Tech Science Press

ICCES, 2024, vol.32, no.2
DOI: 10.32604/icces.2024.012733

PROCEEDINGS

Programmable Mechanical Properties of Additive Manufactured Novel Steel

Jinlong Su[1,2], Chaolin Tan[2,*] and Swee Leong Sing[1,*]

[1]Department of Mechanical Engineering, National University of Singapore, 117575, Singapore

[2]Singapore Institute of Manufacturing Technology, A*STAR, 5 Cleantech Loop, 636732, Singapore

[*]Corresponding Author: Swee Leong Sing; Chaolin Tan. Email: sweeleong.sing@nus.edu.sg; tan_chaolin@simtech.a-star.edu.sg

ABSTRACT

Tailoring thermal history during additive manufacturing (AM) offers a viable approach to customising the microstructure and properties of materials without changing alloy compositions, which is generally overlooked as it is hard to achieve in commercial materials. In this work, a customised Fe-Ni-Ti-Al maraging steel with rapid precipitation kinetics offers the opportunity to leverage thermal history during AM for achieving large-range tunable strength-ductility combinations without post heat treatment or changing alloy chemistry. The Fe-Ni-Ti-Al maraging steel was processed by laser-directed energy deposition (LDED) with different deposition strategies to tailor the thermal history. As the phase transformation and in-situ formation of multi-scale secondary phases of the Fe-Ni-Ti-Al maraging steel are sensitive to the thermal histories, the deposited steel achieved a large range of tuneable mechanical properties. Specifically, the interlayer paused deposited sample exhibits superior tensile strength (~1.54 GPa) and moderate elongation (~8.1%), which is attributed to the formation of unique hierarchical structures and the in-situ precipitation of high-density η-Ni3(Ti, Al) during LDED. In contrast, the substrate heating deposited steel has an excellent elongation of 19.3% together with a high tensile strength of 1.24 GPa. The achievable mechanical property range via tailoring thermal history in the LDED-built Fe-Ni-Ti-Al steel is significantly larger than most wrought commercial materials. The findings highlight the material customisation along with LAM's unique thermal history to achieve versatile mechanical performances of deposited materials, which could inspire more property or function manipulations of materials by AM process control or innovation.

KEYWORDS

Additive manufacturing; directed energy deposition; thermal history control; microstructure tailoring; mechanical property programming

Funding Statement: This work was financially supported by the Career Development Fund (Grant No. C210112051) under the Agency for Science, Technology and Research (A*STAR) of Singapore and 2022 MTC Young Individual Research Grants (Grant No: M22K3c0097) under Singapore Research, Innovation and Enterprise (RIE) 2025 Plan, led by Chaolin Tan.

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