Defect sensitivity of architected random cellular materials produced by LPBF

Selma Leonardi*†[1,2], Anne-Laure Helbert , and Gabriella Tarantino

[1]Laboratoire de Mécanique Paris-Saclay – Université Paris-Saclay, CentraleSupélec, ENS Paris-Saclay, CNRS, LMPS - Laboratoire de Mécanique Paris-Saclay, 91190, Gif-sur-Yvette, France. – France
[2]Institut de Chimie Moléculaire et des Matériaux dÓrsay – Institut de Chimie Moléculaire et des Matériaux d'Orsay (ICMMO) – France

Abstract

Metallic cellular materials with heterogeneous pore features are used in many branches of technology, from lightweight structures to biomedical implants and electrodes. These materials derive their properties from their internal architecture, which can now be precisely-controlled via advanced mfabrication techniques such as additive manufacturing.

Despite the geometrical complexity enabled by additive manufacturing, the produced cellular mesostructures often deviate from their nominal design, and may contain a variety of manufacturing defects within the matrix. Defects, in turn, affect the resulting properties, which differ significantly from the targeted ones. This issue is common to a large number of architected materials and is exacerbated in metallic lattices, which may exhibit variations in strut geometry, size and waviness alongside density defects.

Here, we study the defect sensitivity of architected cellular materials with random pore distributions. Specifically, the materials of this work contain cylindrical pores randomly dispersed into an AlSi10Mg matrix and are fabricated by Laser Powder Bed Fusion (LPBF). Their porous architecture is generated numerically by a Random Sequential Absorption (RSA) algorithm prior to fabrication.

Using Digital Image Correlation (DIC) combined with extensive microstructural analyses, we investigate how defects affect the elasto-plastic response of these materials in compression. Notably, we quantify the influence of a random arrangement of pores, combined with density defects, on the mechanisms of strain localization, and show that the latter ones differ remarkably from those observed in periodic metallic lattices.

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*Speaker

†Corresponding author: selma.leonardi@universite-paris-saclay.fr

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