# NON-CONTACT ULTRASONIC TREATMENT OF CONDUCTIVE MATERIALS IN A HIGH MAGNETIC FIELD ENVIRONMENT

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## Introduction

When induction heating is applied in a high magnetic field environment, the induction heating coil is typically configured in such a way that high intensity ultrasonic treatment occurs naturally. The resulting configuration is that of a highly effective electromagnetic acoustical transducer (EMAT). The synergistic interaction of a high surface current density (induced via induction heating) with the steady-state high magnet field results in an especially effective method for creating a high energy density acoustic environment. The exceptionally high energy efficiency of the resulting electromagnetic transducer is due to the use of a high magnetic field, which greatly reduces the current needed to achieve the same acoustic pressure. This provides an efficient non-contact method for applying high-intensity ultrasonic energy to the processing of conductive materials. Furthermore, the applied ultrasonic excitation can be uniformly distributed over most of the surface of the sample.

## Experimental

A high-field EMAT has been used for non-contact ultrasonic processing of aluminum samples (35 mm diameter x 52 mm long) during solidification. The magnetic field for the EMAT was supplied by a 20 Tesla resistive magnet located at the National High Magnetic Field Laboratory, and the drive current was provided by an induction coil. This combination resulted in an EMAT that delivered 0.5 MPa (5 atmospheres) of acoustic drive to the surface of the sample while coupling less than 100 watts of incidental induction heating. In the initial experiment, aluminum samples of A356 alloy were heated to the liquid state and allowed to solidify at a controlled cooling rate while subjected to non-contact ultrasonic stimulation (at 165 kHz) provided by an induction coil located within the bore of the magnet.

## Results and Discussion

Aluminum samples processed ultrasonically with the high magnetic field EMAT were compared with samples processed without EMAT excitation (no-field), but with the same thermal treatment [1]. Based on visual appearance of the small ingots, samples processed with EMAT stimulation showed notably improved smoother surface conditions as compared with samples solidified without EMAT stimulation. Optical micrographs revealed obvious differences in microstructure. Micrographs for a no-EMAT sample exhibited an obvious variation in microstructure from the top to bottom of the ingot, suggesting segregation of Si, which is manifest in different amounts of primary alpha (~pure Al) versus eutectic (alpha plus Si-rich phase). By comparison, similar micrographs for a high-field EMAT processed sample showed no variations in microstructure uniformity.

## Conclusions

A novel high-field EMAT has been developed and demonstrated as an effective non-contact ultrasonic processing methodology for application during the solidification processing of aluminum samples in a high field magnet.

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## References

[1] Wilgen, J. B., *et al*., accepted for publication in the Proceedings of the 2007 TMS Annual Meeting Symposium "Materials Processing under the Influence of External Fields", Editors: Han, Q., Ludtka, G. M., and Zhai, Q., Orlando, FL, February 25 – March 1, 2007.