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Reviewer's report on a Ph.D. thesis

Powder Metallurgy of Hybrid Materials for Advanced Applications

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reviewer: Prof. Hyoung Seop Kim

The thesis focuses on the application of Field-Assisted Sintering Technology (FAST) for sintering composite materials and blended elemental powders in various areas. The following key aspects were explored:

1) Manufacturing of architectured composites: An architectured composite of Al6061 + Ti-6Al-4V was produced using FAST. However, the process faced challenges due to issues with powder penetration into the lattice, especially given the small lattice dimensions. Mechanical properties of the composite were evaluated through a three-point bending test, showing improved strength compared to the plain, unannealed Al6061 matrix. However, there was a premature fracture when the Al matrix underwent proper aging. As a result, using FAST for manufacturing architectured composites was found to be inconvenient.
2) Consolidation and in-situ aging: In this study, a long, fully dense rod was manufactured using blended elemental powders of the Ti-5Al-5V-5Mo-3Cr alloy. The entire process of consolidation, homogenization, and aging was completed in a single processing run. The resulting tensile properties of the alloy were found to be comparable to those of commercially available materials, achieving a yield strength of 1183 MPa and a ductility of 6%. This demonstrated the potential of FAST for preparing alloys with good mechanical properties from blended elemental powders.
3) Rapid alloy prototyping: The research showed that FAST is a useful method for rapid alloy prototyping using blended elemental powders. This opens up possibilities for exploring new alloy compositions and properties in a more time-efficient manner.
4) High-throughput experimental investigations of multicomponent phase diagrams: The thesis investigated the phase stability of the Ti-(20–29)Nb-7Zr-(0.2–0.8)O system using

deliberately produced Nb concentration gradients. A critical concentration of 22 wt% of Nb was identified, which suppressed the α/α″ precipitation. The study successfully prepared homogeneous alloys from the elemental powder blend, and their phase composition and elastic modulus were measured. The results demonstrated the feasibility of preparing samples with tunable chemical heterogeneity using FAST.

Additionally, the thesis proposed a method for sintering multiple powder blends in a single specimen, enabling the production of heterogeneous samples with a wide range of alloy compositions. This approach allowed for high-throughput investigations of phase equilibria, as demonstrated in the AlTiTaNbZr refractory complex concentrated alloy system.

To summarize, the thesis provides valuable insights into the capabilities and limitations of FAST in various applications related to sintering composite materials and producing alloys from blended elemental powders. While manufacturing architectured composites with FAST showed limitations, the use of blended elemental powders proved promising and useful for research purposes.

My only concern with this thesis pertains to the absence of comprehensive mechanical testing and analyses. Although some limited data, such as tensile curves and the Ashby plot illustrating yield strength versus true fracture strain in Fig. 5.11, indicate a favorable combination of strength and ductility, the reviewer acknowledges that assessing mechanical properties in depth exceeds the scope of this thesis. Nevertheless, the thesis meets the necessary quality standards for a Ph.D. dissertation, and I endorse its advancement for defense, recommending the candidate for the degree award.

Best regards

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