Mechanical Property and Microstructure of Laser Powder Bed Fused Hypereutectic Al-16Ce-1Mg Alloy

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Background and Rationale

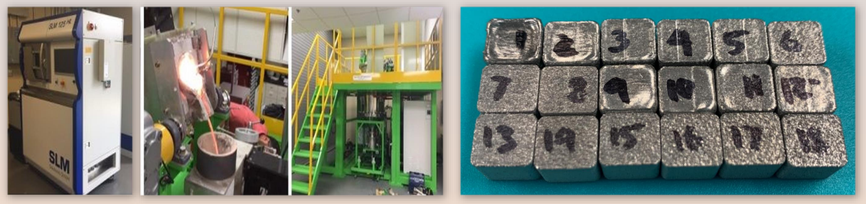
Al-Ce based alloys have shown promise as next-generation lightweight high temperature aluminum alloys. Compared to slow cooling in traditional casting method, the rapid cooling inherent in laser powder bed fusion (LPBF) results in refined microstructure and thus improved mechanical properties. Although many traditional Al-based alloys suffered from solidification cracking during LPBF, Al-Ce based near-eutectic alloys have demonstrated outstanding printability. This work extends the Al-Ce alloy to the hypereutectic composition with alloying of Mg. It is hypothesized that the alloy can be further strengthened with higher volume fraction of fine intermetallics and solid solution strengthening.

Objective

- Identify the LPBF and HIP processing parameters;
- Investigate the tensile properties and fracture surface;
- Determine the compressive creep strain rates;
- Examine the microstructural evolution before and after heat treatment.

Current Obtained Results

1. Samples Preparation



2. Density Test

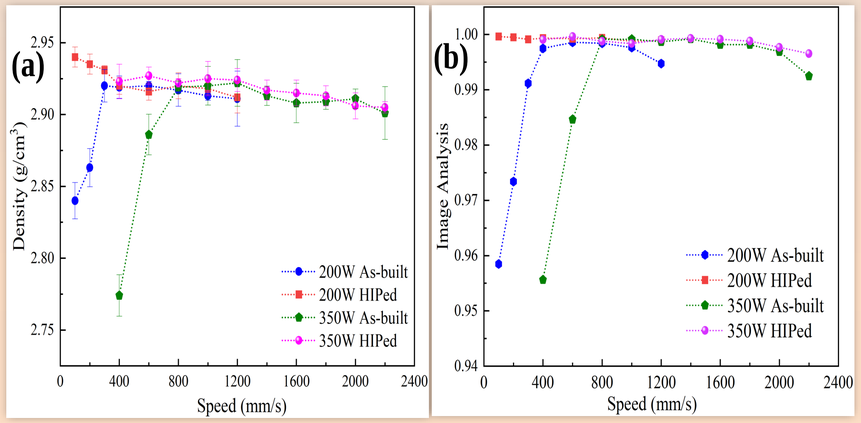
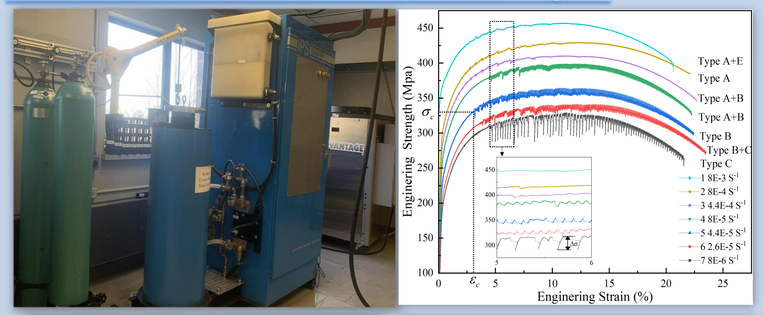


Fig. 1 Density measurement of as built and HIP-treatment samples fabricated by 200 W and 350 W with various scan speeds using (a) Archimedes principle and (b) image analysis methods.

3. Heat treatment(HIP: Hot Isostatic Pressing)



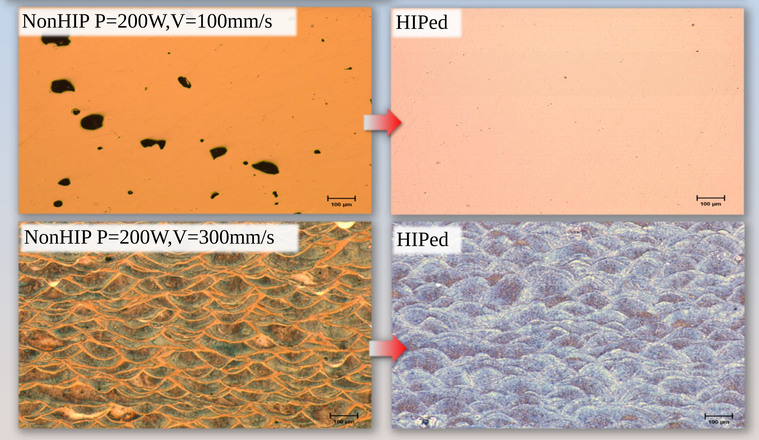


Fig. 2 Effect of the PLC phenomenon and keyholes elimination with different strain rates after HIP

4. Tensile Test

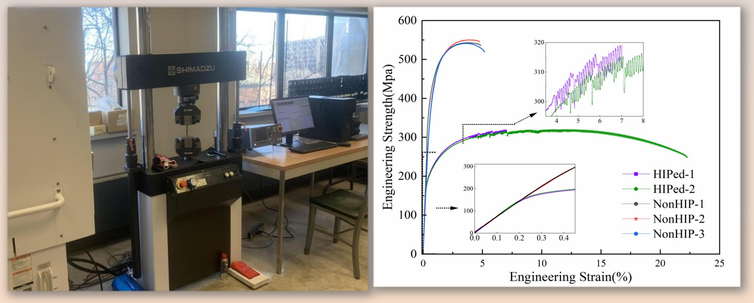
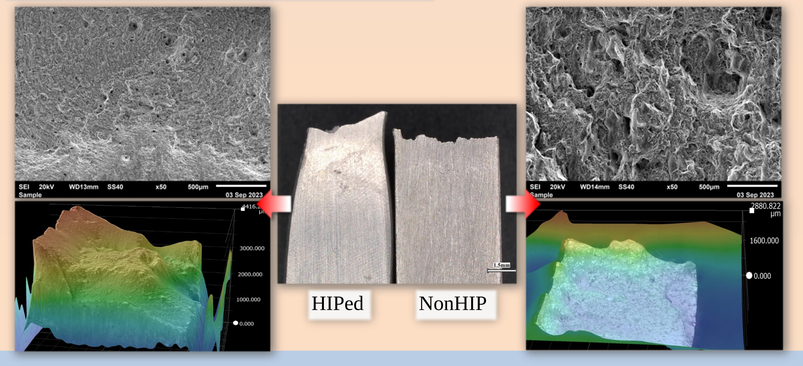


Fig. 3 Uniaxial tensile test with constant load speed 0.002 mm/s

5. Fracture Section Oberservation



6. Creep Test

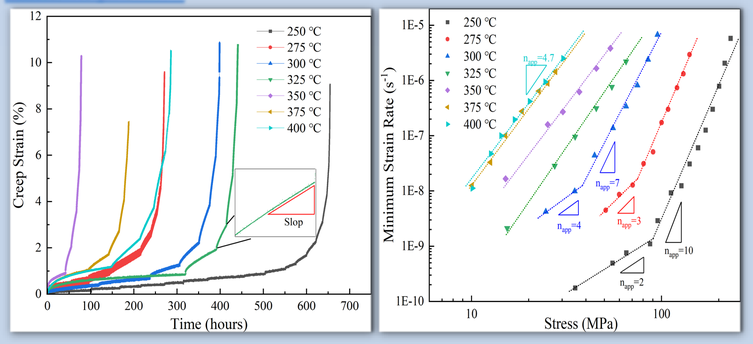


Fig. 4 Compressive creep test at various temperatures from 250 ℃ to 400 ℃ with different scale loads adding

7. SEM Observation

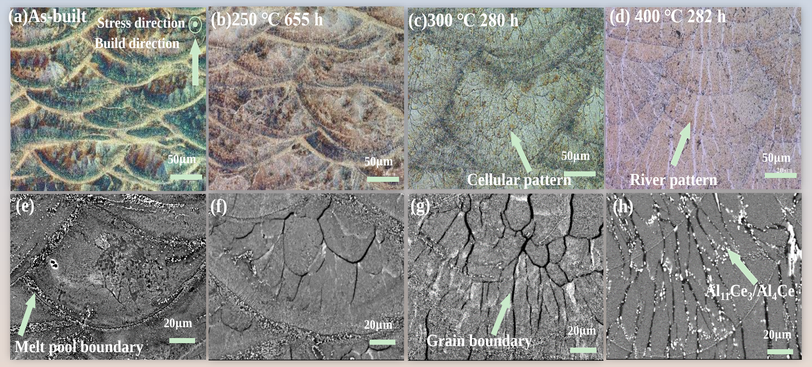


Fig. 5 Microstructure of crept specimens at various temperatures and compression time

Conclusions

- The Al-16Ce-1Mg alloy exhibited outstanding printability with no cracks. HIP nearly eliminated all the pores regardless of the initial porosity.
- The as-printed alloy exhibited strength more than 500MPa while the HIP improved the ductility to more than 25%.
- Creep resistance was slightly improved compared to near eutectic binary Al-Ce alloy.

Future work

- Complete the creep measurement;
- Understand the microstructural evolution during creep;
- Investigate the PLC effect after HIP.

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