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A NUMERICAL FRAMEWORK FOR THE ELECTRO-MECHANICAL ANALYSIS OF CONDUCTIVE TRACKS IN PRINTED ELECTRONICS

Britt H.H.A. Cordewener [1,*], Jeroen J.M. Knippenberg, Marc G.D. Geers[1] and Joris J.C. Remmers[1]

[1] Mechanics of Materials, Department of Mechanical Engineering
Eindhoven University of Technology
PO Box 513, 5600 MB Eindhoven, the Netherlands
https://www.tue.nl/en/research/research-groups/mechanics-of-materials/
[*] b.h.h.a.cordewener@tue.nl

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Over the past decade, the scientific interest in and development of Additive Manufacturing (AM), also referred to as 3D printing, have increased rapidly causing the technique to find its way into a broad variety of applications in all kinds of engineering fields, including embedded electronics. Here, functional nanomaterials and conductive ink formulations are printed with direct writing techniques for the production of lightweight and complex structural parts with embedded electronics and fully encapsulated interconnecting conductive tracks [1,2].

The electro-mechanical performance of these printed conductive tracks strongly depends on the composition of the conductive inks and its microstructure obtained after processing. To analyse the performance in terms of the effective resistivity of a track subjected to mechanical loading, a numerical framework for the electro-mechanical analysis of conductive tracks is developed. In the proposed multi-physics model, the behaviour of the conductive material is described in terms of the mechanical- and electrical response, and an auxiliary crack phase-field variable that accounts for damage development and crack propagation.

The phase-field approach to brittle fracture [3,4] is extended via the direct coupling of the damage variable to the mechanical stiffness and electric conductivity of the material to account for the effects of material degradation. It is therefore assumed that the fracture process is purely mechanically driven. As a result, the increase in effective resistivity is assumed to be a direct consequence of fracture of the solid microstructure of the conductive medium, that is caused exclusively by mechanical strains imposed on the body.

The electromechanical behaviour, in terms of the effective resistivity, of simplified 2D and 3D representations of conductive tracks under mechanical loading, is analysed using both immersed and conformal meshing approaches. Overall, an increase in resistivity is observed, as a direct consequence of crack formation in the conductive material. The observed findings are compared and validated by experimentally performed conductive tensile tests on 3D printed conductive tracks.

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