Tech Science Press

ICCES, 2024, vol.31, no.4
DOI: 10.32604/icces.2024.011290

PROCEEDINGS

Multi-Scale Microstructure Manipulation of an Additively Manufactured CoCrNi Medium Entropy Alloy for Superior Mechanical Properties and Tunable Mechanical Anisotropy

Chenze Li[1], Manish Jain[1,2], Qian Liu[1], Zhuohan Cao[1], Michael Ferry[3], Jamie J. Kruzic[1], Bernd Gludovatz[1] and Xiaopeng Li[1,*]

[1]School of Mechanical and Manufacturing Engineering, The University of New South Wales (UNSW Sydney), Sydney NSW 2052, Australia

[2]Sandia National Laboratories, Albuquerque, NM 87185, United States

[3]School of Materials Science and Engineering, The University of New South Wales (UNSW Sydney), Sydney NSW 2052, Australia

[*]Corresponding Author: Xiaopeng Li. Email: xiaopeng.li@unsw.edu.au

ABSTRACT

Laser powder bed fusion (LPBF) additive manufacturing (AM) technology has become a versatile tool for producing new microstructures in metal components, offering novel mechanical properties for different applications. In this work, enhanced ductility (~55% elongation) and tunable mechanical anisotropy (ratio of ductility along vertical to horizontal orientation from ~0.2 to ~1) were achieved for a CoCrNi medium entropy alloy (MEA) by multi-scale synergistic microstructure manipulation (i.e., melt pool boundary, grain morphology and crystallographic texture) through adjusting key LPBF processing parameters (e.g., laser power and scan speed). By increasing the volumetric energy density (VED) from 68.3 to 144 J/mm^3, the melt pool size enlarges, and the crystallographic texture transitions from <100>//BD to <110>//BD due to the maximum thermal flux direction changing for different melt pool dimensions, which affects the proportion of grains that have different growth directions. Moreover, excellent mechanical properties of 890 MPa ultimate tensile strength and ~55% elongation to failure can be achieved for loading perpendicular to the build direction with only a ~15% reduction in properties for loading along the build direction. The superior combination of mechanical properties is achieved by processing parameter-controlled strengthening of melt pool boundary interfaces, heterogeneous deformation induced strengthening through bimodal grain structures, and favorable grain orientation for dislocation slip and twinning formation, which was significantly more activated in the <110>//BD texture than in the <100>//BD. This study offers new insights into achieving multi-scale synergistic microstructure manipulation via LPBF for desired strength, ductility, and mechanical anisotropy in a CoCrNi MEA.

KEYWORDS

Laser powder bed fusion additive manufacturing; CoCrNi medium entropy alloy; melt pool; crystallographic texture; heterogeneous structure

Acknowledgement: X.L. would like to acknowledge the financial support from Australian Research Council (ARC) Discovery Early Career Researcher Award (DECRA) DE190101495. B.G. additionally acknowledges support from the ARC Future Fellowship (project no. FT190100484) and the UNSW Scientia Fellowship schemes. C.L. would like to thank the support from the Australia Government Research Training Program (RTP) Scholarship. The authors would like to thank the technical support from the Mark Wainwright Analytical Center at UNSW including the facilities and staff of Microscopy Australia at the Electron Microscope Unit (EMU).

Funding Statement: 1. Australian Research Council (ARC) Discovery Early Career Researcher Award (DECRA) DE190101495, Xiaopeng Li, https://www.arc.gov.au/. 2. ARC Future Fellowship (FT190100484), Bernd Gludovatz, https://www.arc.gov.au/.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.