Continuous bi-metallic structures by DED: towards controlled transitions between crystal structures

Vincent Jacquier, Wilfried Pacquentin, Philippe Zeller, Sylvie Chatain, Frédéric Schuster, Hicham Maskrot, Julien Zollinger

Continuous bi-metallic structures by DED: towards controlled transitions between crystal structures

JACQUIER Vincent[1], PACQUENTIN Wilfried[1], ZELLER Philippe[2], CHATAIN Sylvie[2], SCHUSTER Frédéric[3], MASKROT Hicham[1], ZOLLINGER Julien[4]

1. DEN – Service d'Etudes Analytiques et de Réactivité des Surfaces (SEARS), CEA, Université Paris-Saclay, F-91191, Gif sur Yvette, France
2. DEN – Service de la Corrosion et du Comportement des Matériaux dans leur Environnement (SCCME), CEA, Université Paris-Saclay, F-91191, Gif sur Yvette, France
3. CEA Cross-Cutting Program on Materials and Processes Skills, 91191 Gif-sur-Yvette, France
4. Université de Lorraine, Institut Jean Lamour, Department of Metallurgy and Materials Science and Engineering, Nancy, France

vincent.jacquier@cea.fr

Key words: Additive Manufacturing, Direct Energy Deposition, Functionally Graded Materials

Laser deposition of metallic powder allows the formation of high quality coatings with metallurgic bonds, low dilution and fine dense microstructures. In recent years, the technology has been refined to allow near net shape 3D constructions and in-situ alloying, by controlling the mixing of different powders in the molten pool. This enables the manufacturing of continuous multimaterial structures with enhanced performances [1]. We present here the design and fabrication of Cr-Ni bimetallic samples, featuring a BCC to FCC transition, through controlled projection and fusion of dissimilar metallic powders.

Two powder feeders allow the controlled mixing and projection of pure Cr and Ni powders, fused by a 3kW fiber laser, to create various coatings including vertical compositional gradients. With analysis of layers dimensions, chemical distribution, microstructures and hardness, we investigate the influence of process characteristics and compositional sequence.

We specifically examined the in-situ alloying of the two powders, as well as the compositional and crystal structure gradients, with regard to laser velocity, melt pool size and nature of previous layers. In particular, lack of fusion frequently occur when coating a metal with a more refractory one, hence the need to optimize the deposition. Tracks aspect ratio greatly affects defects, dilution, and microstructural morphologies. Laser power needs to be successively adapted to maintain a desired track width; this can be facilitated by adequate methods, involving numerical process simulations.

By varying the ratio of projected powders to create a chemical gradient, abrupt changes in microstructures and properties between the miscible metals can be effectively smoothed. If a tailored gradient is to be made to maximize the coating performances, the effect of successive dilutions is to be anticipated, thus there is a strong need for reliable multimaterial numerical modeling.

1. Banait SM, Paul CP, Jinoop AN, Kumar H, Pawade RS, Bindra KS. Experimental investigation on laser directed energy deposition of functionally graded layers of Ni-Cr-B-Si and SS316L. Optics & Laser Technology. 2020;121: 105787.