Micro- to meso-structure: Simulation of additively manufactured composite structures

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Keywords. additive manufacturing, composites, functionally graded lattices, tool paths, finite element analyses

Abstract.
Additive manufacturing has profited greatly from implicit modelling tools, easing the design of complex architectured meso-structures such as functionally graded lattices (FGLs) and thus providing more advanced engineering solutions. However, product development cycles today are not entirely streamlined i.e. digitalized, stemming from the lack of robust means for precisely predicting their performance through simulation and synthesized data bases. This work presents a finite element analysis approaches for fibre-reinforced FGLs, that aim at shedding light on ways to capture the response of the meso-structure in compression under consideration of micro-structural aspects related to e.g. the print direction and the infill patterns i.e. the tool path strategy. Preliminary investigations into the elastic-plastic finite element analysis (FEA), employing a homogenized crushable foam model, have shown good agreement with experiments while FEA of single unit cell revealed limitations. In-plane stress analyses provide valuable insights for selecting stiffness-optimal infill patterns that adhere well to principle stress trajectories and comparisons between the tool paths elucidated potential advantages in terms of manufacturability of composites, facilitating better bottom-up design choices. Overall, this research constitutes a two-fold (meso- and micro-structure) analysis of FGL composites that will aid the development of more reliable and realistic simulation tools in the future.