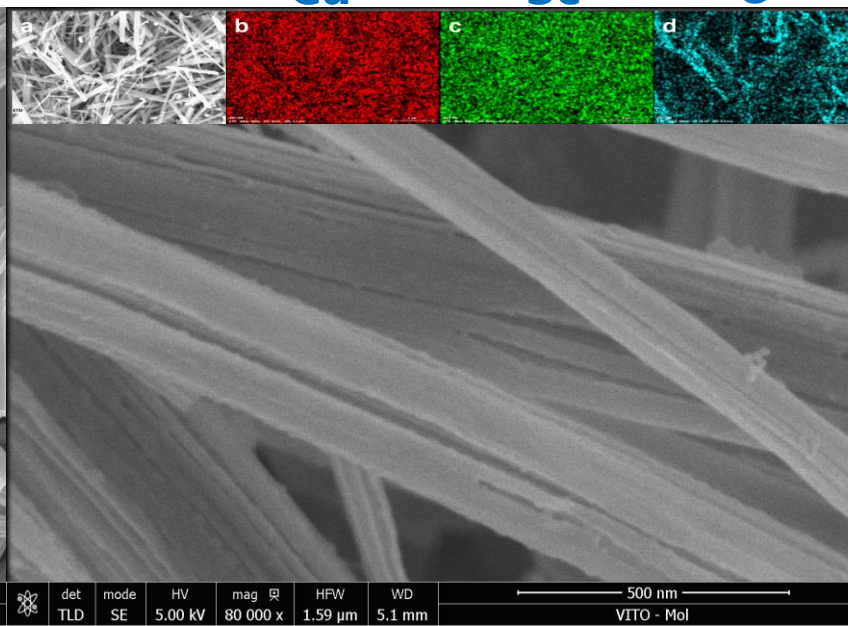




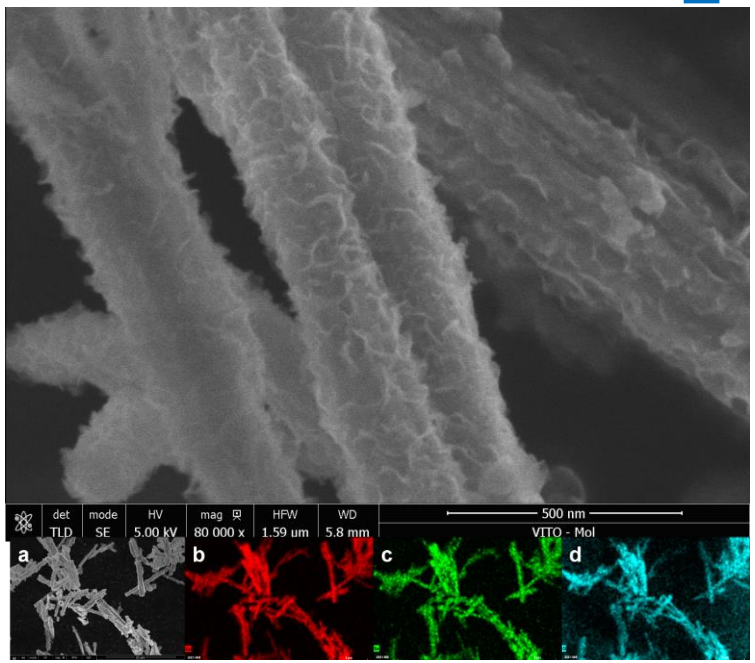




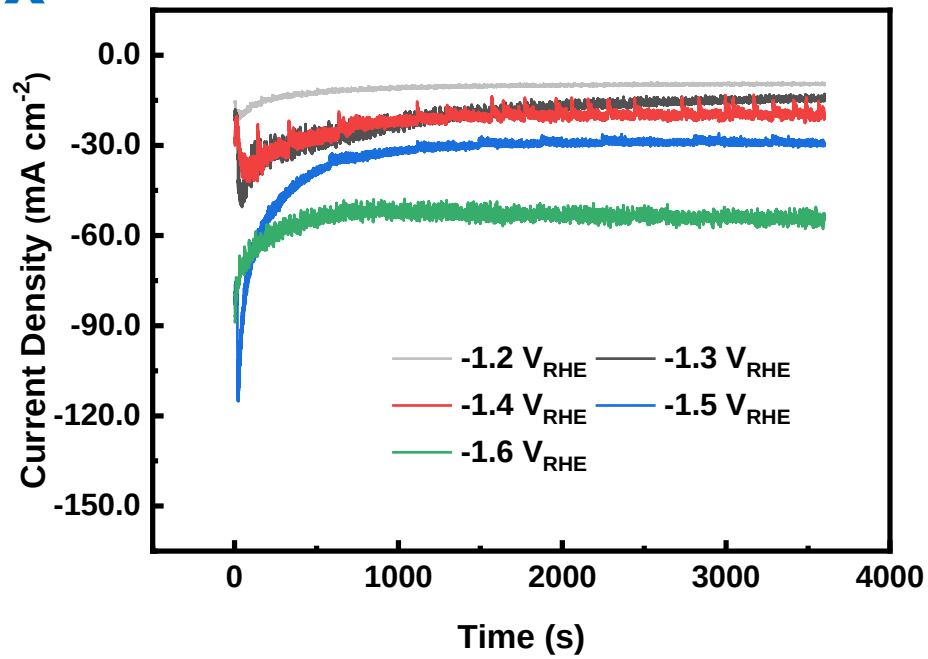


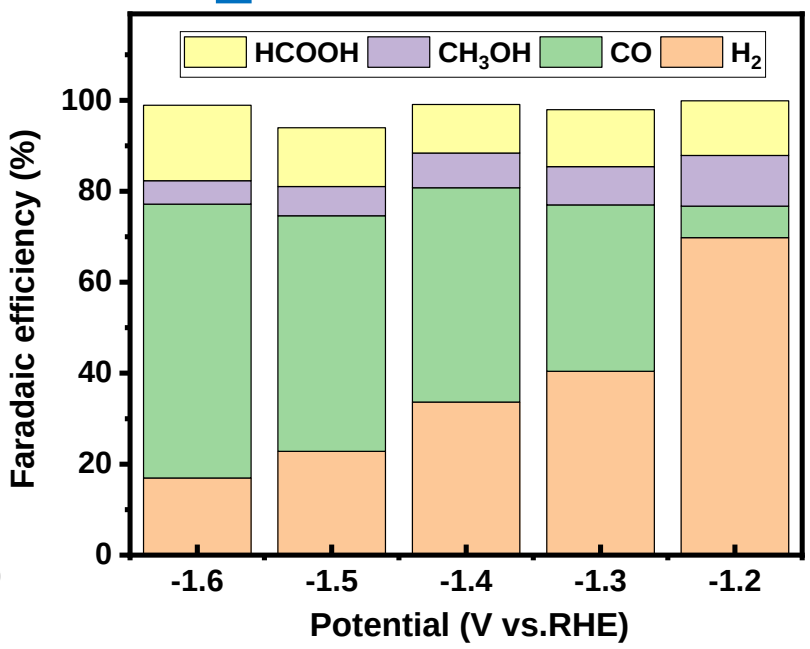


Oxidized $Cu_{2-x}Se$ nanowires for CO_2 reduction



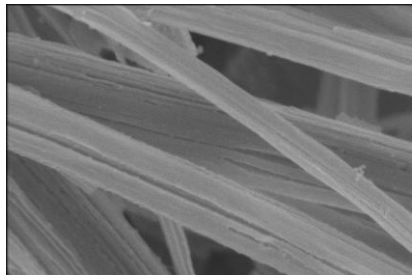
Cu Se O



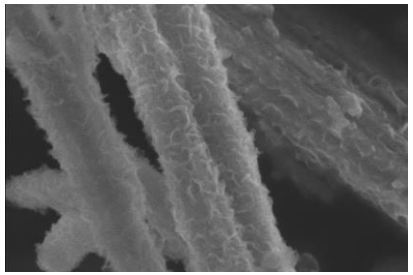


Conclusion

- Appropriately oxidized $Cu_{2-x}Se$ nanowires can provide more active sites for ECR of CO_2 to CO.
- The optimized $Cu_{2-x}Se$ catalysts exhibited a promoted CO_2RR performance with a Faradaic efficiency of 60.2% for CO and a highest partial current density of 36 mA cm^{-2}.
- More tests and characterizations are needed to analyze the reasons for the better performance.



<



Combination of factors?

Electrochemical active area?

BET, ECSA, SEM after reaction—— VITO
TEM——UA

Valence state of Cu?

XRD after reaction——VITO
XPS of Cu—— KUL
XANES of Cu——ESRF

Oxygen or hydroxyl species?

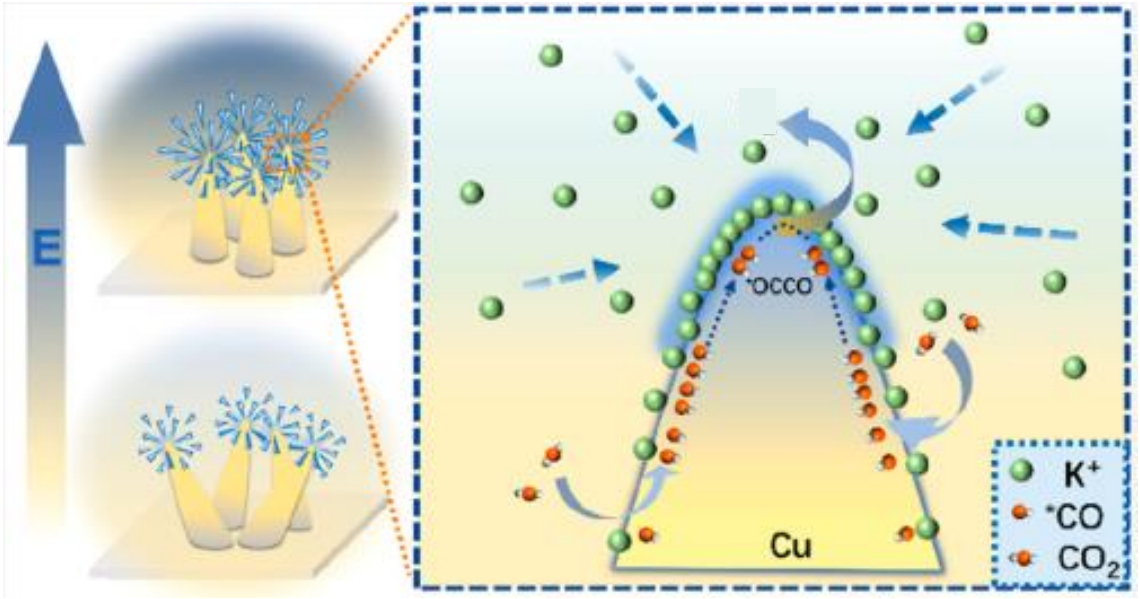
Raman spectra of OH——KUL
XPS of O—— KUL

Even the valence state of Se or its precipitation?

XPS of Se—— KUL

Step 2: Further increase CO seletivity by Zn cluster modification

1. There is adsorption and activation effect on CO_2 of Zn cluster



Teer coatings

João Coroa – ESR 2

0.2% loading

Each clusters around 5000 8000 11000 atoms of Zn

2. Enhance the local electric field promoting CO production

Min Liu* et al. Nano Lett. doi.org/10.1021/acs.nanolett.1c04653

Research plan 2

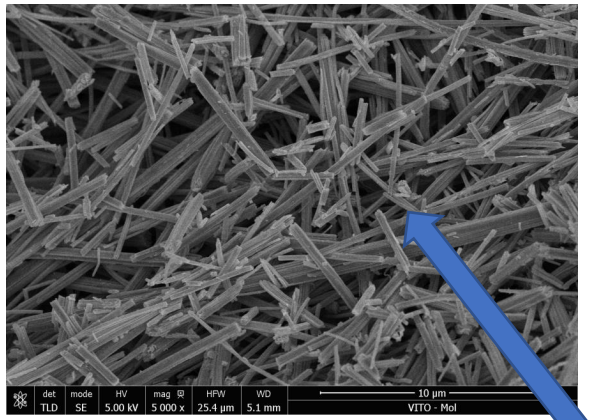
Engineering of the gas diffusion electrodes and reactor for Pilot experiment

Systematic engineering

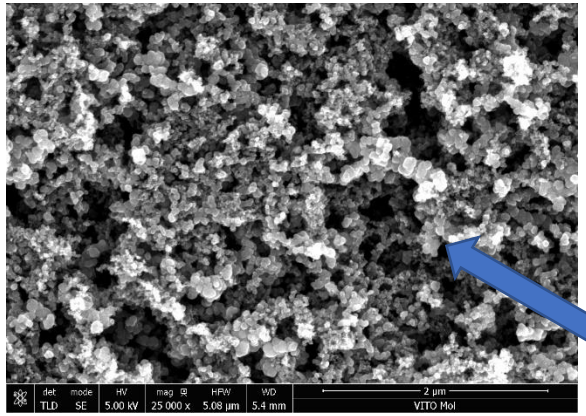
Cataly
Gas d
Electr
Electr
Membrane…

All these matters!

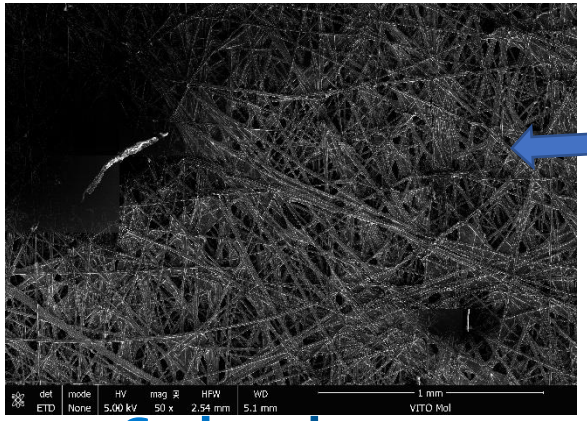
Gas diffusion electrode



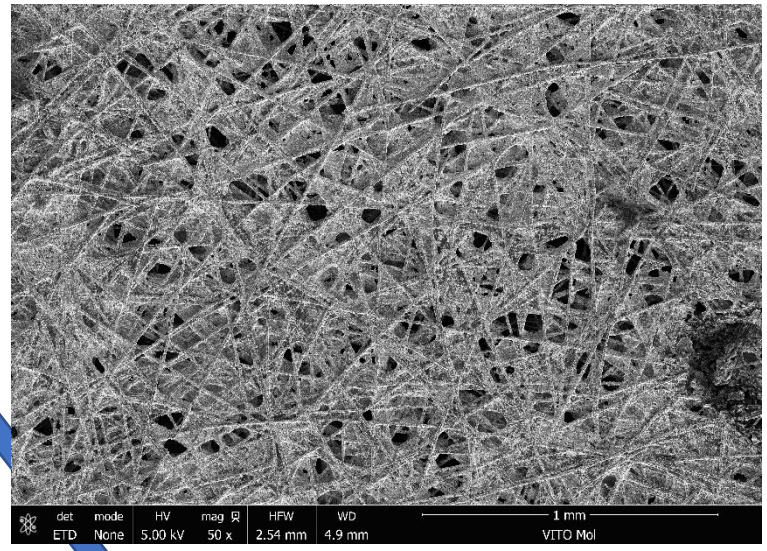
$Cu_{2-x}Se$ nanowires

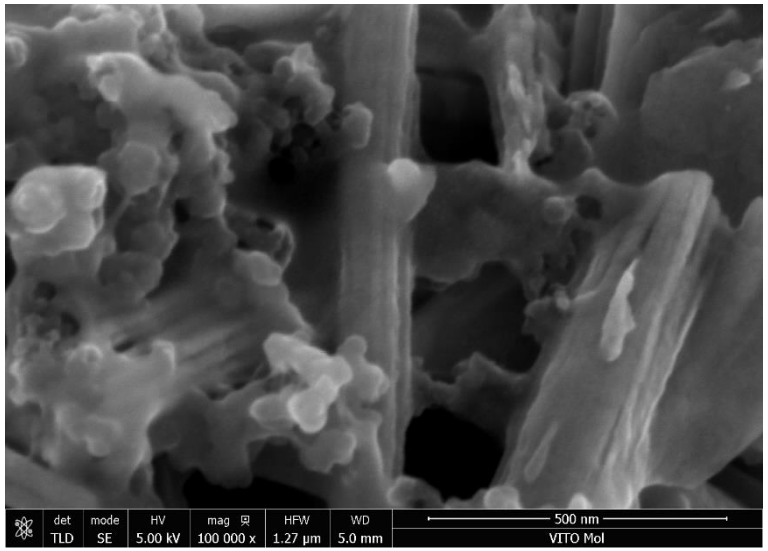


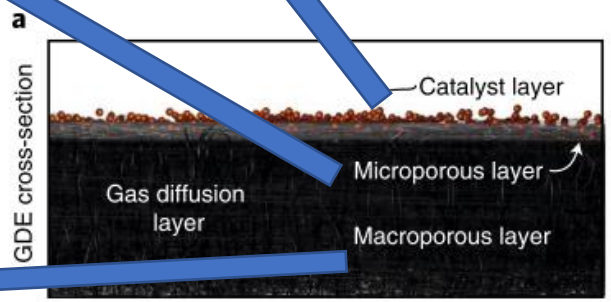
Carbon black

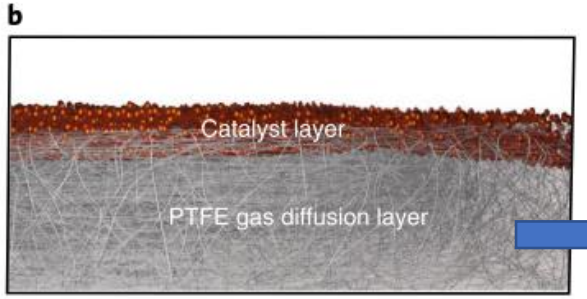


Carbon layer

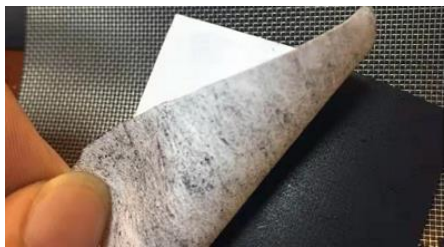


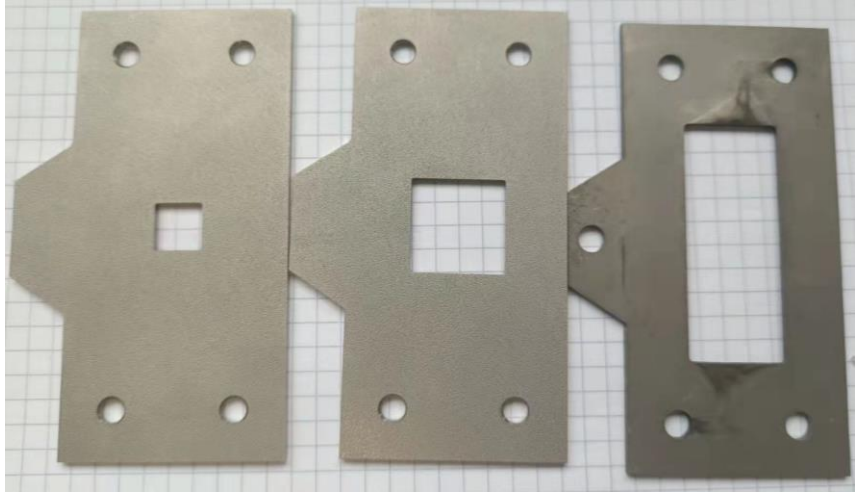






Edward H. Sargent*, Thomas F. Jaramillo*, Christopher Hahn* and et al. Nature Energy, volume 7, 130–143 (2022)



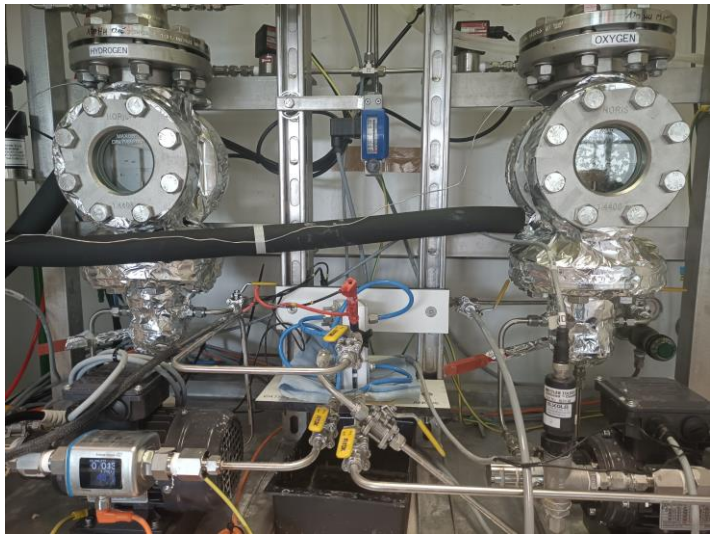


From lab scale:

1 cm², 4 cm², 10 cm²

To Pilot scale:

20 cm² up to 600 cm²



Booster:
20V 20A

High pressure reactor: 20 bar

In this PhD

Collaborations

João Coroa (ESR 2) —— Clusters
Imran Abbas (ESR 1) and Dimitra Papamichail (ESR 8) —— Clusters and XPS, Raman spectra…
Deema Balalta (ESR 10) —— (S)TEM…
Maximilian Winzely (ESR 14) —— In situ XAS
Filippo Romeggio (ESR 11) and Esperanza Sedano Varo (ESR 12) —— Secondment in DTU, January, 2023

Potential Collaborations

Bárbara Zamora Yusti (ESR 6) —— Theoretical modelling
For all the ESRs —— Catalysts Testing and Prototyping of a Model Gas Diffusion Electrode (WP5)

Thank you!