Electro-catalyst systems for energy storage through coupled water oxidation and CO_2 reduction

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Contact:
Tintula Kottakkat
Room: 15.02
Telephone: +49 030 838 71605
Email: tintula.kottakkat@fu-berlin.de
ORCiD: https://orcid.org/0000-0002-7569-4276

Project Publications

1. K. Klingan, T. Kottakkat, Z.P. Jovanov, S. Jiang, C. Pasquini, F. Scholten, P. Kubella, A. Bergmann, B.R. Cuenya, C. Roth, H. Dau, Cavity versus Surface Catalysis on Electrodeposited Cu Foams for Electrochemical CO_2 Reduction, in preparation.

2. T. Kottakkat, K. Klingan, Z.P. Jovanov, H. Dau, C. Roth, Electrodeposited nanostructured Ag-Cu catalysts for enhanced reduction of CO_2 to CO, in preparation.

Project Summary

The steadily rising atmospheric content of CO_2 due to burning of fossil fuels generates much concern with respect to changing global climate. Considering the ambient operating conditions and the possibility of direct integration with renewable resources, electrochemical conversion of CO_2 to fuels and useful chemicals opens door to a sustainable carbon neutral fuel cycle. However, the main challenge is to find a suitable catalyst to overcome the high activation barrier for the reduction of thermodynamically stable CO_2. In addition, when **operated in an aqueous medium (pH ~ 7)**, the selected catalyst material has to impede the hydrogen evolution reaction (HER) initiated already at much lower overpotentials.

Cu is in the focus of electrochemical reduction of CO_2 owing to its ability to catalyze CO_2 reduction towards energy-dense hydrocarbon products. However, the electrochemical reduction of CO_2 on Cu is challenged by insufficient selectivity and a wide spectrum of products formed. The surface of the catalyst plays a key role in affecting the intermediate adsorption and by controlling the number of active sites for the reactants. The performance of Cu-based catalysts can be improved by tuning the structure, morphology and composition of the catalyst.

Evaluation of Cu-based nanostructured materials with controlled morphology for CO_2 reduction

By utilizing the **hydrogen bubble templated electrodeposition method,** the morphology and the pore size can be easily controlled by changing the deposition current and time. During the electrodeposition of Cu at high current densities, the hydrogen bubbles originating from the cathodic reaction create a continuous path from the electrode surface to the electrolyte air interphase, and these bubbles act as a dynamic negative template for the Cu deposition (Fig. 1).

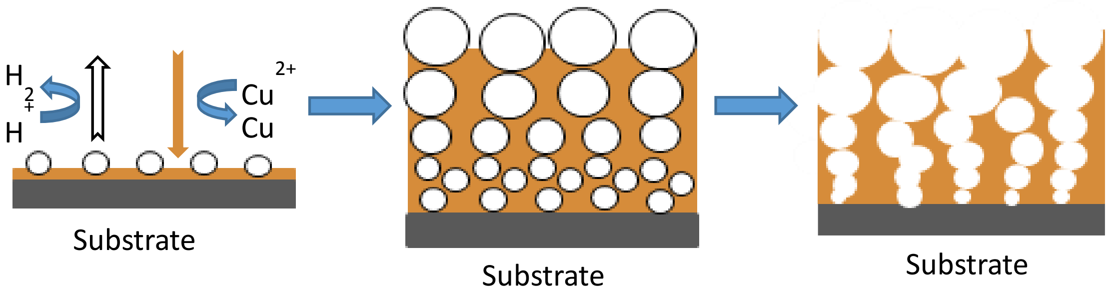

Figure 1. Hydrogen bubble templated electrodeposition of Cu

Apart from the Cu only structures, we also develop bimetallic electrocatalysts for CO_2 reduction, namely **AgCu** and **CuZn** by electrochemical synthesis. Fig. 2 shows the porous Cu and bimetallic AgCu synthesized by hydrogen bubble templated electrodeposition method.

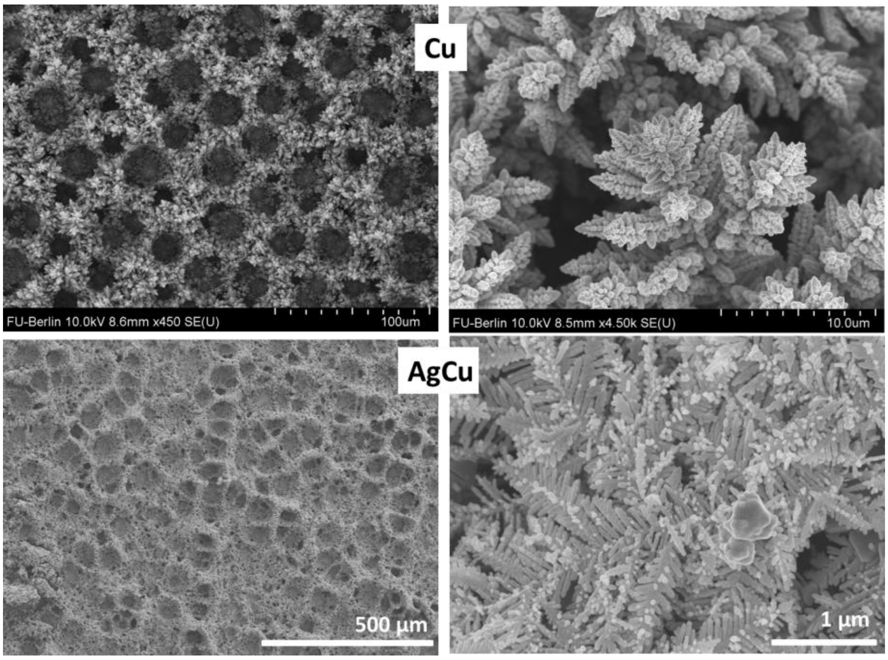

Figure 2. SEM images of Cu and Ag-Cu structures electrodeposited using the hydrogen bubble templated electrodeposition method.

The synthesized materials are initially characterized for the electrochemical CO_2 reduction by means of linear sweep and cyclic voltammetry and chronoamperometry. Determination of the product distribution of the electrochemical CO_2 reduction is carried out by an online gas analysis using a gas chromatograph.