Textural Contributions to Strengthening in a Mg-RE Alloy with Nano-spaced Stacking Faults

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THE SETUP
- ❖ A study by Jian et al. found high strength of a Mg-alloy with nano-spaced stacking faults

THE QUESTION
- ❖ Can form nano-spaced stacking faults using severe plastic deformation (SPD)
- ❖ SPD by hot rolling tends to form textural components that can strongly influence strengthening

Was the work by Jian et al. affected by texture?

THE NUTSHELL
- ❖ We report on textural evolution of a Mg-Gd-Y-Ag-Zr alloy hot rolled up to 80% reduction
- ❖ Nano-spaced stacking faults and associated high strength observed only at high rolling reductions
- ❖ Textural changes were minimal with increased rolling

THE TAKEAWAY
- ❖ Texture plays a minimal role in strengthening of hcp systems with nanoscale faults.

Nano-spaced stacking faults led to significant strengthening of a Mg-alloy

MATHAUDHU RESEARCH

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BACKGROUND & MOTIVATION

BACKGROUND
Magnesium is a candidate for use in industry as a structural material

PROS	CONS
light-weight	low strength
high specific strength	poor formability

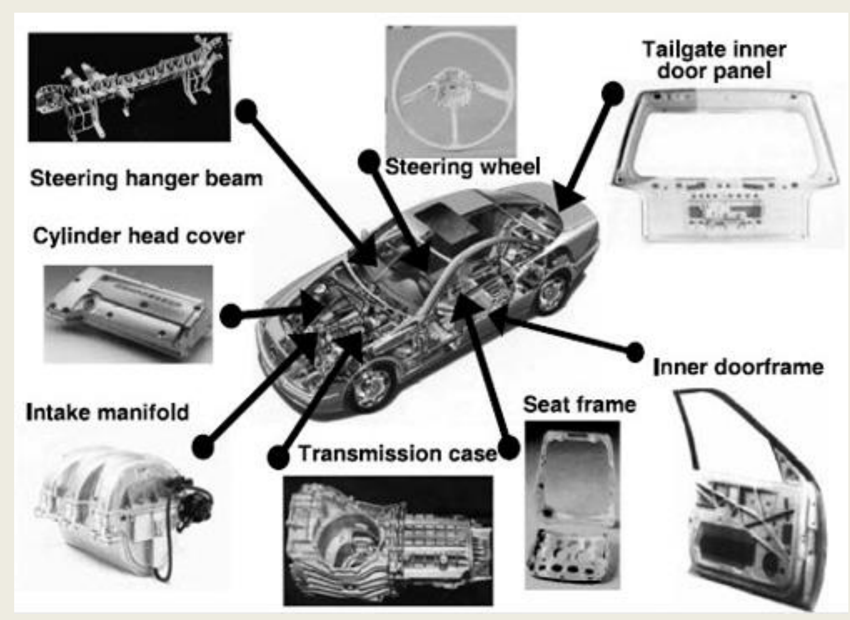

Figure 1. Examples of applications using magnesium alloys in motor vehicles [1]

ULTRASTRONG MAGNESIUM
Jian et al. achieved unprecedented strengthening of a magnesium alloy via nano-spaced stacking faults [2]

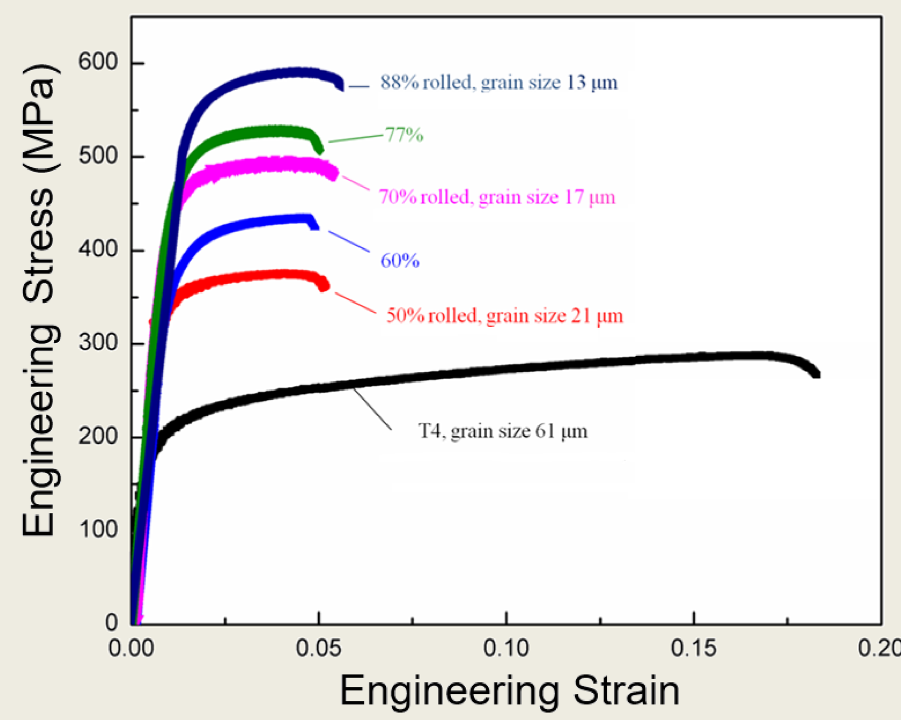

Figure 2. Engineering stress-strain curves of Mg alloy samples under T4 treatment and hot rolling with different thickness reductions (marked by the curves) [2]

THIS EXPERIMENT
Aims to understand if texture played a role in the strengthening found by Jian et al.

METHODS AND MATERIALS

MATERIAL: Mg-8.5Gd-2.3Y-1.8Ag-0.4Zr (wt%)

HOT ROLLING
- ❖ Heated in furnace to 450°C for 15 minutes
- ❖ Hot rolled <5% reduction per pass
- ❖ Hot rolled up to 88% reduction

CHARACTERIZATION
- ❖ Hardness testing
- ❖ X-ray Diffraction (texture)
- ❖ Light microscopy (grain size)

Typical rolling texture for these orientations reach a texture intensity of 11 (indicating 11 times the random orientation present in the system) [3,4]

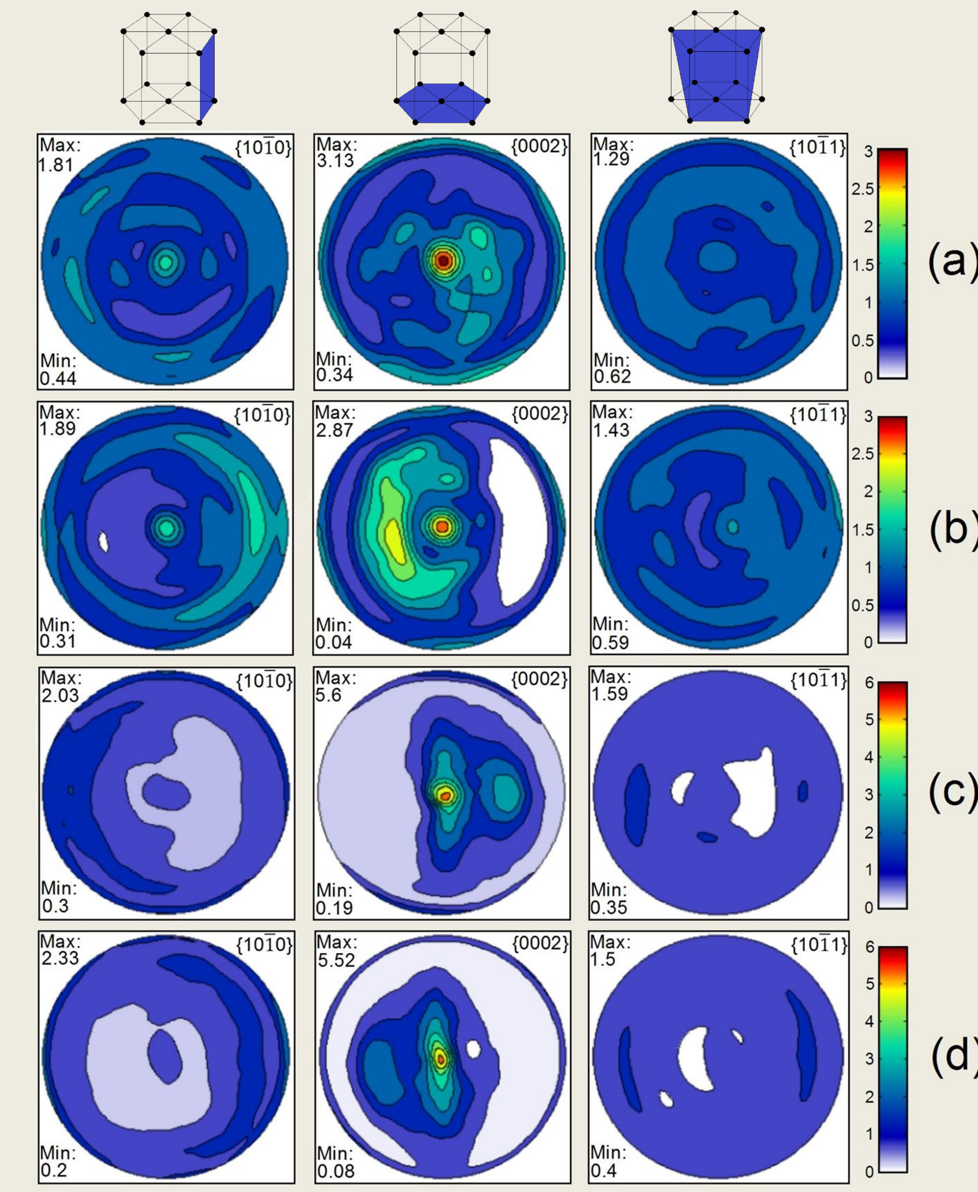

Figure 3. Hot rolled sheet surface pole figures for (a) 10% (b) 15% (c) 78% (d) 80% reduction

Most intense texture - plate surface basal orientation 5.6 intensity found at 78% reduction (about half as intense as previous rolling studies)

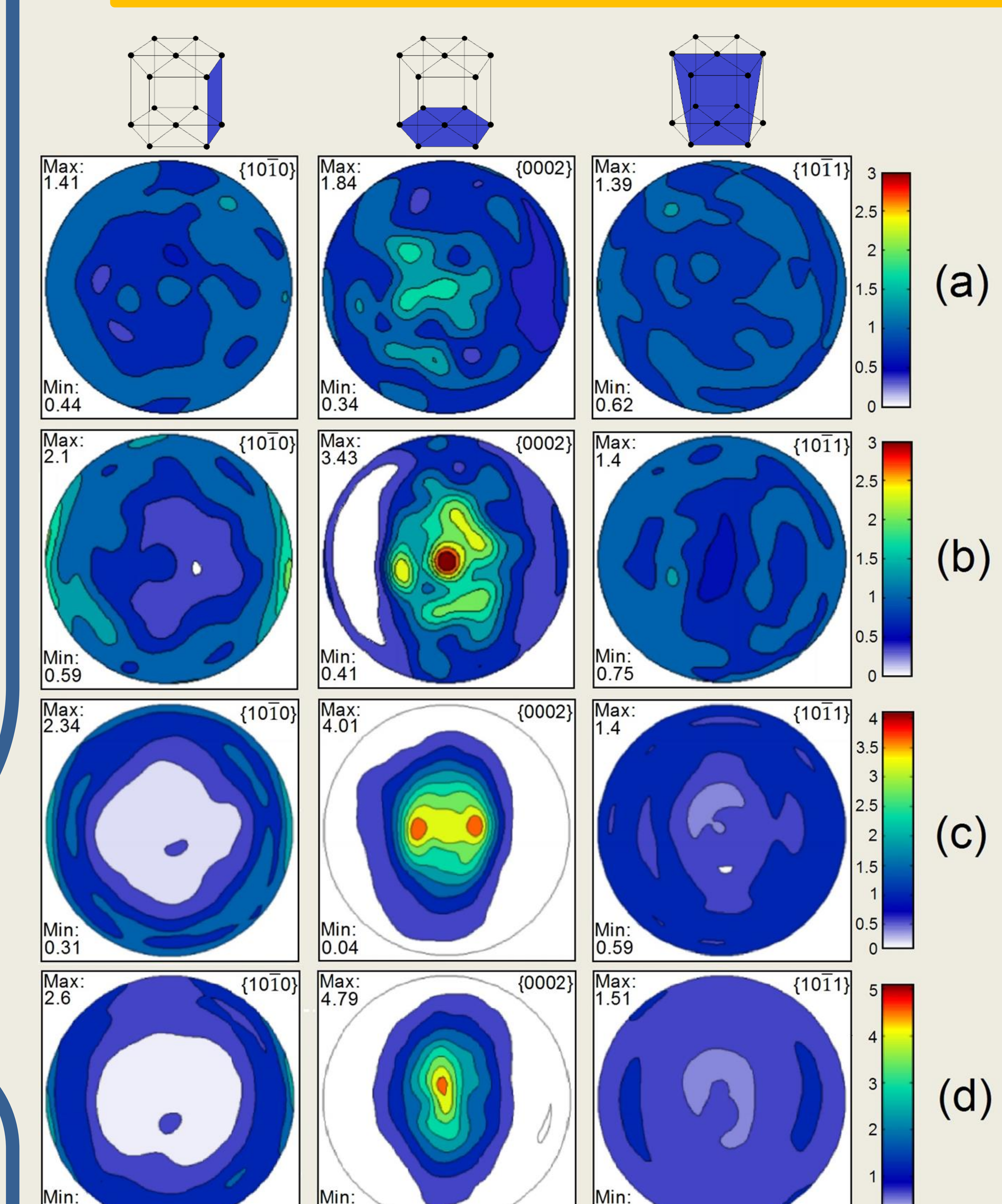

Figure 4. Hot rolled sheet mid-plane pole figures for (a) 10% (b) 15% (c) 78% (d) 80% reduction

Basal textures are more intense than pyramidal or prismatic orientations

Basal texture also showed greatest evolution with rolling passes

Sheet surface: basal texture intensity increases and peak broadening decreases with rolling passes

Sheet mid-plane: a double peak forms at 78% rolling reduction, then returns to single peak

The evolution in all orientations is minimal

DISCUSSION

POSSIBLE CONTRIBUTIONS TO STRENGTHENING
- ❖ **Solid Solution Strengthening** ☒
  - ➢ Strength of the initial material matched typical values for magnesium
- ❖ **Precipitates** ☒
  - ➢ Level of precipitates found not at level to promote significant strengthening
- ❖ **Grain Size Reduction** ☒
  - ➢ Grain size reduced from ~80μm to ~8μm
  - ➢ Grain size does not start to significantly increase strength until submicron stage [5,6]
- ❖ **Texture** ☒
  - ➢ Developed texture is weak
  - ➢ Texture does not evolve significantly with rolling reductions
- ❖ **Stacking Faults** ☑
  - ➢ Hardness trend follows what was found in the study by Jian et al. → stacking faults have formed

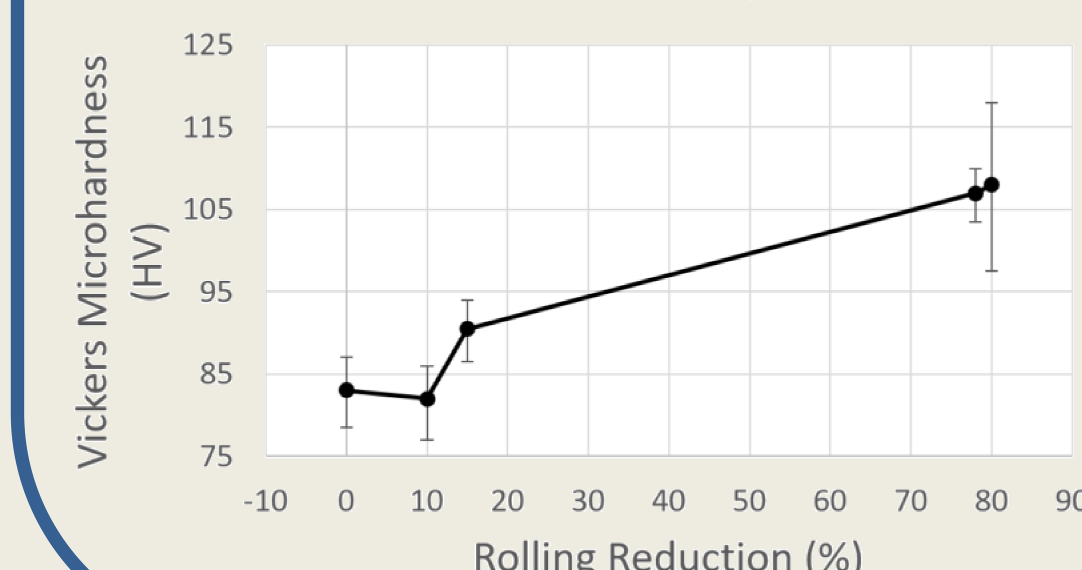

Figure 5. Vickers microhardness measurements as a function of rolling reduction

CONCLUSIONS

Determined unprecedented strengthening found by Jian et al. was due to nano-spaced stacking faults as texture did not play a significant role

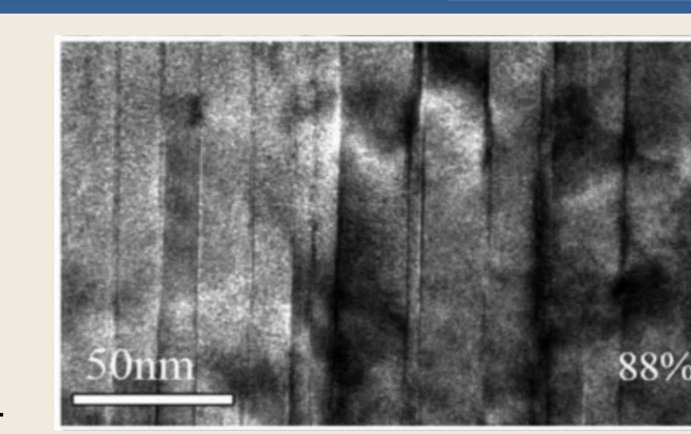

Figure 6. TEM image of 88% reduction via hot rolling with a stacking fault spacing, d = 16nm [2]

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