Precipitation during in-situ and post-heat treatments of Al-Mg-Sc-Zr alloys processed by powder-bed fusion

Štefan Nagy[1], Mohammad Sadegh Mohebbi[2], Vasily Ploshikhin[2]

[1]Institute of Materials and Machine Mechanics, Slovak Academy of Sciences, Bratislava, Slovakia
[2]Airbus Endowed Chair for Integrative Simulation and Engineering of Materials and Processes (ISEMP), University of Bremen, Germany

nagy.stefan@savba.sk, mohebbi@isemp.de, ploshikhin@uni-bremen.de

Corresponding author: *Š. Nagy (nagy.stefan@savba.sk), Institute of Materials and Machine Mechanics, Slovak Academy of Sciences, Bratislava, Slovakia*

ABSTRACT

This study explores the evolution of Sc-rich precipitates in Scalmalloy® fabricated via Powder Bed Fusion (PBF) additive manufacturing. Through a combination of microstructural characterization, thermodynamic modeling, and an adapted precipitation model, we investigate how these precipitates evolve during solidification, in-situ heat treatment (IHT), and post-heat treatment (PHT). A comprehensive classification framework is established for primary and secondary Sc-rich precipitates, based on their origin, location, morphology, composition, interactions, and size. Primary precipitates are predominantly found within the fine-grained (FG) zone, with their characteristics indicating further transformation during IHT and PHT. The developed precipitation model, integrated with multi-scale thermal simulations, successfully predicts the formation of fine, homogeneous secondary $L1_2$-Al_3Sc precipitates during PBF and PHT—demonstrating its capability as a valuable tool for optimizing PBF processes in components with complex geometries and varying thermal profiles. Our results show that the applied IHT conditions did not trigger secondary precipitation, whereas subsequent PHT at 400 °C for 1 hour promoted the formation of secondary precipitates through both continuous and discontinuous mechanisms. Future work should focus on resolving current uncertainties in primary precipitate formation during PBF and incorporating both homogeneous and heterogeneous nucleation mechanisms to enhance understanding of Scalmalloy® precipitation behavior and PBF process optimization.

Acknowledgment: Funded by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia under the project No. 09I03-03-V04-00715.

BIOGRAPHY

Ing. Stefan Nagy Ph.D. is currently a researcher at the Institute of Materials and Machine Mechanics of the Slovak Academy of Sciences. He completed both Engineering and Doctoral studies at the Faculty of Materials Technology, STU in the field of Advanced Materials and Material Design. The area of his expertise is metal matrix composite materials, aluminium alloys, additive manufacturing and electron microscopy (TEM, STEM, SEM).

- Category: Oral presentation
- Research Interest: additive manufacturing, composites, electron microscopy