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Anomalous Eutectic Microstructures in Mg-Al Structural Alloy Prepared by Rapid Solidification

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Introduction

Magnesium is the lightest engineering metal [1]. However, conventional Mg alloys typically suffer from low strength and poor deformability due to very few slip systems and easy twinning [3]. Alloying Mg with other materials and microstructural engineering are promising approaches to increase ductility and strength of Mg. In the current work, non-equilibrium solidification conditions were applied to induce a transition from regular to anomalous eutectic in Mg-Al eutectic alloy such that four distinguished microstructures were acquired and the corresponding formation mechanisms were investigated.

Methods

- ✓ Mg-33wt.%Al nanocomposite fabrication: Arc melting and melt spinning at speeds of 5-50 m/s.
- ✓ Microstructural examination: FEI Helios 660 dual-beam SEM and FEI Tecnai Osiris at 200 kV.
- ✓ TEM lamellae preparation: Lift-out technique using focused ion beam (FIB).

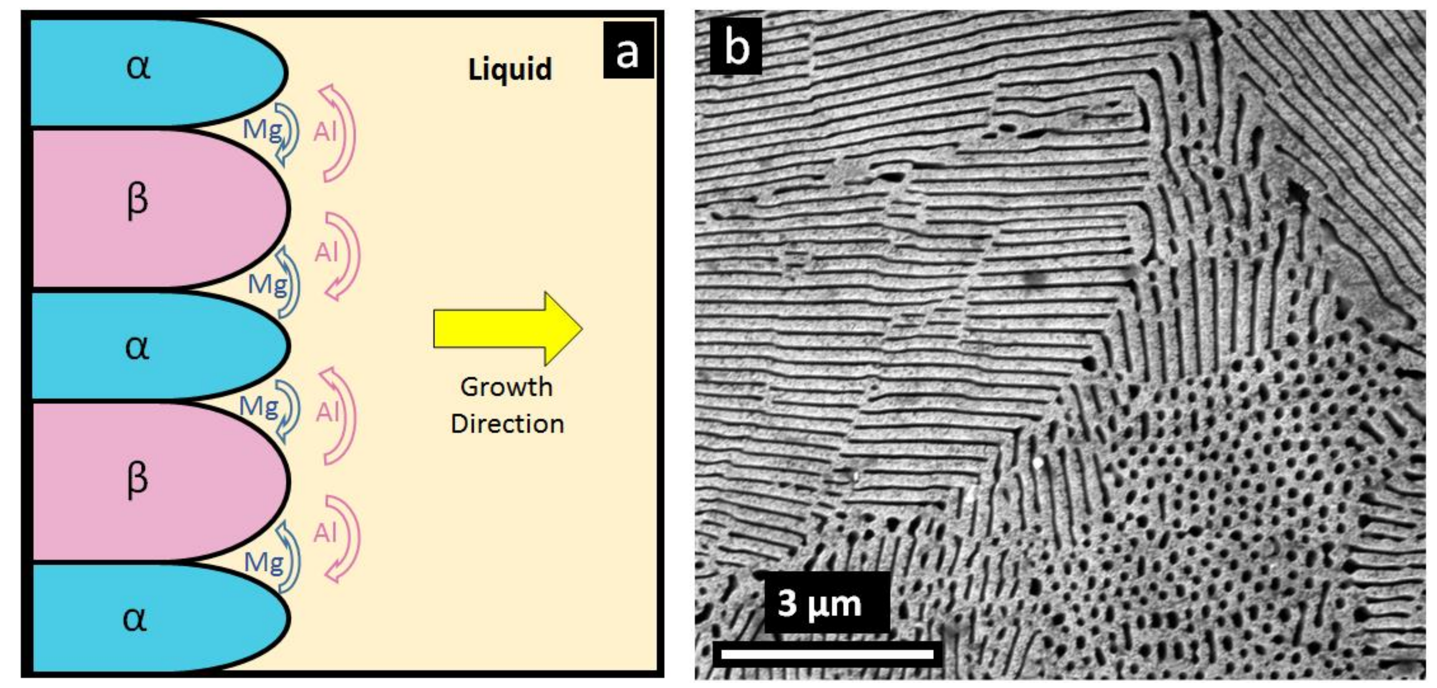
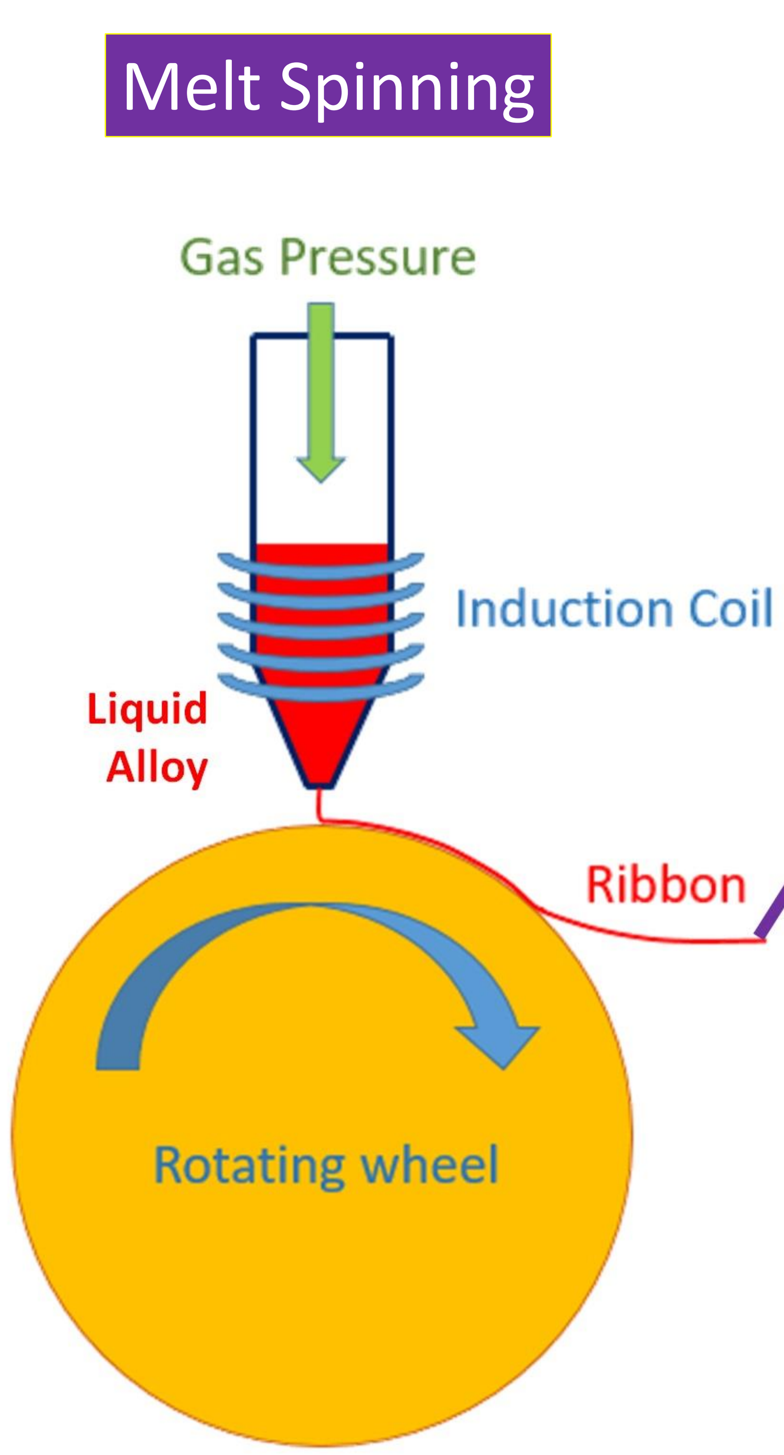


Figure 1. (a) Schematic of the regular eutectic growth and (b) Mg-Al regular eutectic.

Anomalous Eutectic Microstructures

❖ Four distinctive anomalous eutectic microstructures were observed, depending on the wheel speed, with unique formation mechanisms;

- ✓ Type A: At low wheel speeds and formed by remelting of primarily grown regular eutectic due to solute trapping and high interfacial energy
- ✓ Type B: At low and intermediate wheel speeds formed due to a coupled-to-decoupled-growth transition
- ✓ Type C: At intermediate wheel speeds formed by decoupled nucleation and growth of the eutectic phases followed by a coupled dendritic growth
- ✓ Type D: At high wheel speeds formed by decoupled nucleation and growth of the eutectic phases



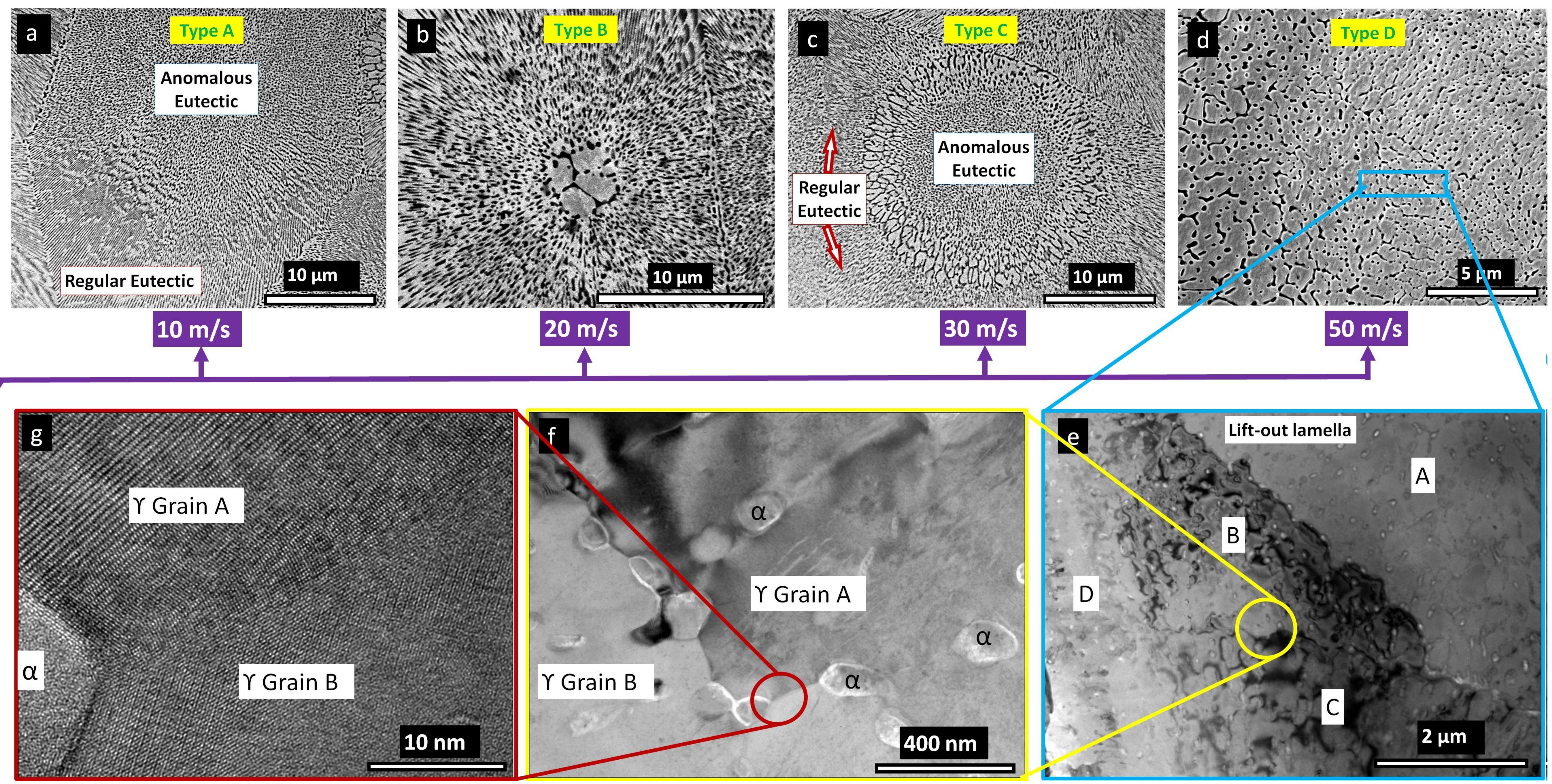


Figure 2. Schematic of the melt spinning process. (a-d): microstructures of Mg-Al eutectic processed at different wheel speeds, (e-f) TEM images of specimen formed 50 m/s.

Conclusion

Melt spun Mg-33.3%Al ribbons cast at different wheel speeds demonstrated diverse microstructures. It was evident that the cooling rate is the most determining parameter in the resultant microstructure such that it altered the growth kinetics of the eutectic phases and gave rise to four distinctive microstructures. **Future work** will be the examination of the mechanical properties of each microstructure and select the optimum (Figure 3).

References

[1] Davies, G (2003) Magnesium.Materials for automotive bodies, Elsevier, G. London,p. 91,158-159.

[2] Handbook, A.S., Magnesium and Magnesium Alloys. ASM International, 1999, p. 106-118.

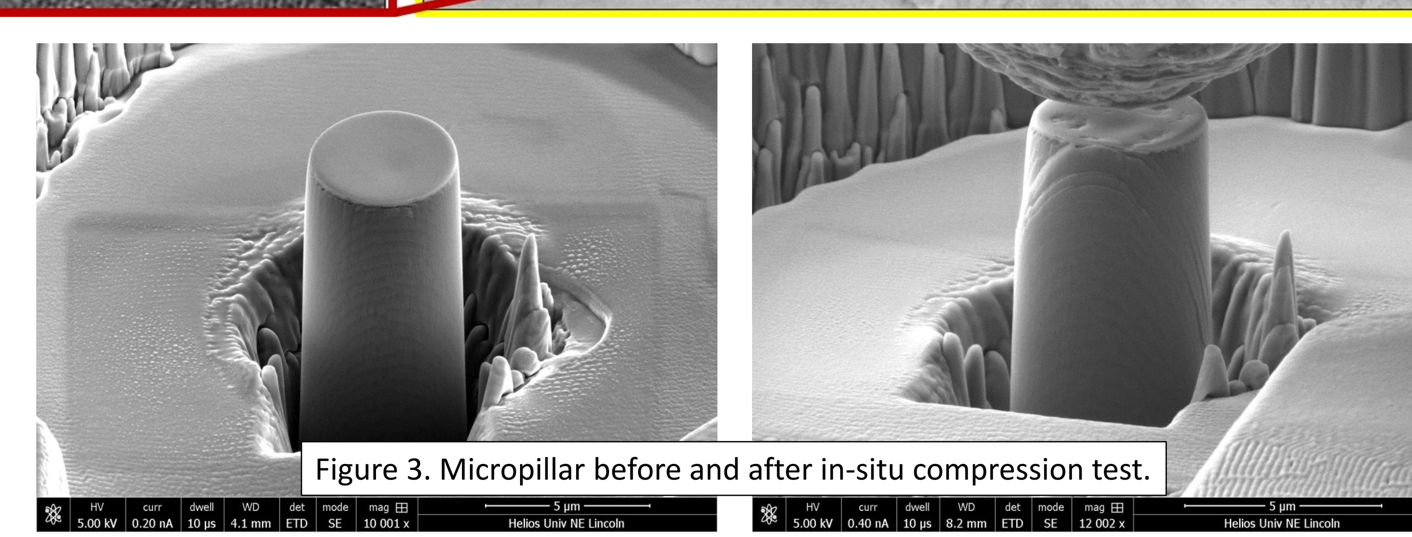


Figure 3. Micropillar before and after in-situ compression test.

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