Microstructural analysis of Additive Manufactured walls of AA5083 and AA4043 alloys produced by Cold Metal Transfer

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ABSTRACT

We have studied the microstructure and mechanical properties of two additively manufactured walls using AA5083 and AA4043 aluminium alloys deposited by cold metal transfer (CMT). The dimensions of the produced walls were 20 cm × 5 cm × 0.5 cm as illustrated in Figures 1a and b. Microstructural characterisation was performed via scanning electron microscopy (SEM) on a *Hitatchi TM3000* SEM and a *FEI Nova NanoSEM* 450, as well as transmission electron microscopy (TEM) and electron diffraction (ED) on a *JEOL JEM-2100F* and a Cs probe corrected *FEI TITAN G2 60-300*. The SEM samples were prepared by polishing, chemical etching and electropolishing, while the TEM specimens were prepared by twin jet-polishing and Focused Ion Beam (FIB) thinning. The porosity of the samples was measured by image analysis using imageJ.

The mechanical behaviour of the samples was assessed by Vickers hardness and tensile tests. It was observed that the AA4043 alloy had a lower average hardness than the AA5083 in agreement with the average porosity, which was higher for the AA4043 alloy than the AA5083. Tensile test samples were made from material taken from both vertical and horizontal direction of the wall structures. The AA4043 exhibit a similar σ-ε behaviour in both directions in contrast to the AA5083, which exhibited a remarkable anisotropy in the two directions. In the horizontal direction, σ-ε curves were presenting distinct elastic and plastic regions. However, in the vertical direction, the nominal stress was abruptly dropped at a very low strain, probably due to lack of fusion and/or an uneven distribution of the alloying elements, both resulting in weak joints between the weld beads.

Sample polishing revealed 22 deposition layers in both samples with their corresponding heat affected zones (HAZ) while the HAZ area was decreasing from the bottom towards the top layer, indicative of changes in heat flux effect upon deposition of subsequent layers. This was more pronounced for the AA4043 alloy where further analysis revealed presence of high purity silicon dendrites in each reheated zone, as seen in Figure 2a and Figure 3. Analysis of the HAZ in the electropolished AA5083 (Figure 2b), uncovered a complex dendritic network and a higher accumulation of precipitates in both HAZ and along the sample edges, as compared to the

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surrounding areas. TEM analysis of AA5083 revealed little or no crystallographic orientation relationship between these precipitates and the matrix. Uneven Mg distribution was observed in the Al-matrix, with a Mg-rich phase located between the Al dendritic arms. Solution treatment was performed at 400 °C based on the thermodynamically calculated parameters in order to mitigate compositional inhomogeneities. Homogenisation resulted in an evenly distributed level of magnesium throughout the material matrix.

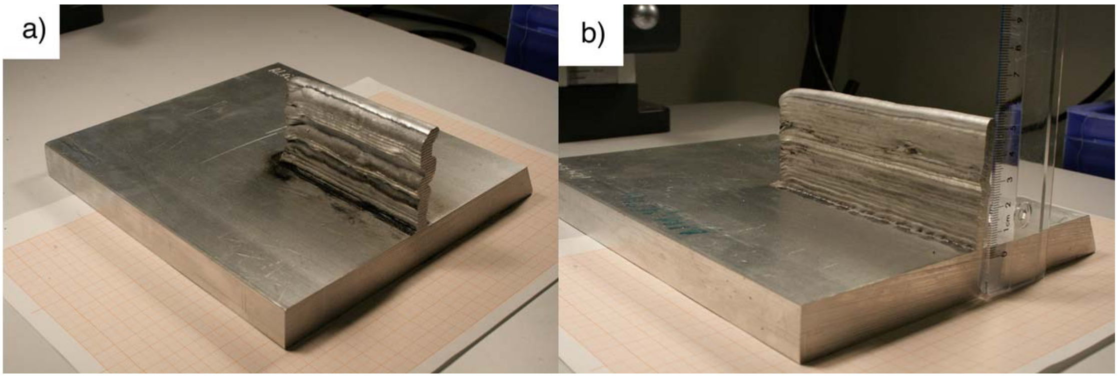

Figure 1: a) A section of the AA4043 wall. b) A section of the AA5083 wall

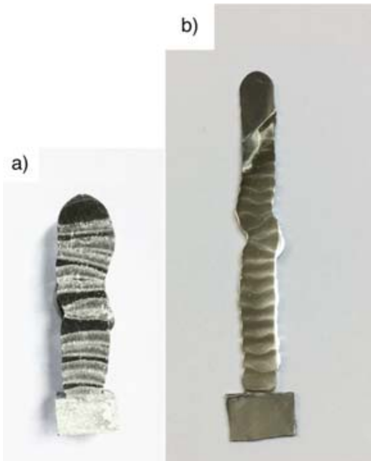

Figure 2: a) Chemically etched AA4043 and b) Electropolished AA5083

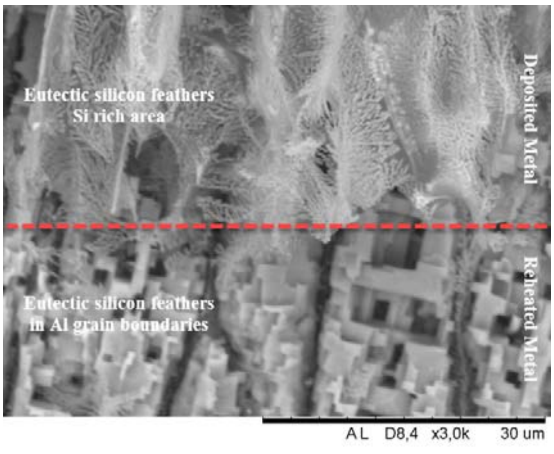

Figure 3: SEM image from the interface region between the deposited and reheated material.