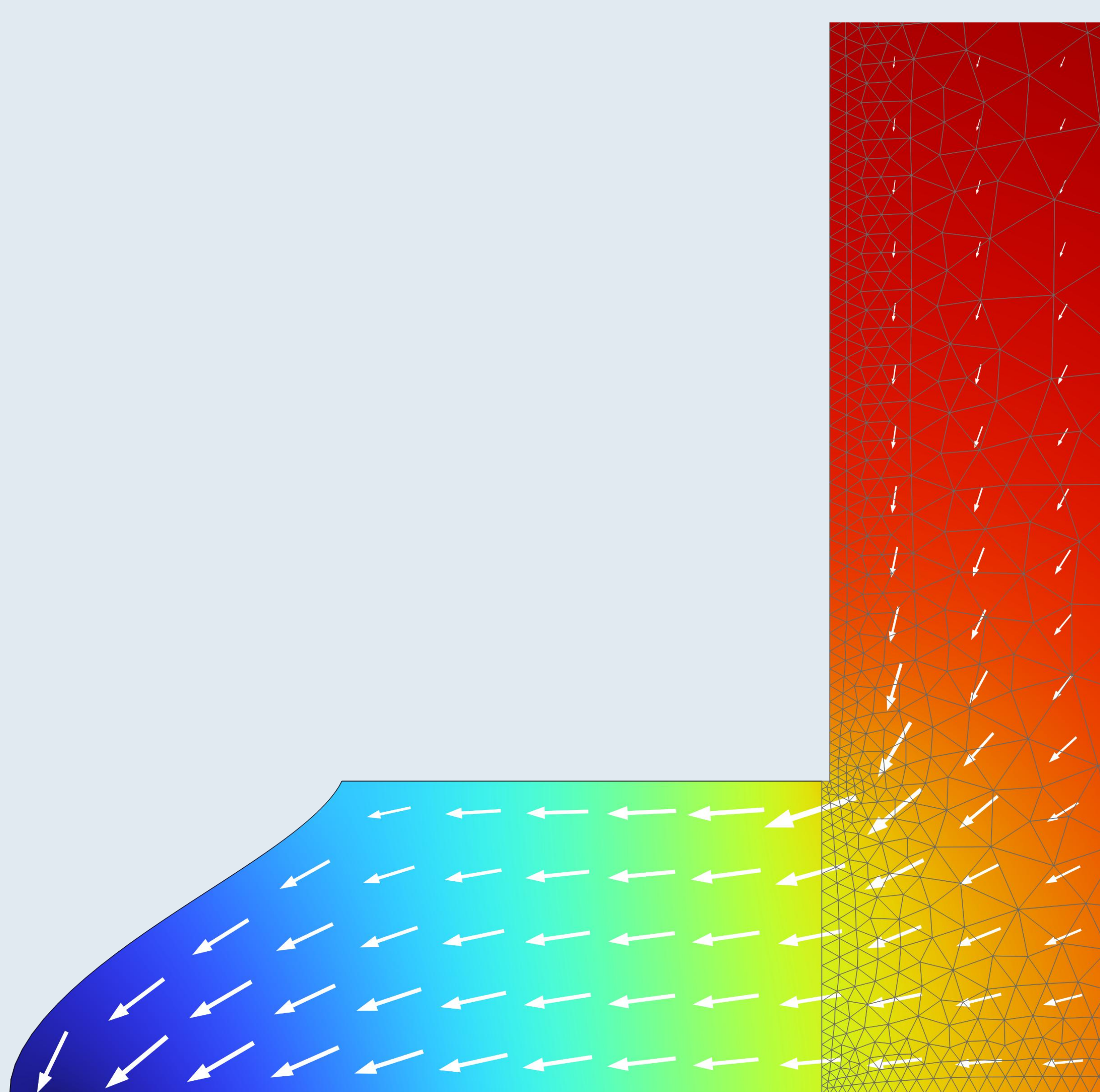




Numerical Analysis of Solder Joint Corrosion in Photovoltaic Modules

Corrosion of solder joints can significantly impair the reliability and performance of PV modules. This work investigates whether a finite element model can describe corrosion mechanisms and predict material loss at PV interconnections.

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Introduction

Photovoltaic (PV) modules are exposed to harsh environmental conditions throughout their service life, including temperature fluctuations, humidity, wind loads and solar irradiation. These stressors promote degradation mechanisms that reduce module efficiency and long-term reliability. Among them, corrosion of solder joints at the interconnections between busbars and silver contacts is of particular importance, as it decreases the effective contact area, increases electrical

resistance and thereby impairs module performance.

This work investigates the corrosion of solder material occurring at these contact interfaces using COMSOL Multiphysics®. The aim is to assess the suitability of an FEM-based approach for describing the underlying corrosion mechanisms in PV interconnections and for estimating their temporal progression over time.

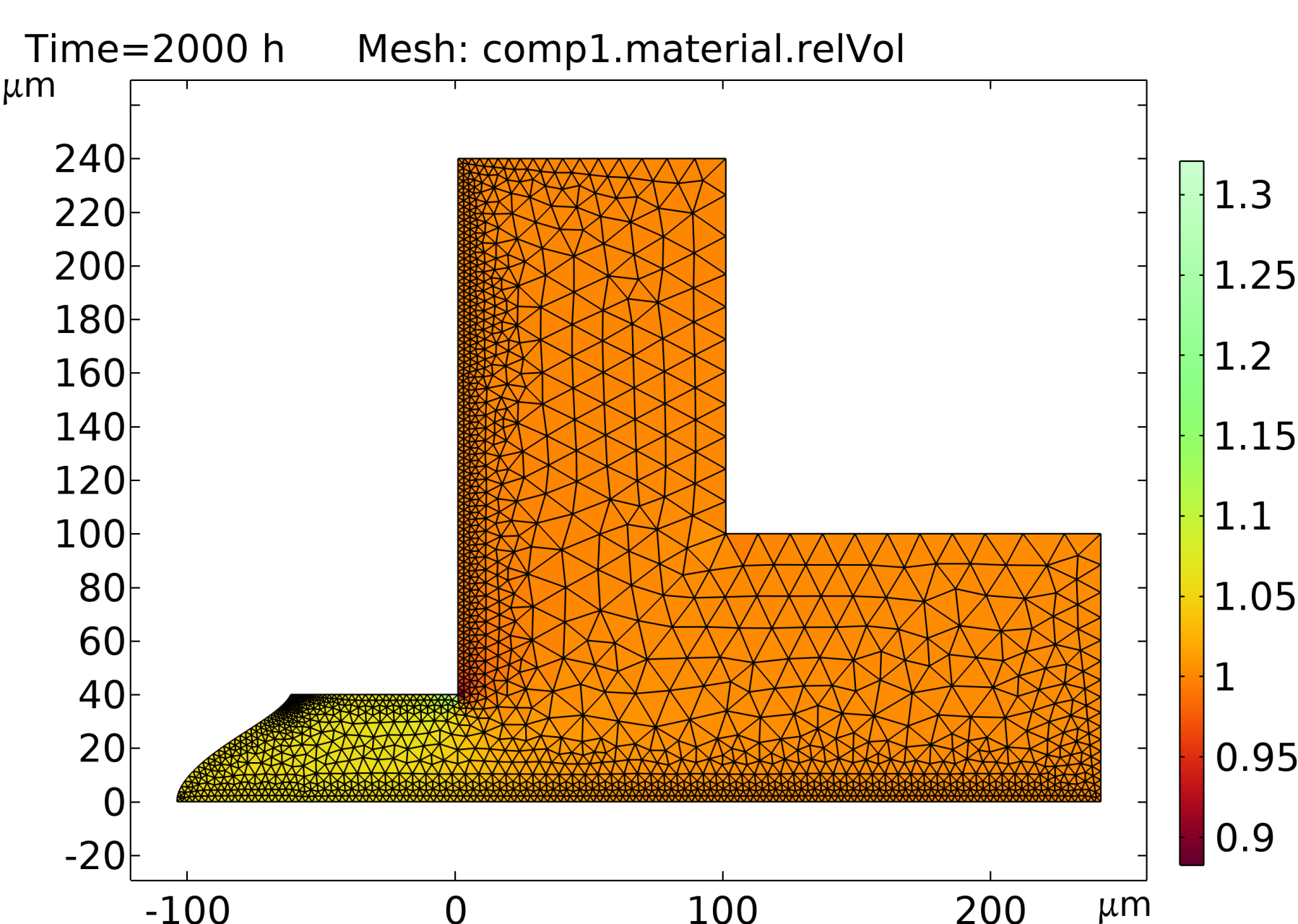
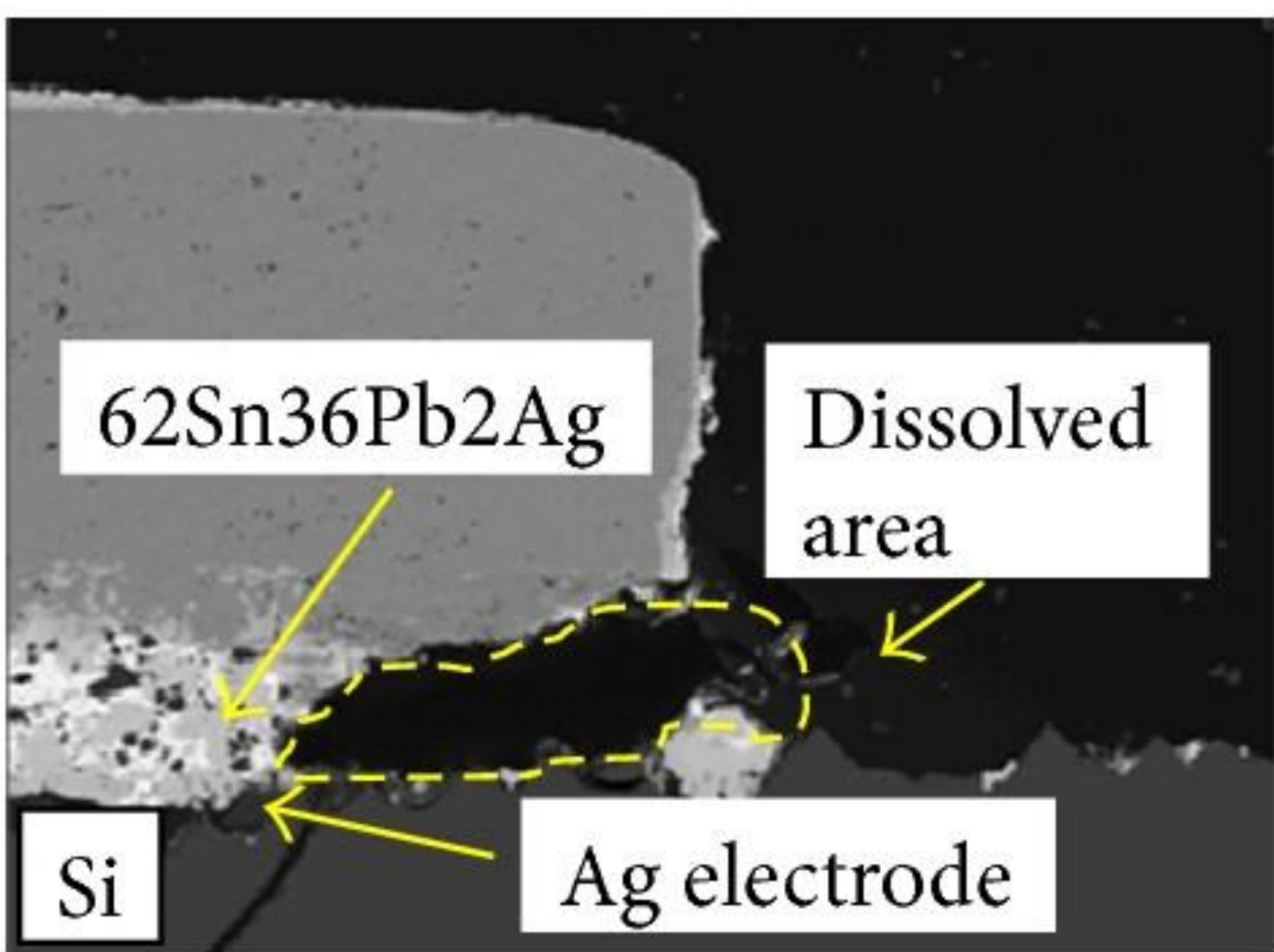


Figure 1: Left: Cross-sectional SEM image at the solder interconnection [1], right: Deformed geometry resulting from the simulation of corrosion using TDS over 2000 h with a 100 μm-thick electrolyte film

Modelling Approach

Corrosion of the solder joints is simulated using the Secondary Current Distribution (SCD), Deformed Geometry (DG) and Transport of Diluted Species (TDS) interfaces. SCD describes current transport and electrode kinetics, while DG accounts for material loss and surface deformation. TDS models oxygen diffusion and consumption at the cathodes, representing the rate-limiting process.

In addition, parameter studies were conducted for electrolyte film thicknesses of 50 μm, 100 μm, and 150 μm, both with and without oxygen transport.

Results and Outlook

The simulations yield plausible results and predict a solder material loss that is qualitatively consistent with comparable values reported in the literature. Moreover, including TDS provides more realistic results. Furthermore, the model indicates faster corrosion near the silver electrode than near the copper electrode, consistent with experimentally observed trends from SEM images (see Figure 1). Regarding electrolyte film thickness, variations result in differences in material loss of only 1 – 1.5 μm over 2000 h, indicating that other processes may have a stronger influence on the corrosion kinetics.

Overall, the results demonstrate that the proposed FEM approach is suitable for the qualitative investigation of corrosion processes in PV solder joints, while further studies are required for improved parameterization and quantitative accuracy.

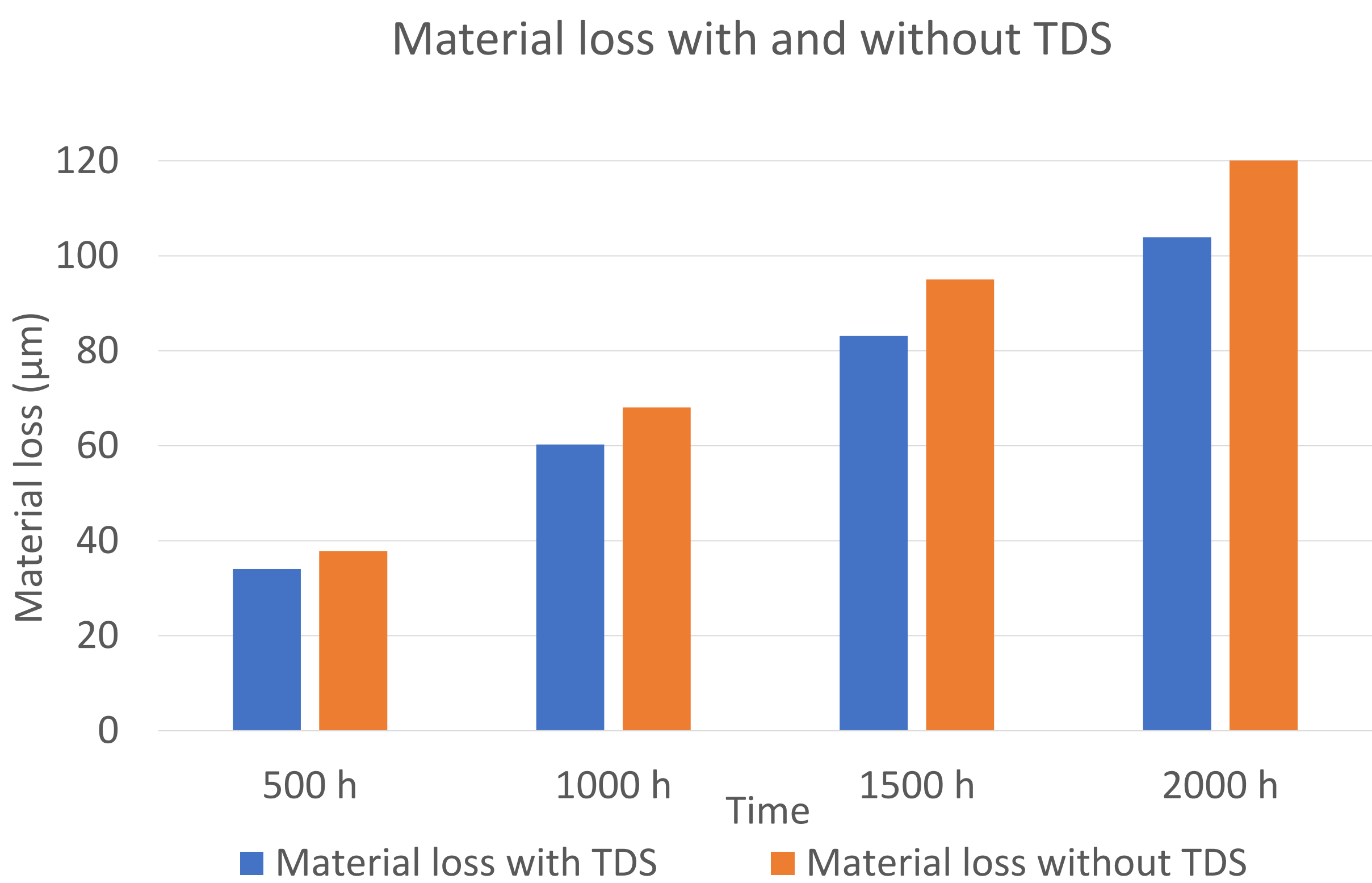


Figure 2: Material loss over 2000 h with and without TDS

REFERENCES

[1] J.-H. Kim, J. Park, D. Kim, and N. Park, “Study on Mitigation Method of Solder Corrosion for Crystalline Silicon Photovoltaic Modules,” *International Journal of Photoenergy*, vol. 2014, pp. 1–9, 2014, doi: 10.1155/2014/809075.

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