Corrosion Dependence on Processing-induced Dislocations in Mg Alloys

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Introduction

Magnesium alloys are the lightest structural metals with bone-like mechanics and natural biodegradability, ideal stent and scaffold implants.

Deformation processing is often used to improve the mechanical properties by reducing grain size and introducing dislocations.

How does processing alter degradation rate and hardness, and which microstructural features play the dominant role?

Objective

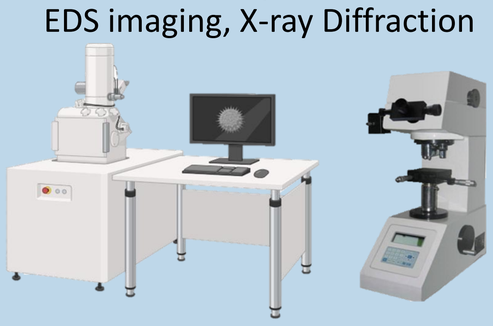
The proposed component design focuses on mechanical stability after post-processing, demonstrating how processing strategies can tailor materials for biomedical applications with targeted property and behavior requirements.

Methodology

1. Processing
Homogenizing and Cold Rolling

2. Corrosion
DMEM at 37˚C for 100 hours

3. Characterization
Hardness studies, EBSD and SEM-EDS imaging, X-ray Diffraction

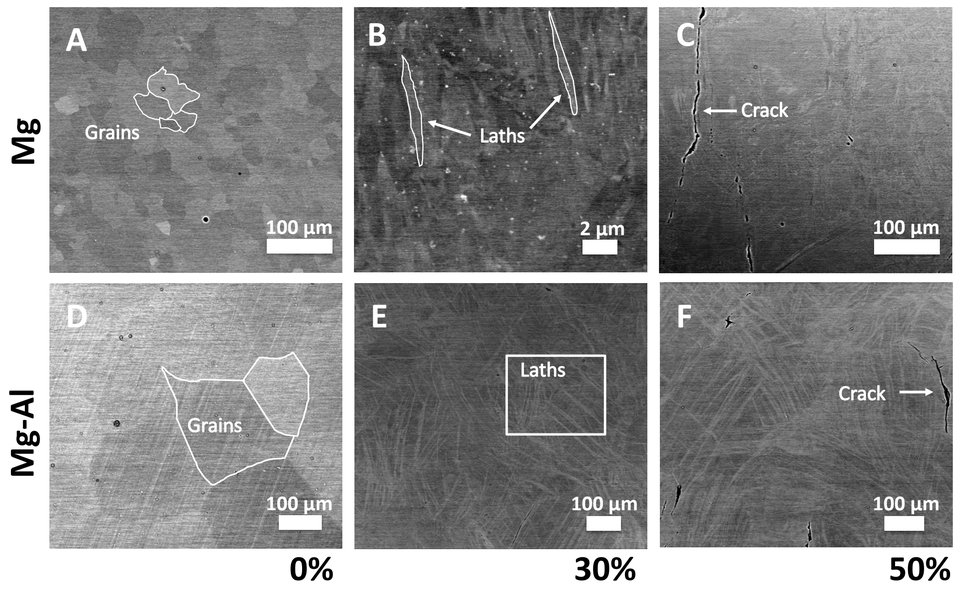


Optimal processing strategy relies on the following standards:

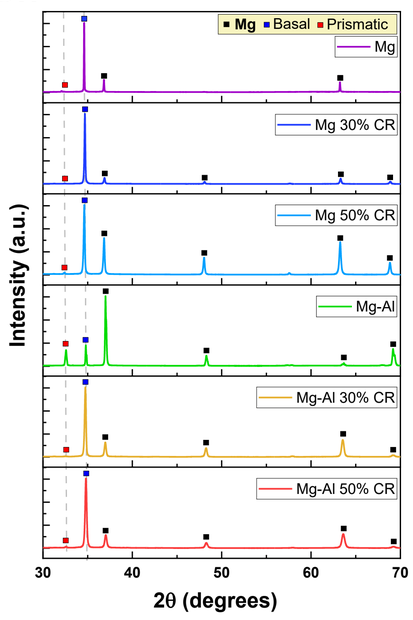
- ASTM G31-72 & E112-13
- ISO 6507-1:2023

Results

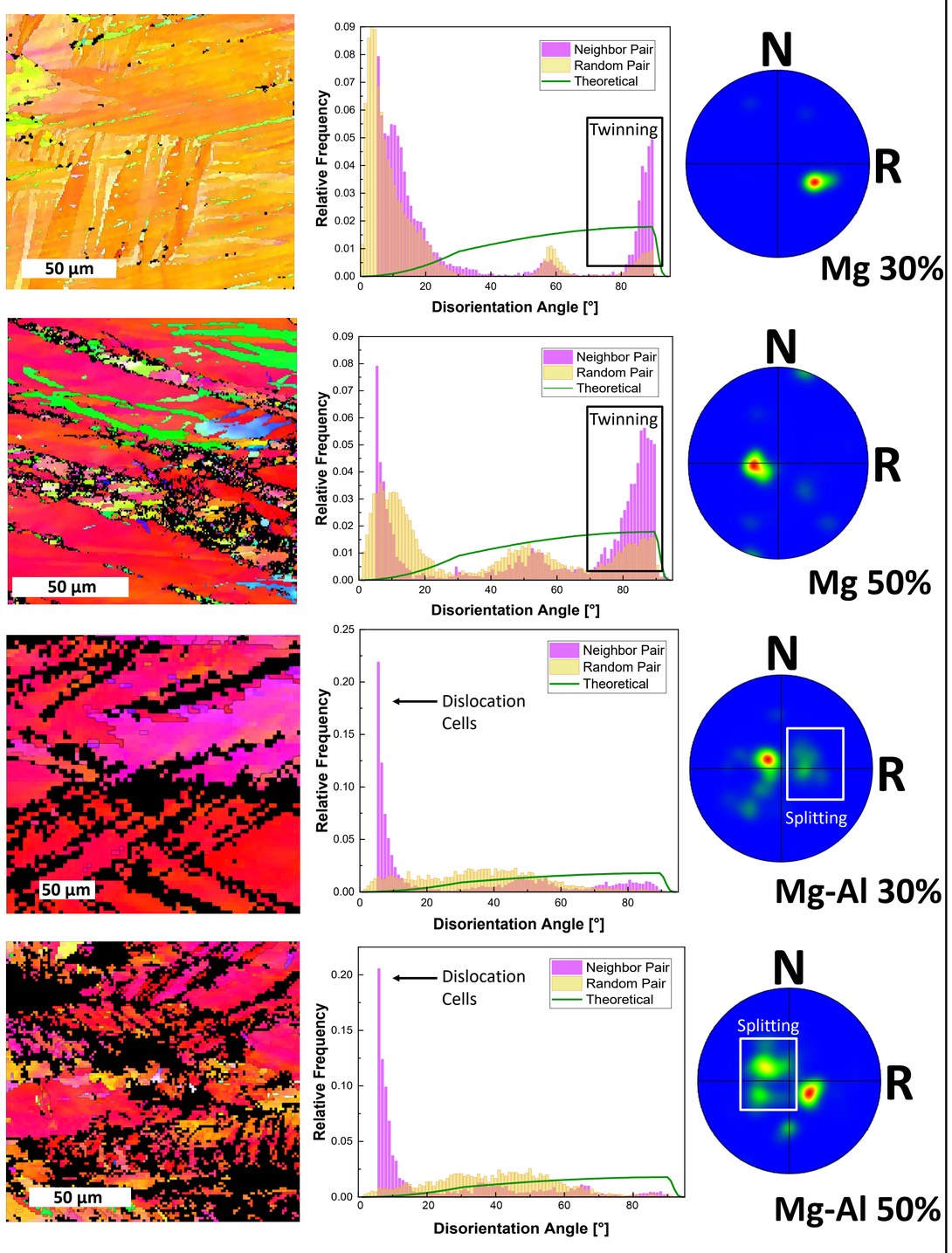
1. Microstructural Features – Scanning Electron Microscopy & X-ray Diffraction



- Distinct grain boundaries, laths, and cracks can be observed
- An absence of secondary phases can be seen in both the SEM images and XRD scan
- We see the evolution of non-basal planes with more deformation

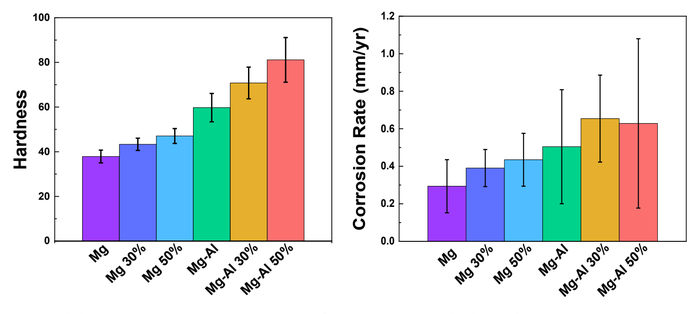


2. Textural and Defect Analysis of Rolled Samples



- Pure Mg evolves twins as evident by the higher dislocation angle frequency and inverse pole figures
- While there's no twins in the deformed Mg-Al, a significantly higher presence of dislocation cells due to stress
- Mg-Al shows multiple plane systems in pole figures

3. Mechanical Behavior and Corrosion



- Non-basal planes in rolled Mg-Al corrode faster due to higher energy
- Mg-Al's hardness and corrosion increases faster than Mg from the dislocation cell's higher strain energy

Conclusions

1. **Increasing defect density increases strain energy within the metal, driving the evolution of different microstructures to accommodate applied stress.**
2. **The addition of Al inhibits twin growth and instead promotes dislocation cells in Mg-Al alloys.**
3. **Dislocation cells dominate mechanical behavior over twins because of their higher strain energy.**
4. **The hierarchy of deformation-induced defects may be used to design magnesium-based implants for future biomedical applications.**

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Supplemental information and references can be found in the QR code on the right.