
Mechanical Behavior of Interpenetrating Phases Composites under Dynamic Loadings

Paul Jabin Echeveste^{*1,2,3}, Louise Le Barbenchon^{†2,3}, Lorène Héraud^{‡2,3}, Arthur Coré^{§1},
and Philippe Viot^{¶1,2,3}

¹CEA CESTA – CEA CESTA – France

²Institut de Mécanique et d'Ingénierie – Arts et Métiers ParisTech, I2M CNRS UMR 5295 – France

³ENSAM TALENCE – École Nationale Supérieure d'Arts et Métiers (ENSAM) - Bordeaux – France

Abstract

In recent years, metamaterials such as IPCs (Interpenetrating Phase Composite) have come under increasing investigation, as their enhanced mechanical behavior makes them ideal candidates for applications such as shock and vibration absorption, as well as structural lightening. However, little is known about the causes of this improvement. This is why the aim of this investigation is to examine the effects of a secondary solid phase on the mechanical properties of TPMS and lattice architected metallic structures under quasi-static and dynamic loadings. The IPCs chosen in this study consist of a Stainless Steel 316L reinforcements made by LPBF process and a polymer filler matrix in epoxy or PDMS. The IPCs in this study are manufactured by vacuum infiltration of the liquid matrix through the reinforcements in moulds. They were subjected to mechanical tests at low speed (quasi-static regime, $\epsilon = 0.007\text{s}^{-1}$) and at high speeds (dynamic regime, $\epsilon = 208\text{s}^{-1}$). Quasi-static tests showed that the addition of an epoxy matrix improved the plateau stress and the absorbed energy. This improvement can be explained by the role of the matrix stabilising the struts in the structure. In the case of a TPMS Diamond reinforcement, the epoxy resin limits stage-by-stage collapse and homogenises the strain in the architected structure. In the case of the 3D auxetic Re-Entry geometry, the matrix stabilise the vertical beams, which are sensitive to buckling, in the loading axis over a wide range of loads. In the dynamic regime, the epoxy resin shows an exacerbated mechanical behaviour that is also present in IPC 316L/epoxy.

*Speaker

†Corresponding author: louise.le_barbenchon@ensam.eu

‡Corresponding author: Lorene.HERAUD@ensam.eu

§Corresponding author: Arthur.CORE@cea.fr

¶Corresponding author: philippe.viot@ensam.eu