In-Situ X-Ray Compression Testing with DVC and FEA Analysis of Zr-Modified Al7075 TPMS Gyroid Lattice Structures Processed by LPBF and HIP

Mohammed Farag*[1], Grzegorz Pyka[1], Nicolas Nothomb[1], Moataz Attallah[2], Jean-François Remacle[1], and Aude Simar[1]

[1]Institute of Mechanics, Materials and Civil Engineering, UCLouvain, Belgium – Belgium
[2]School of Metallurgy and Materials, University of Birmingham, United Kingdom – United Kingdom

Abstract

Additive manufacturing has revolutionized the design of architected materials, offering the ability to create complex structures with tailored mechanical properties. This study focuses on Zr-modified Al7075 alloy lattice structures based on Triply Periodic Minimal Surfaces (TPMS) with a Gyroid structure, produced at a volume fraction of 10-15%. These structures are designed for use as architected materials or Metal Matrix Composites, providing exceptional performance in lightweight and load-bearing applications.
The specimens used were manufactured in a cylindrical form in accordance with ISO compression testing standards. To extensively investigate deformation and failure processes, insitu X-ray compression experiments were conducted to capture real-time interior structural changes. Micro-scale strain fields were mapped using Digital Volume Correlation (DVC), offering key insights into structural response under load. Finite element analysis (FEA) models allow to predict strain distributions and validate experimental results.
We further investigate the improvement of these lattice structures using Hot Isostatic Pressing (HIP) to minimize porosity and promote material densification. This is followed by a solution heat treatment that refines the microstructure and improves mechanical properties. Our findings suggest valuable connection between lattice structure, material behavior, and load-bearing efficiency, underlining the potential of Zr-modified Al7075 Gyroid structures as strong and lightweight structure for use in Metal Matrix Composites for advanced engineering applications.

*Speaker