Design and fabrication of W-Cu composite structures with triple periodic minimal surface via laser powder bed fusion and copper infiltration

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Tungsten-copper (W-Cu) composites are metal matrix composites known for their outstanding characteristics, such as high thermal conductivity and electrical conductivity, low coefficient of thermal expansion, high strength, high hardness, and corrosion resistance. Laser-based powder bed fusion (LPBF) of W lattice structures combined with infiltration of molten Cu phase enables the fabrication of W-Cu composites with a wide composition and structure variation range.

Design of W skeleton using triply periodic minimum surface (TPMS) structures will help reduce stress concentration in the W skeleton, leading to improved mechanical behavior. The most widely used TPMS structures are Gyroid, Neovious, Schwarz, Diamond, Lidinoid, Split P, Neovius. The diamond TPMS structure provides a unique combination of mechanical strength and efficient thermal conductivity properties, making it a versatile choice for manufacturing heat-resistant and conductive W-Cu composite. Furthermore, TPMS structures can be categorized into two types of design: walled and skeletal. Walled TPMS structures consist of a constant wall thickness throughout the entire design, skeletal are defined by a reduced overall volume. A comparison between walled and skeletal TPMS structures will provide a crucial comprehension of their characteristics, thereby facilitating future research and development of composites with appropriate properties for their application.

The experimental phase involves manufacturing W structures using LPBF, followed by infiltration with molten Cu. To achieve this purpose, cubes with 1.5 cm sides and porous Diamond TPMS structures with skeletal and walled architectures ranging from 10 to 90% porosity were designed and fabricated by LPBF. As-fabricated W lattice structures were analysed in terms of density and microstructure and compared to the designed models. Following Cu infiltration, the effect of unit cell type (walled/skeletal) on the formation of W-Cu composite samples was evaluated. This estimate included the results of mechanical testing and finite element modeling (FEM). The outcomes will aid in optimizing the design for the manufacture of W-Cu composites with improved properties.