LASER POWDER BED FUSION OF REFRACTORY METALS

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ABSTRACT

In this study we have analysed the densification, microstructure and mechanical properties of refractory metals during laser powder bed fusion. A high intensity laser was successfully used to melt pure tungsten and pure tantalum powder. Light optical microscopy, SEM and mechanical properties testing were used to evaluate the quality of the process. The results showed that the laser powder bed fusion process energy of 348 J/mm^3 for tungsten and 188 J/mm^3 for tantalum were adequate to process the refractory metals. The final density of the parts obtained from optical analysis was 98% for both tungsten and tantalum. Examination of the microstructure revealed that material solidification occurred in a favoured orientation due to an epitaxial growth mechanism within the melt pool produced by the laser beam. Hardness test results of the of tungsten were 325 HV in the x-y cross-sectional plane and 395 HV in the build direction plane. Tensile tests of the as-printed Ta LPBF samples exhibited a strength ranging from 470 to 592 MPa and an elongation range of 15 to 21%.

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INTRODUCTION

The Laser Powder Bed Fusion (LPBF) is an additive manufacturing (AM) technique that is increasingly being embraced as either an alternative or a complementary processing method by various industrial sectors to reduce the manufacturing cost of components with intricate topography, particularly for low volume high-value production and complex shapes as shown by Aliyu *et al.* [1]. The processing of pure tungsten (W) using LPBF is difficult because of W has a high thermal conductivity, high melting temperature and a ductile-to-brittle transition temperature which renders W susceptible to cracking. Therefore, processing of W via LPBF although technically challenging, leads to an advantage. Tantalum (Ta) also has a number of special physical properties, such as a high melting temperature of 3017°C, a relatively high density of 16.6 g/mm^3, high corrosion resistance and relatively high thermal conductivity. These properties make Ta ideal it an ideal choice for ultra-high temperature and applications within many technology fields such as military, electronics, chemical processing and biomedical implants, see Sidambe *et al.* [2]. Hence there is an increased interest of using the LPBF process to fabricate pure Ta.

METHODOLOGY AND RESULTS

Highly spherical Plasma-spheroidised commercial purity W and Ta powder were used for producing the parts in a Renishaw AM125 LPBF system. The results of the porosity showed densities of 98%, whereas the microstructure of the LPBF W and Ta was anisotropic between cross-sectional and build-directions due to an epitaxial growth mechanism within the melt pool. The Vickers micro-hardness of the of W was 325 HV in the x-y cross-sectional plane and 395 HV in the build-direction plane. Tensile tests of the as-printed Ta LPBF samples exhibited a strength ranging from 470 to 592 MPa and an elongation range of 15 to 21%.

CONCLUSION

This study has identified some of the main barriers that limit the effectiveness of LPBF processing of pure W and pure Ta. The effect of key processing parameters has been demonstrated and test samples could be built with satisfactory part quality, at selected laser energy densities for W and Ta.

REFERENCES

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