The objective of this research is to consistently monitor, using several techniques, and quantify the microscopic features during mechanical loading, to obtain critical relationships between microstructural changes and local/global strain distributions of a Mg alloy. Quantify the effect of texture and twinning in shear band nucleation, development, and eventual damage initiation in Mg alloys.

INTRODUCTION

- The current automotive industry demand typically targets both weight reduction and fuel economy. To achieve this, while maintaining designability as well as an extended product life cycle, alloying of metals becomes the solution. With efforts of reducing our dependency to hydrocarbon reserves, inevitable weight reduction in the transportation industry is transforming from a need to an urge.
- Magnesium is one of the most important metals commercially, since its properties make it easy to weld, forge, cast or machine. Mg alloys have most of the requirements to revolutionize the transportation industry. To this end, understanding of the events listed below is necessary to improve mechanical deformation behaviors.

OBJECTIVE

- Despite frequent observations of shear banding, the formation of shear bands, their development, and overall contribution to rolling and recrystallization textures is still not understood from both material and mechanics perspectives.

MATERIALS & METHODS

- Rolled magnesium alloy (Mg–3% Al–1% Zn) known commonly as AZ31 was used to produce test samples machined with a Wire EDM. Specimens were mechanically ground using 800, 1200, and 2400 SiC papers, followed by a detailed TAMG Mg - polishing procedure. EBSD data was collected using a Scanning Electron Microscope (SEM FEI XL30) controlled by TSL software. Digital Image Correlation (DIC) was used to acquire in-situ full field deformation measurements for both textures as seen in Figure 10.

RESULTS

- In-situ acoustic emission (AE) monitoring, not shown here, was also performed during tensile loading to investigate the characteristics of twin nucleation.
- The results presented can be used to control/optimize the microstructure in Mg alloys, opening a way for tailoring their mechanical behavior needed for commercialization.
- In-situ acoustic emission (AE) monitoring, not shown here, was also performed during tensile loading to investigate the characteristics of twin nucleation.

CONCLUSIONS

- Shear band formation at very early stage of plastic deformation (~0.4% strain) is tightly associated with twinning.
- Noticeable differences on the plastic flow were identified through DIC in both textures.
- Induced notched geometry affects the s-type behavior in the stress vs. strain curve.
- Average εyy strain inside the shear band region exponentially grows up to 2.75ε the average strain acquired through the sample. It is then followed by a slow decay.
- The results presented can be used to control/optimize the microstructure in Mg alloys, opening a way for tailoring their mechanical behavior needed for commercialization.

FUTURE WORK

- Collaboration with Sandia National Laboratories for improved in-situ surface morphology and topology measurements.
- In-situ mechanical testing using a loading stage inside a SEM
- Provide experimental data to build a mathematical model that will serve as an input into Finite Element Codes ie. ABAQUS.
- Develop/use/implement a constitutive model for shear band formation into Crystal Plasticity Finite Element Methods (CPEM)

REFERENCES & ACKNOWLEDGEMENTS


This work couldn’t be possible without the continuous help from:
- Jacob Hochhalter – NASA Langley Research Center
- LSAMP – BTD (Bridge to Doctorate) Fellowship