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Coupled Electro-Chemo-Mechanical Model of Electrodepositon in Through-Glass Vias

Master Thesis (30 CP)

Electrodeposition is a key manufacturing process in modern micro- and nanoelectronic technologies, where it is widely used to create electrically conductive interconnects, such as through-glass and through-silicon vias, in advanced chip architectures. In these systems, process reliability and performance are strongly influenced by the coupling between electrochemical transport, electric field distributions, and mechanically induced stresses that develop during deposition. In particular, the filling of high-aspect-ratio through-glass vias (TGVs) presents unique challenges due to the interplay between ionic diffusion, electric field concentration near the via openings, and the resulting non-uniform growth kinetics that can lead to void formation or overplating. Optimizing such deposition processes and channel geometries therefore requires a detailed understanding of the underlying electro-chemo-mechanical interactions. Continuum-based modeling provides a systematic way to investigate these coupled phenomena and to assess their impact on deposition kinetics, concentration distributions, and stress evolution under controlled conditions.

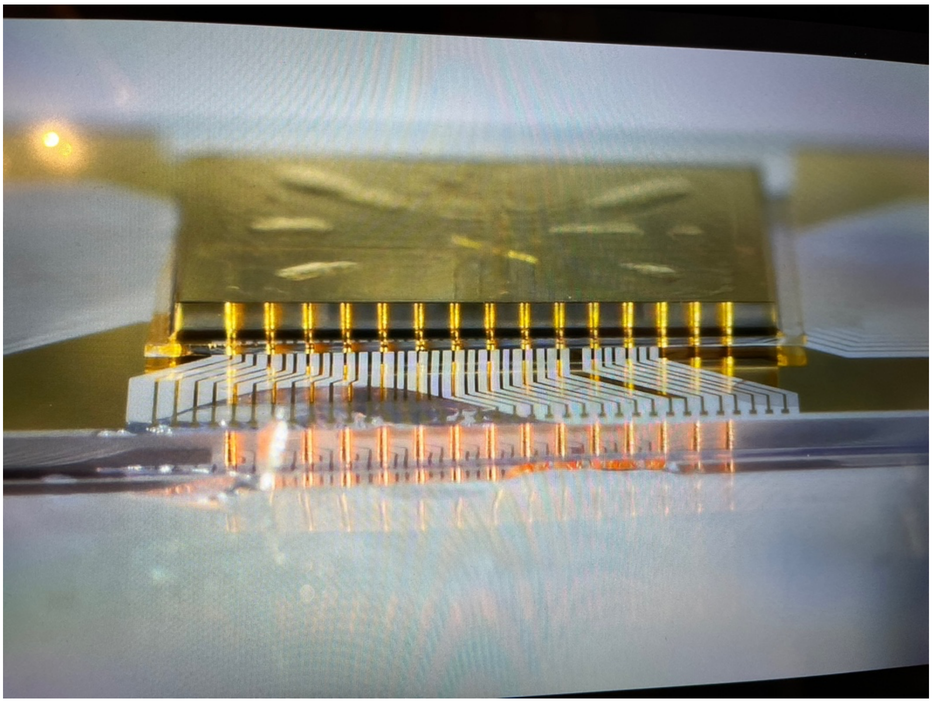

Figure 1 Assembly of an ion trap with TGVs filled with gold on an Interposer with TGVs filled with copper.

In this master's thesis, jointly supervised with the Institute of Quantum Optics, Leibniz Universiät Hannover, a continuum modeling framework for electrodeposition is developed, extended to account for electro-chemo-mechanical coupling at the solid/electrolyte interface using a phase field approach. The governing equations are formulated within a Finite Element setting and implemented either in the open-source Julia-based Finite Element toolbox Ferrite.jl or in the Finite Element Software COMSOL Multiphysics. The implementation is intended to provide a flexible and extensible numerical framework for studying coupled effects during electrodeposition and to serve as a basis for future model extensions and parametric studies.

Work program:

- Literature review
- Implement Poisson-Nernst-Planck formulation of electrolyte
- Implement a phase field approach for electrodeposition at the interface
- Numerical studies investigating the influence of via geometry and field concentration on deposition uniformity
- Design and execute numerical studies

Start: As soon as possible

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