3D Reconstruction of High-Pressure Die-Cast AE44 Microstructure

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Introduction

Microstructures are crucial to the mechanical properties of materials. Usually, microstructures are examined in 2D. Unfortunately, microstructures are three-dimensional structures. Three-dimensional reconstruction of microstructures can be used to determine a more accurate representation of the mechanical properties of the materials through analyses such as the finite element method.

In this experiment, a high volume 3D reconstruction of the high-pressure cast AE44 eutectic structure was created. AE44, a magnesium alloy, is studied for USCAR as a replacement for heavier steel alloys. The alloy will be used to manufacture a front engine cradle for a sports automobile. The magnesium alloy has a higher strength to weight ratio, increasing fuel efficiency and decreasing fuel emissions. Also, it requires less energy for manufacturing and recycling.

Procedure

A sample of AE44 was mounted in Bakelite. It was then ground and polished using an automatic polisher, which had been calibrated to the nearest micron. An area of interest was then found on the sample, using optical microscopy. Using a micro-hardness indenter, indents were then made around the area. The indents were used to align each serial section and to measure the polishing depth by using the diagonals, where the slope of the indent was used to measure the depth. New indents were made as older indents became less visible. A 5X5 montage was then taken of the sample.

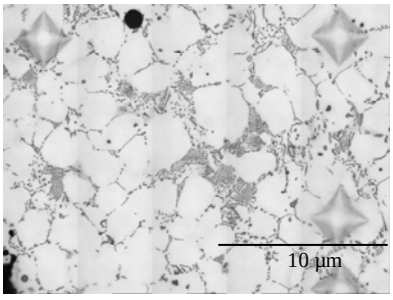
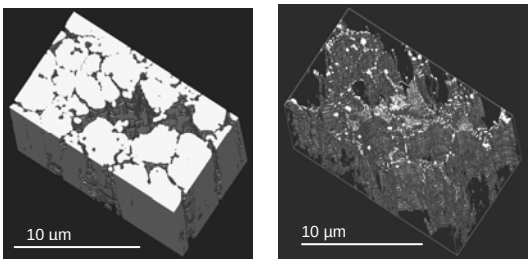


Fig. 1 5x5 montage of AE44, including three indents for aligning and measuring.

Approximately 0.8 µm was polished off of the sample after calibrating the polishing machine between each montage. This was repeated for each serial section. A large volume (approximately 0.1 mm^3) of the microstructure was reconstructed after 180 serial sections. Finally, the montages were aligned, using the center of the indents. A peel-off movie that shows each serial section and the 3D microstructure was then created using computer software.

Results and Discussion

The three-dimensional representation of the microstructure was successfully created. The eutectic and dendritic structures can now be visualized and characterized.



(a) (b)

Fig. 2 Three-dimensional reconstruction of (a) dendrites and (b) intermetallic structure.

By using the finite element method, the properties of the alloy can be predicted and modeled. After the finite element method is used, one can determine if AE44 is a better candidate as a that what is currently used.

Conclusions

The three-dimensional reconstruction has several uses and can benefit in further understanding the processing-microstructure-properties relationship. It is also suitable for use of the finite element method. This can lead to a conclusion on whether AE44 is a good candidate for use as a structural alloy when manufacturing a front engine cradle.