Executive Summary Deliverable 2.1

“Recipe book” report with metal-metal process parameters

This deliverable aims to provide a “recipe book” style procedure for graded material processing, and metal-metal hybrid additive manufacturing bonding strategies. This deliverable addresses Objective 2 in the Grant Agreement to develop a first-of-a-kind hybrid manufacturing method for joining dissimilar metal-metal materials by building upon a combination of powder plasma direct energy deposition (P-DED/PA) and laser powder bed fusion of metals (PBF-LB/M) for achieving graded materials and powder laser direct energy deposition (P-DED/LB) and PBF-LB/M for achieving joined materials. The process development and material characterization tasks have been successfully implemented and are now being used to fabricate TRL 5-6 level demonstrator components for industrial applications from the use-case partners.

The alloy systems and manufacturing techniques chosen for joining are based on the project use-case component designs. In the first two use-case components, a rocket engine combustion chamber and a marine engine heat exchanger, the material-process combination is the P-DED/LB deposition of a Ni-718 alloy onto a PBF-LB/M CuCrZr structure. In the third use-case, a hydrogen storage tank with an integrated heat exchanger, the material-process combination is the wire arc DED (W-DED) deposition of an Al-5183 alloy onto a PBF-LB/M Al-6000 series alloy. These two material and process combinations are studied and optimized for strong metallurgical bonding of the materials with minimal interface defects. The processing parameters and investigations of the metal-metal joint properties are reported in detail. Crack and pore-free joints between CuCrZr and Ni-718 result in an interface layer with superior tensile strength to the base Cu alloy. Porosity develops at the interface between the w-DED and PBF/LB-M Al-alloys due to the inherent hydrogen content and porosity in the PBF-LB/M substrates. Therefore, strategies to minimize dilution by modifying the W-DED parameters are described. The interfacial joints are weaker in tensile strength (130 MPa) than either base material due to the porosity but are sufficiently strong to support the use-case application mechanical loads.