Synthesis of Copper Nanoflakes

Diotime Pellet, Elif Nur Dayi, Giulia Tagliabue

Laboratory of Nanoscience for Energy Technologies (LNET), EPFL

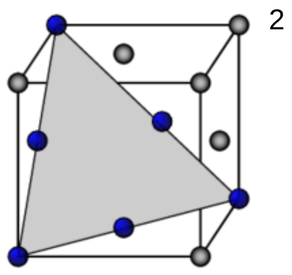
INTRODUCTION

- High CO_2 levels are pushing a transition from fossil fuels to renewable energy.
- **Nanocatalysts** can convert solar energy to fuels and useful products, thanks to their optical, electrical and chemical properties resulting from **increased surface area** to volume ratio and **quantum effects**.

- Copper-based catalysts can drive reactions that lead to useful **multi-carbon products**, due to their rare ability to sustain **carbon-carbon bond formation.**
- Controlling the morphology of nanoparticles allows to tune the **reaction selectivity**, thus favouring certain products.

COPPER NANOFLAKES

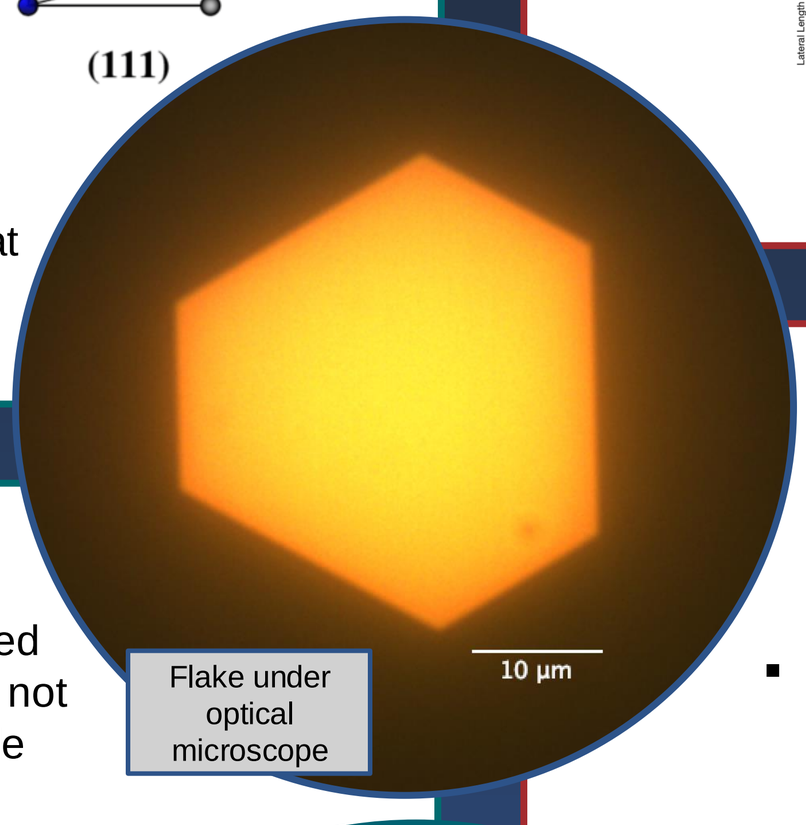
- **2D** copper nanostructures of high aspect ratio (small thickness and large surface area) that expose the **(111) facets** of the copper crystal.

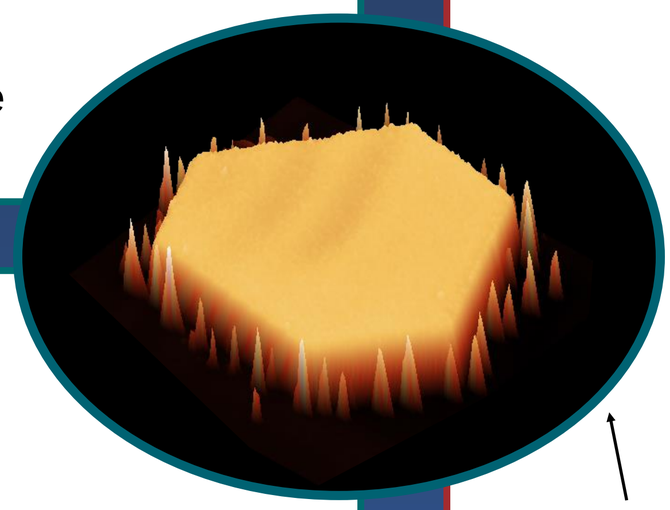


- This specific atomic arrangement results in electronic properties that facilitate the **electroreduction of CO_2/CO into acetate.**[1]

PROJECT RELEVANCE

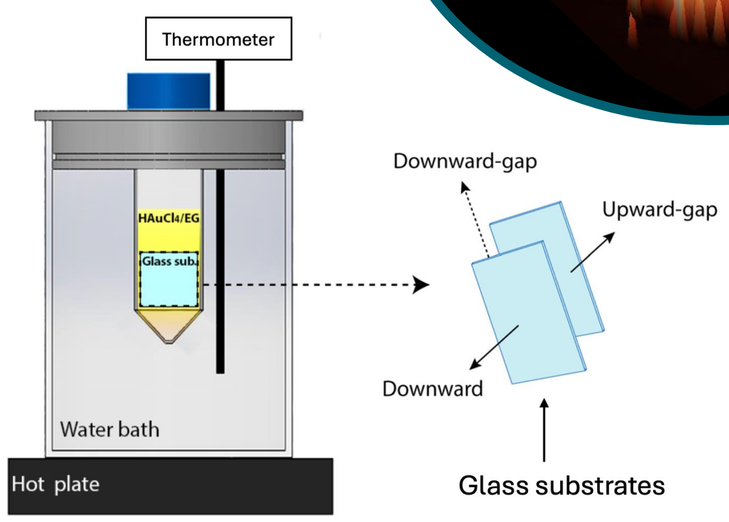
- Previous studies have only reached small-sized (1 µm) flakes that are not well separated from unwanted side products.
- Reaching **high-quality** results would open the door to the exploration of the properties described above.





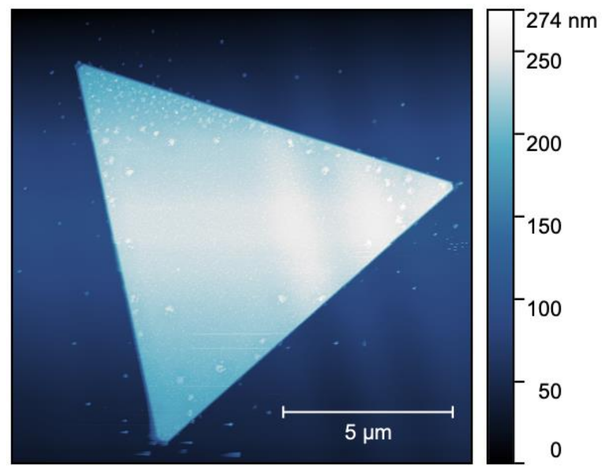
METHOD

- A chemical synthesis using a **precursor**, **reducing agent** and **capping agent**.
- **Gap-assisted** process involving on-substrate growth.[3]



RESULTS

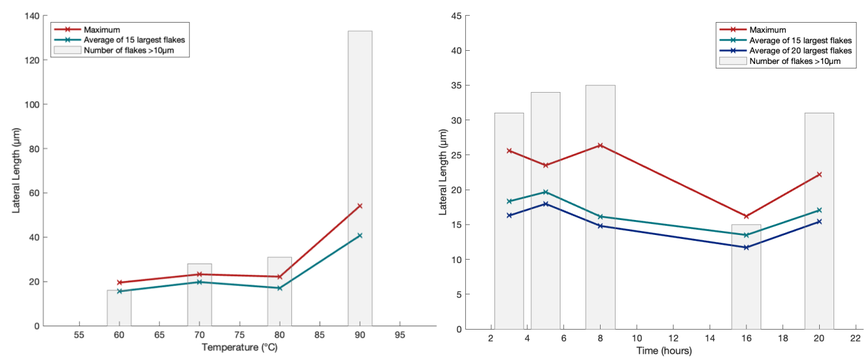
- High quality copper flakes were synthesised, of sizes reaching **52 µm**.
- This was done **without surfactants,** which were previously believed to be essential to their synthesis but block the active sites of nanocrystals.



Atomic Force Microscopy (AFM) image of a copper flake.

- Thicknesses ranging from 100-150 nm.

- **Halide-directed growth**.
- Various **trends** are witnessed: time, temperature and concentration dependence are established, allowing to gain insight on the **growth mechanisms** of copper crystals.



CONCLUSION AND PROSPECTS

- An efficient, surfactant-free and simple synthesis recipe has yielded flakes of **large lateral size and high-quality**.
- Further fine-tuning of the recipe is yet to be carried out, with the **optimisation** of the substrate material, for example.

- Adapting the growth onto a **conductive substrate** will allow for characterisation by Scanning Electrochemical Microscopy (SECM).
- The flakes could also be **transferred**, notably via Nanotransfer Printing, which we are currently investigating.
- We aim to explore the **photocatalytic response** of these nanoflakes.

To be investigated: AFM image leads to questioning on the oxidation of the flakes…

REFERENCES

1. Luc, W. et al. (2019). Two-dimensional copper nanosheets for electrochemical reduction of carbon monoxide to acetate. *Nature Catalysis, 2*, 423-430. https://doi.org/10.1038/s41929-019-0269-8
2. Mayrhoferm K.J.J. (2005). Oxygen Reduction and Carbon Monoxide Oxidation on Pt - from Model to Real Systems for Fuel Cell Electrocatalysis. [Doctoral Thesis: Vienna University of Technology]. *Research Gate*. https://resolver.obvsg.at/urn:nbn:at:at-ubtuw:1-19600
3. Kiani, F., & Tagliabue, G. (2022). High Aspect Ratio Au Microflakes via Gap-Assisted Synthesis. *Chemistry of Materials, 34*(3), 1278–1288. https://doi.org/10.1021/acs.chemmater.1c03908

CONTACT

Email: diotime.pellet@epfl.ch