A numerical framework for the electro-mechanical analysis of conductive tracks in printed electronics

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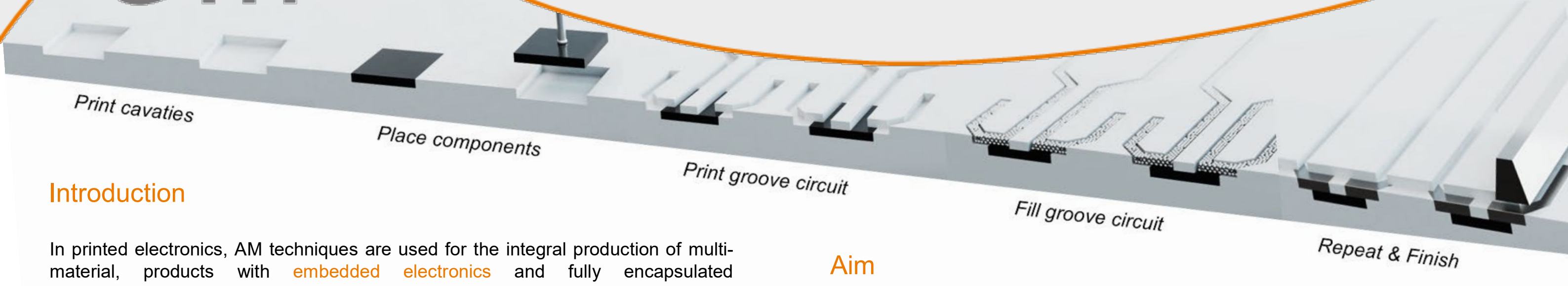
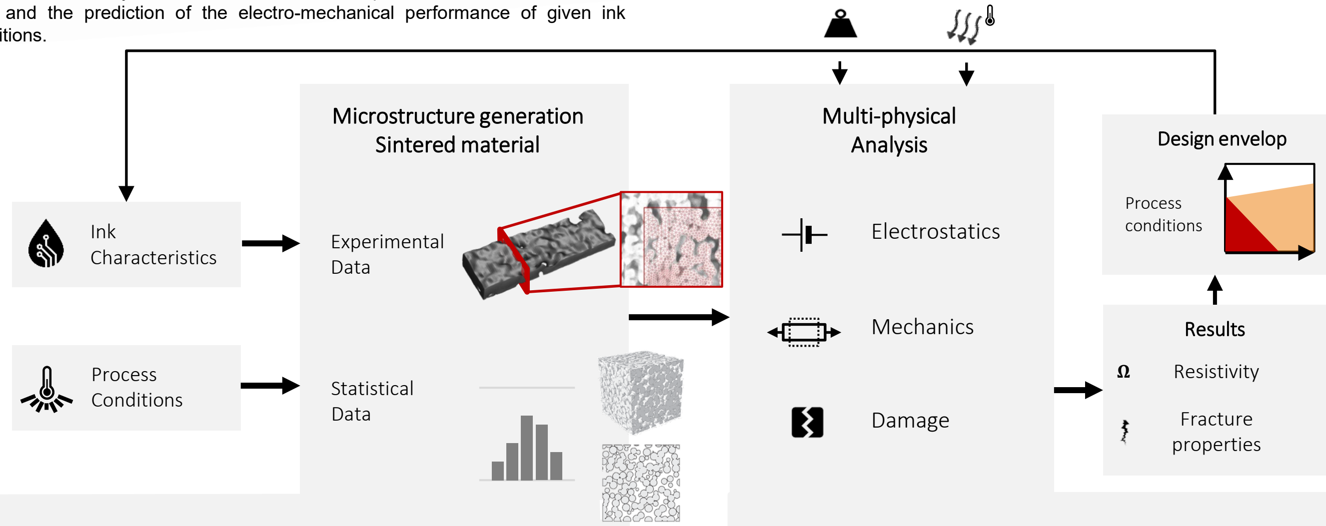


Introduction

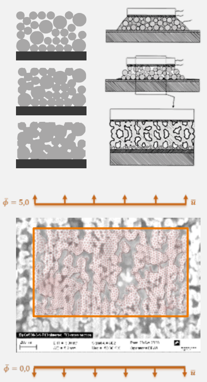
In printed electronics, AM techniques are used for the integral production of multi-material, products with embedded electronics and fully encapsulated interconnecting conductive tracks. The electro-mechanical performance of the printed conductive tracks is strongly depending on the composition of the conductive inks and the microstructure obtained after processing of the inks. To analyze this performance in terms of the resistivity, a multi-physics model is created that allows for the analysis of the effects of strains imposed on the microstructure of a track and the prediction of the electro-mechanical performance of given ink compositions.

Aim

| Prediction of performance for given ink compositions
| Analyze & predict malfunctioning/failure tracks
| Improved strategies for printing of conductive materials



Microstructure generation

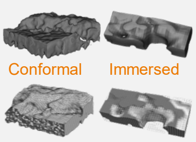


Why |

An adequate geometrical representation of the microstructure is required as an input for the multi-physics model. Microstructure of sintered track depends on process conditions and Ink characteristics and governs the Electro-mechanical performance.

How |

- Experimental Data
  - 2D → FIB SEM images
  - 3D → CT scans
- Statistic generation
  - Particle size distribution
  - Sintering



Numerical Framework

What |

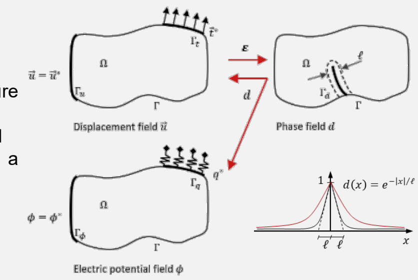
Modelling electro-mechanical fracture with two successive mechanisms:

I. Mechanical fracture of the solid
II. Decrease of conductivity as a direct result

How |

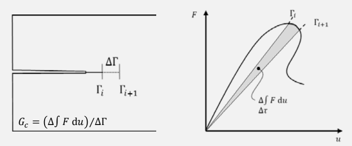
Multi-field approach:

- $\boldsymbol{u}$ Displacement
- ϕ Electric potential
- d Crack phase-field



Solver |

The system is implemented in a finite element framework and solved using a staggered procedure in combination with a dissipation based solver.



Results |

The effective resistivity of simplified representations of conductive tracks under mechanical loading is analyzed. The contour plots show the development of damage and its consequence on the potential field distribution.

- An increase in resistivity is observed, which is caused by crack formation in the conductive material, that resembles the trends observed in experimental research.
- Besides the porosity, the percolation path is identified as a relevant geometric feature for the fracture properties.
- Parameter studies with synthetic RVE's will give insights in the effects of sintering times and particle size distributions.