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Enabling Ductility of Brittle Intermetallics through AM

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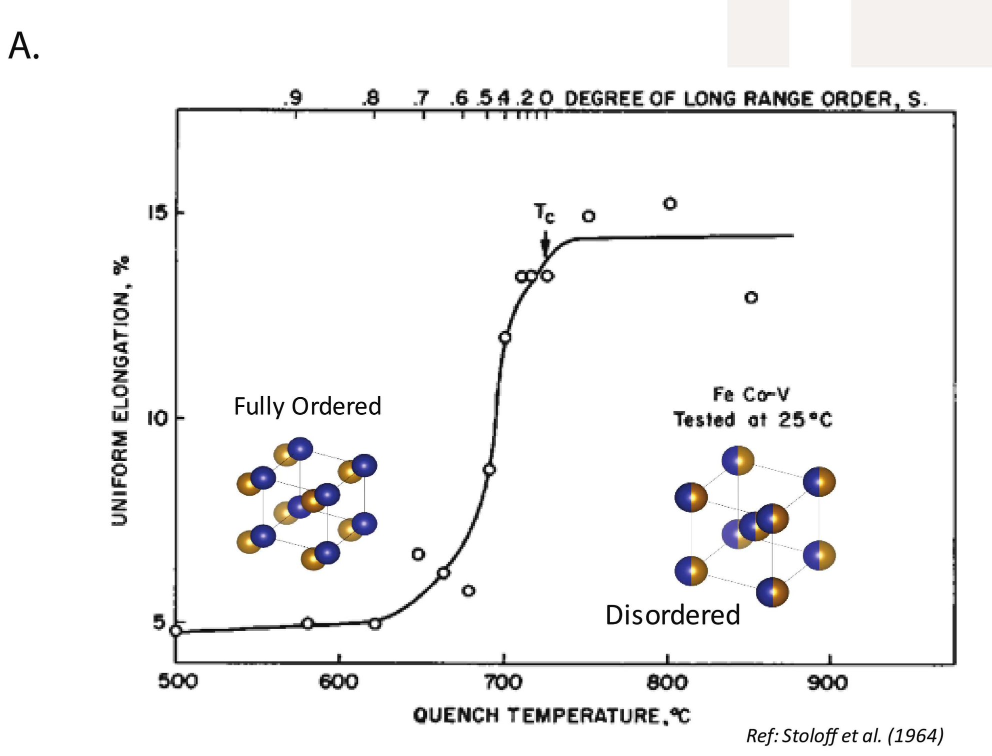
Introduction

FeCo alloys are ideal materials for magnetic applications. Binary FeCo is not manufactured using traditional manufacturing methods such as forging due to estreme brittleness resulting from its ordered B2 atomic structure.

Atomic ordering is dependent on the cooling rate of the matieral and can be controlled by varying it. To suppress ordering, cooling rates over 4000 °C/s are required. AM's high cooling rates are favorable for the manufacturing of brittle intermetallics by reducing the atomic ordering.



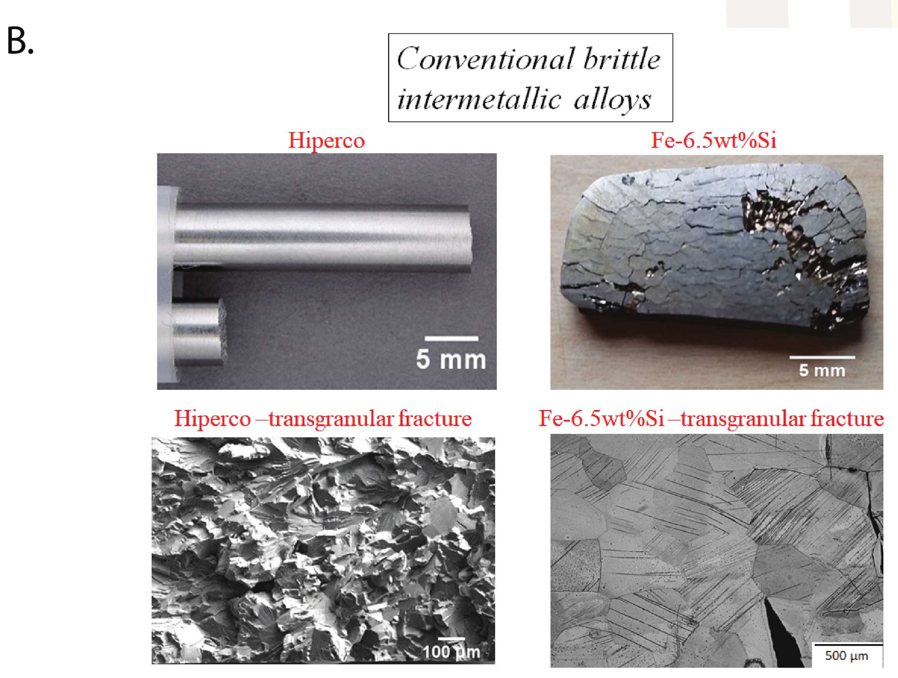


Figure 1. (A) Uniform Elongation as a function of Quench Temperature for Fe-Co-V (Hiperco) alloy. Samples were cooled in an iced brine from different annealing temperatures. (B) Fracture of commerical brittle intermetallic alloys

Materials and Methods

Selective laser melting (SLM) using a Renishaw AM 400 and a custom LENS system was used to manufacture pre-alloyed stoichiometric binary FeCo (Sandvik Opsrey Company)

Results

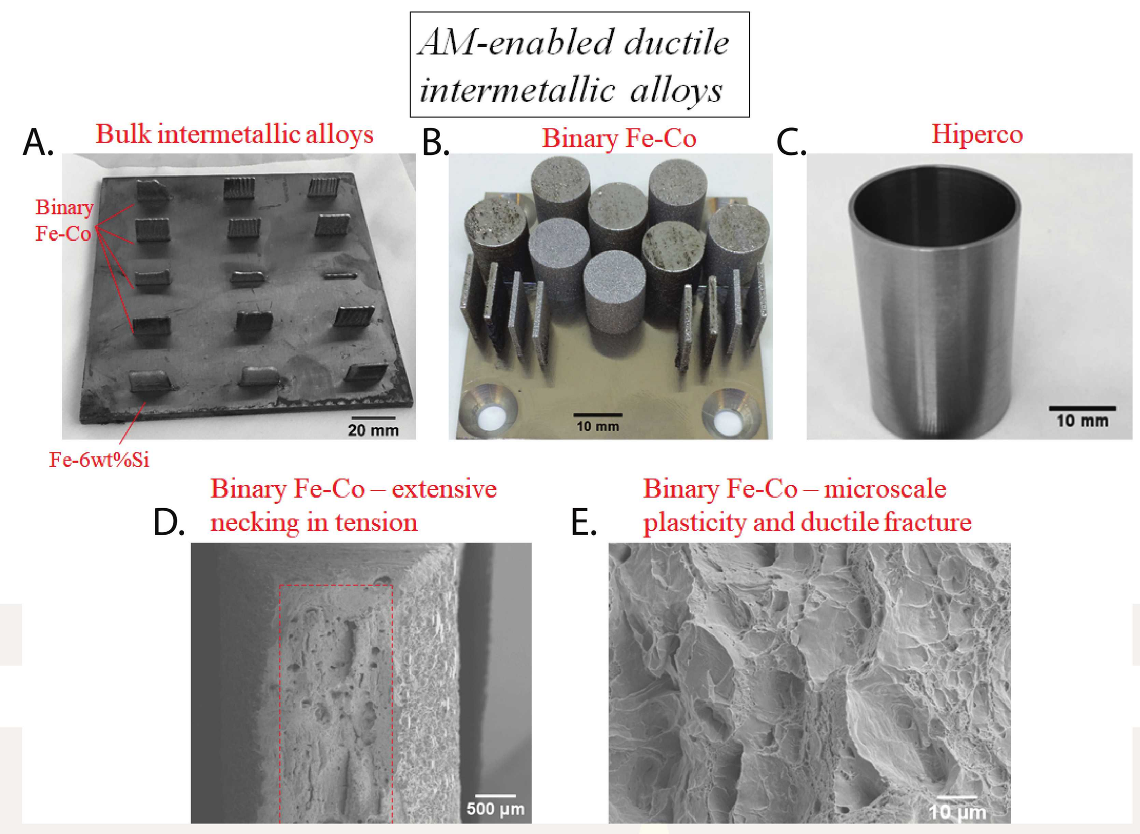


Figure 2. (A) LENS processed binary FeCo and FeSi and (B) SLM processed binary FeCo. (C) LENS processed Hiperco (FeCo-V). (D,E) Fracture region of SLM processed binary FeCo tensile specimens.

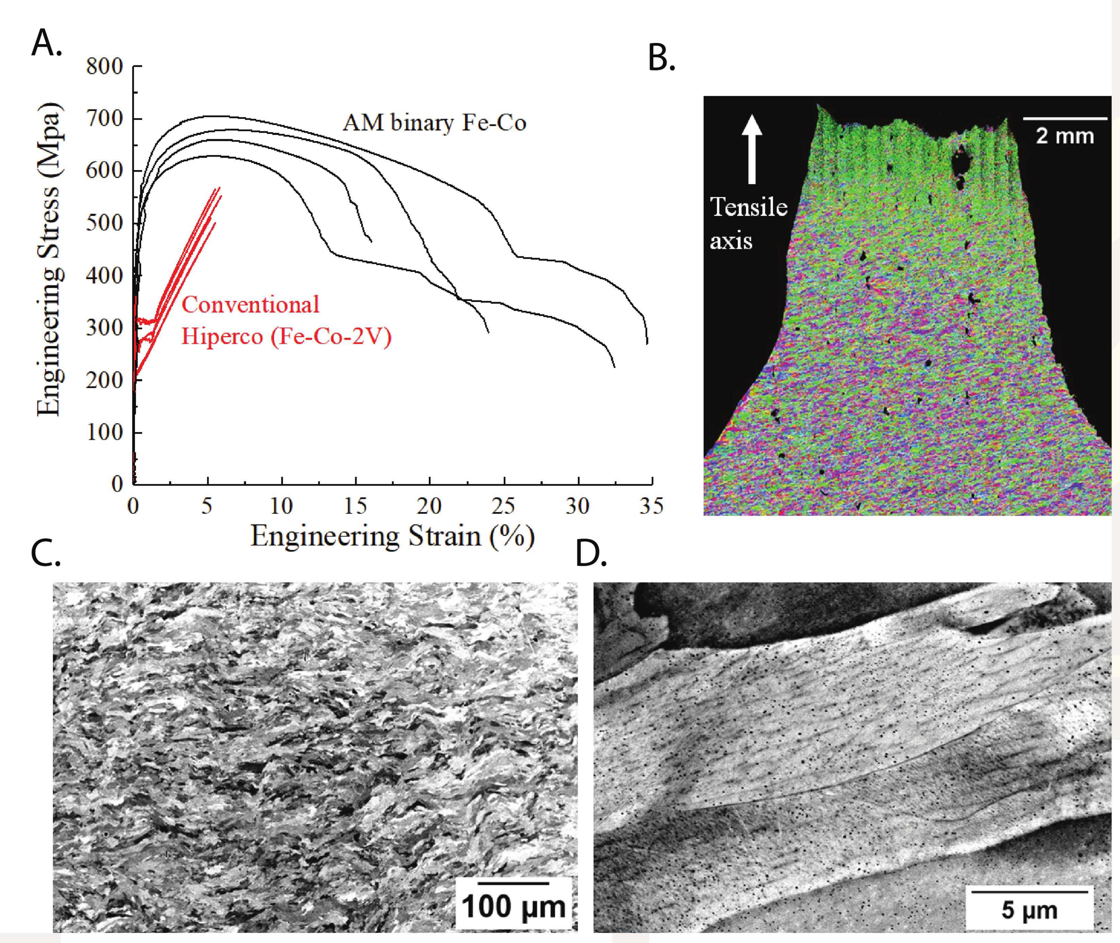


Figure 3. (A) Stress vs. Strain diagram for AM binary FeCo and conventional FeCo-2V. (B) EBSD image of the fracture region of AM binary FeCo. (C,D) BSE of as-deposited AM binary FeCo.

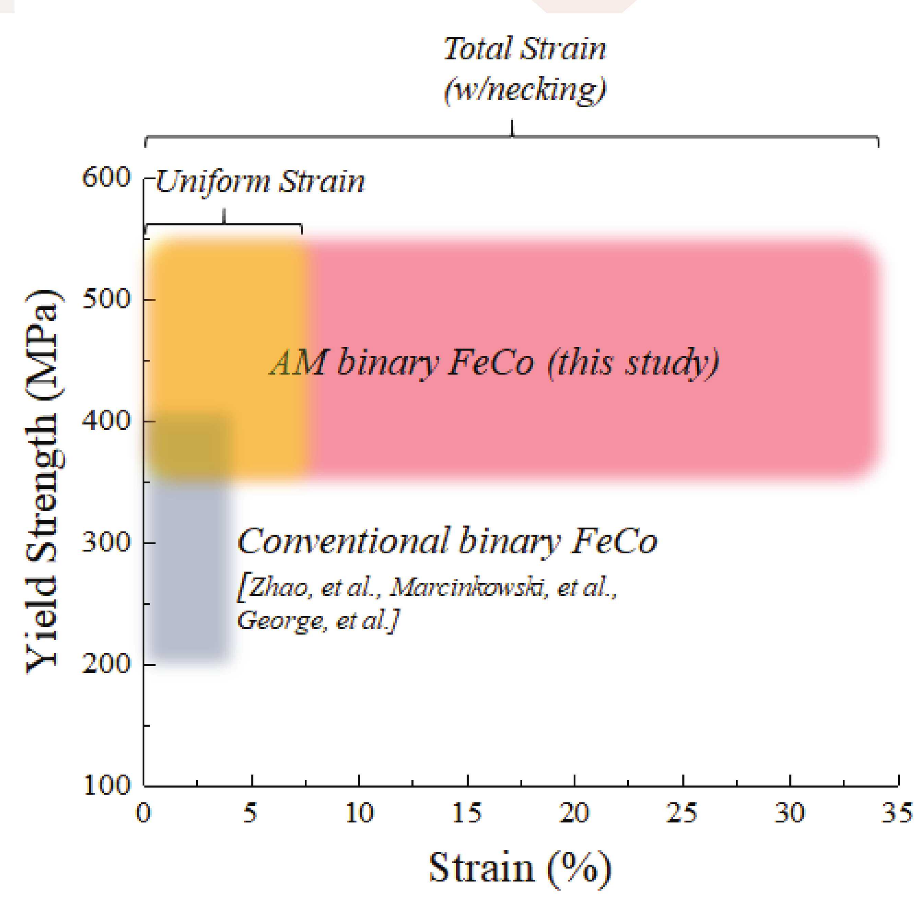


Figure 4. Yield strength vs. Strain for AM processed binary $Fe_{0.5}Co_{0.5}$.

Discussion

Additively manufactured Fe-Co alloys show significant increases in ductility (34%) over conventional Fe-Co alloys (6%). XRD shows a decrease in ordering for as-printed Fe-Co alloys.

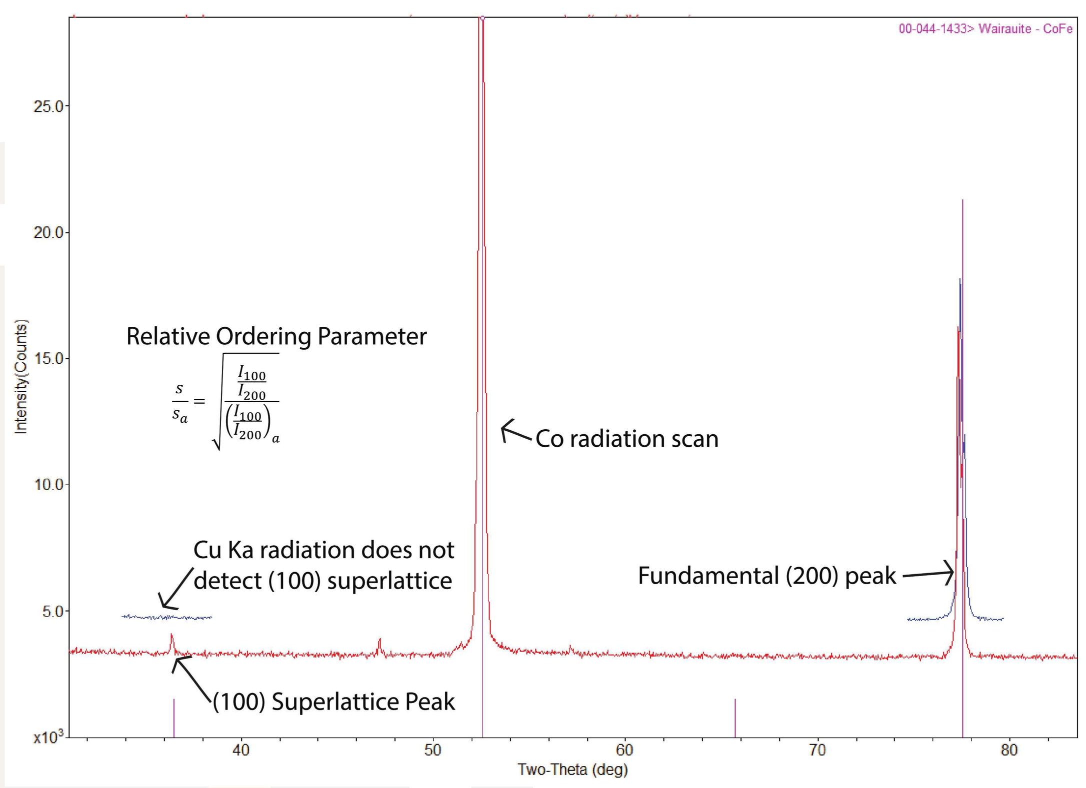


Figure 5. XRD scans of AM Hiperco using both a Cu and Co radiation source

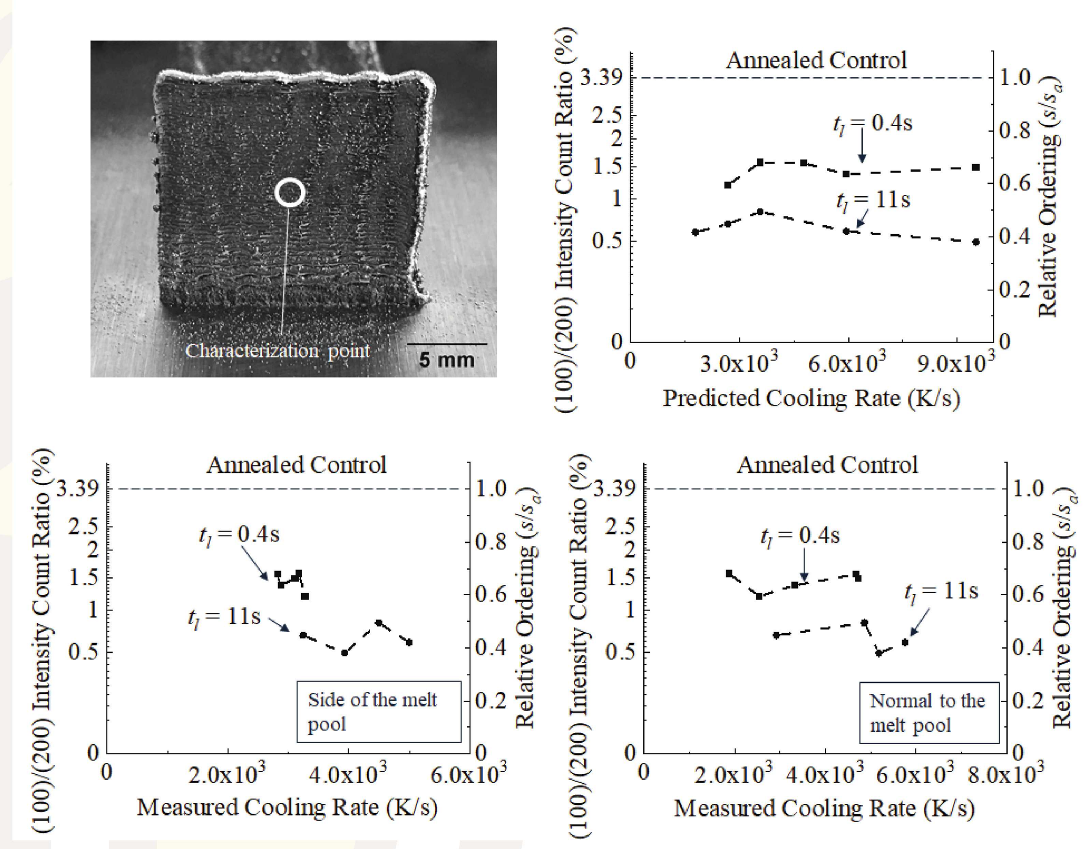


Figure 6. Relative ordering of LENS processed Hiperco

Conclusions

SLM and LENS AM was used to manufacture brittle intermettalic Fe-Co alloys. SLM and LENS were both successful in the manufacture of binary Fe-Co and Fe-Co-2V. AM binary Fe-Co showed significant increases in ductility over its conventional counterpart. AM Fe-Co saw a decrease in atomic ordering allowing for the increase in ductility.

Further work needs to be done to investigate the impact of AM on Fe-Co magnetic properties and the true impact atomic ordering has on the ductility.

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