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Physics-based simulation of electrochemical nanowire growth in porous templates

Master Thesis (30 CP)

Electrochemical deposition of copper nanowires is a promising low-temperature technology for future 3D interconnects. While nanowire growth in single pores is well established, transferring the process to large-area substrates containing billions of pores requires a predictive understanding of transport limitations, electrochemical kinetics, and geometry-induced non-uniformities. In particular, ion depletion effects during pulse plating and the influence of pore geometry strongly affect growth rate and uniformity. The long-term objective of this research line is to transform an empirical electroplating recipe into a scalable and predictable process technology.

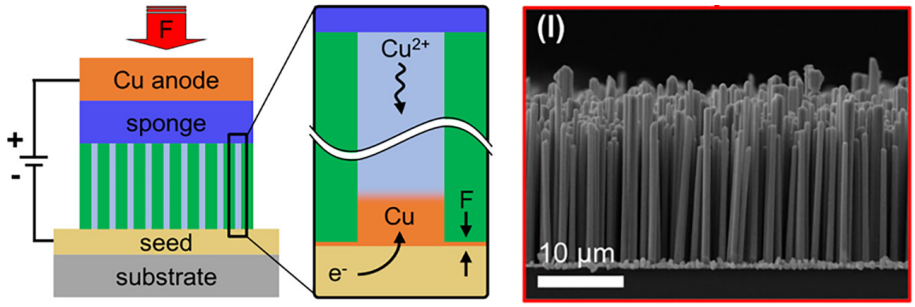

Figure 1: Schematic illustraion of electroplating in pore channels (left); cross-sectional SEM image highlighting nanowiere alignment on a wafer surface (right); reprint from Vergin et al. (2025) DOI: https://doi.org/10.1021/acs.langmuir.5c03780

This master's thesis focuses on the first simulation stage, establishing a validated, physics-based model for nanowire growth in an isolated pore. The goal of this thesis is to develop and analyze a time-dependent electrochemical simulation that predicts current density, ion concentration, and nanowire growth rate inside a single pore during pulse plating. The model will be used to identify transport-limited regimes and to derive first process maps linking pulse parameters and pore geometry to growth uniformity. For this, the work will focus on a 2D axisymmetric pore model consisting of an electrolyte reservoir, a cylindrical pore channel, and a cathodic pore bottom. The simulation will be implemented in COMSOL Multiphysics using electrochemical transport and kinetics.

Work program:

- Literature review
- Model setup of a 2D axisymmetric pore geometry in COMSOL Multiphysics
- Implementation of electrochemical modeling framework, including ion transport and electrode kinetics
- Calibration of model parameters
- Parametric studies

Start: As soon as possible

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