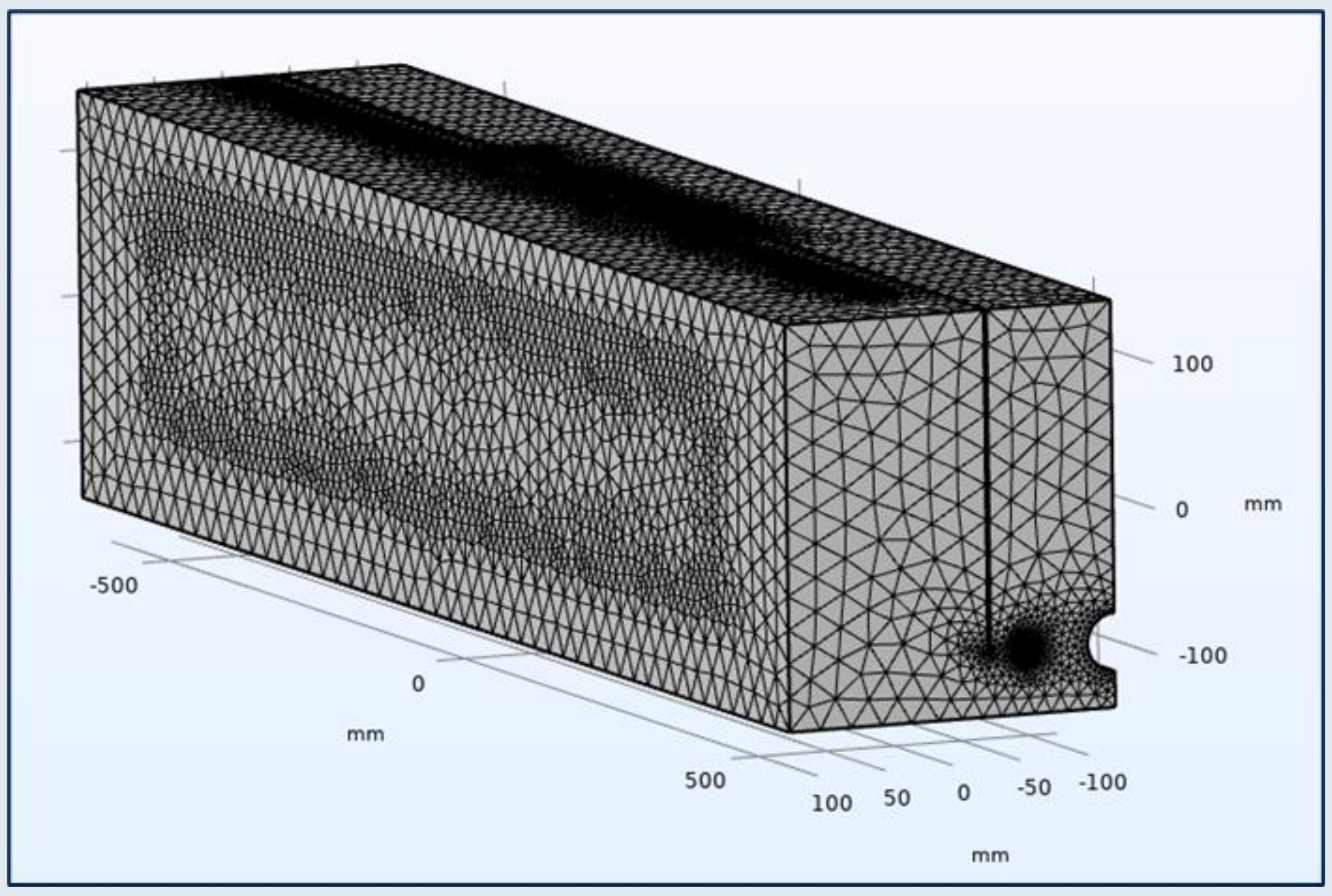

Multiphysics Simulation for Optimization of Chip Manufacturing Processes

Geometric Optimization of Electroplating: Enhancing Uniformity and Efficiency in Chip Fabrication through Advanced Simulation Techniques

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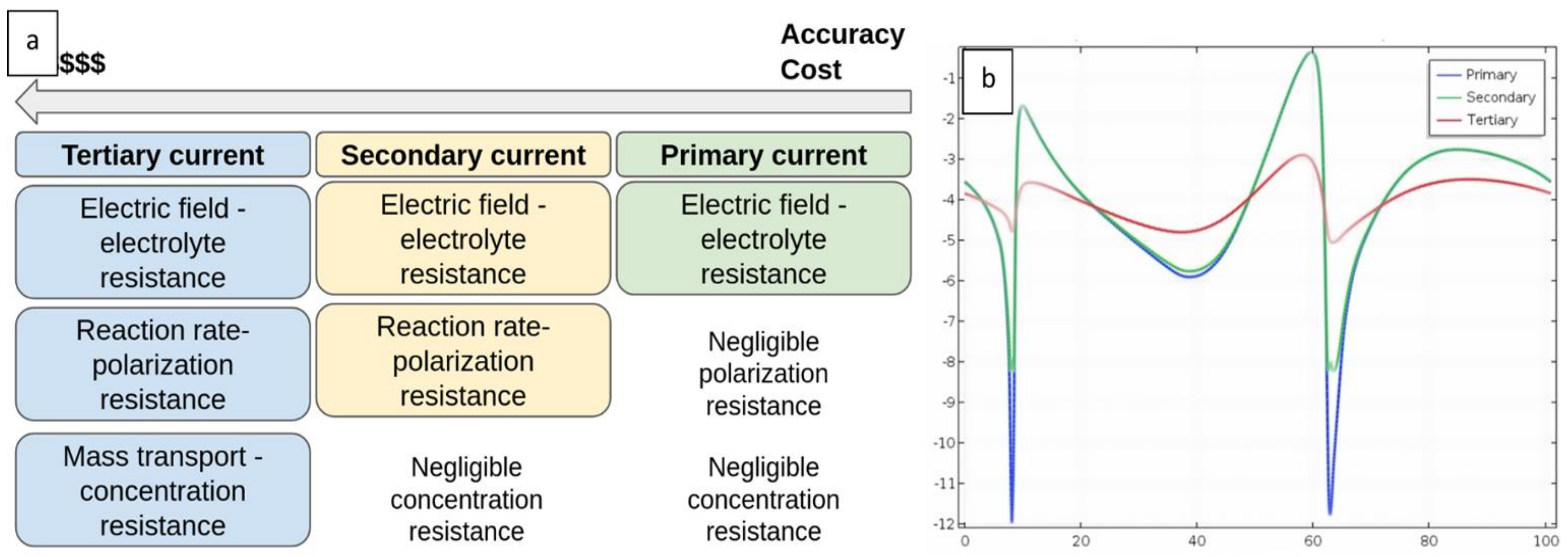
Abstract

In collaboration with STMicroelectronics, UNIFI utilized advanced multiphysics simulations to optimize electroplating processes for chip manufacturing. By using COMSOL Multiphysics® software, we created virtual prototypes to simulate current density distribution to optimize the geometry of an electroplating cell, thus dramatically reducing the need for costly physical prototypes. Key parameters such as current density, shielding and anodes positioning were optimized to ensure uniform copper deposition on microchips. The simulations were validated against experimental data, demonstrating their effectiveness in reducing costs, speeding up development, and improving chip production quality.



Tertiary current	Secondary current	Primary current
Electric field - electrolyte resistance	Electric field - electrolyte resistance	Electric field - electrolyte resistance
Reaction rate-polarization resistance	Reaction rate-polarization resistance	Negligible polarization resistance
Mass transport - concentration resistance	Negligible concentration resistance	Negligible concentration resistance

FIGURE 1: (a) Description of the main three levels of approximation, (b) results on a non-uniform section showing improved accuracy in deposited thickness as the model moves from primary to tertiary current.

Methodology

The primary current approximation in electroplating simulations is a powerful tool for rapid and efficient process optimization [1,2]. By focusing on the primary current distribution, which assumes uniform potential across the electroplating cell, engineers can quickly evaluate the influence of bath geometry and electrode positioning on current density [3]. With respect to secondary and tertiary current distributions this method simplifies the complex interactions within the system while providing valuable insights into key variables. Although less detailed the primary current model offers a fast, computationally efficient way to optimize basic design parameters, significantly reducing the time and cost associated with developing new electroplating processes.

Results

Our work demonstrates the successful use of multiphysics simulations to optimize the electroplating process for chip production. Key outcomes include improved uniformity in copper layer deposition across microchips, reduced reliance on physical prototypes, and faster process development. By optimizing geometrical parameters of the electroplating cell the simulations helped achieve consistent copper thickness and enhanced product quality. The study highlights the significant role of adjustable shielding and anodes positioning in ensuring deposition uniformity, ultimately reducing costs and accelerating time-to-market for new chip designs.

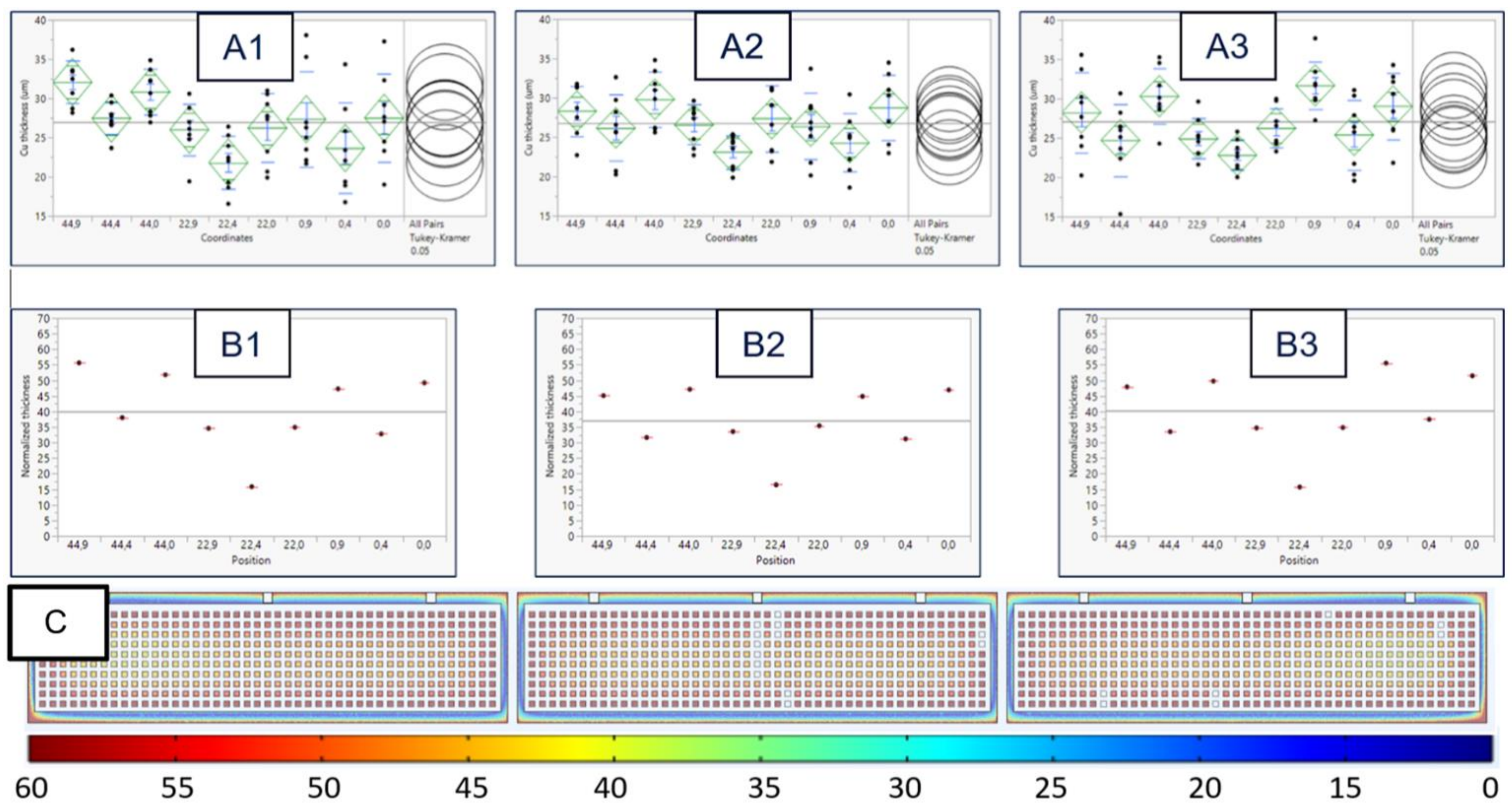


Figure 2: Comparison of simulated (A) and experimental (B) Cu thickness (µm) by sampling coordinate. (C) Deposited Cu thickness on chips, with a color scale in µm.

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