CONTACTLESS GENERATION OF ULTRASOUND

S. Goli (REU Program, NHMFL); J. Powell, A. Suslov (NHMFL)

Introduction

Electromagnetic acoustic transducers (EMATs) are widely used in science and industry for noncontact generation and detection of ultrasound [1]. An EMAT consists of a magnet and a coil. The latter induces dynamic electromagnetic fields at the surface region of a sample. In the case of conductive (or magnetic) material in the presence of magnetic field these electromagnetic fields are converted into an ultrasound wave due to electron-phonon (or magneto-phonon) interactions in the sample. In this study a NHMFL resistive magnet has been used to provide biasing magnetic field of up to 33 T.

Experimental

Two identical pancake coils have been prepared from commercially available copper covered circuit board material using a printed circuit board milling machine. The coils were 5 mm in diameter, with 0.2 mm between the turns and a 0.2 mm line width. Several samples made from aluminum, brass, and stainless steel with length from 6 mm to 22 mm have been used for the test. Two opposite surfaces of each sample were flat and parallel to each other. The coils have been placed near these surfaces of the sample with the gap of about 0.1 mm. The sample with the coils was positioned in the center of the magnet (Fig. 1(a)). One of the coils (transmitter) has been excited by a short pulse and the ultrasound signal has been detected on the second coil (Fig. 1(b)). The experiments have been performed at room temperature. The signal emerged from the noise at fields above about 2 T and rise up with the magnetic field as is shown on Figs. 1(b), (c). In the chosen configuration a transverse wave with circular polarization has been exited. Sound velocity $V$ and attenuation $Γ$ were calculated from the sound time delay and the echo amplitude decay respectively. Experimental values $V_{Al} = 0.314\pm0.003 \text{ cm/μs}$, $Γ_{Al} = 0.61 \text{ dB/μs}$, $V_{Brass} = 0.209\pm0.003 \text{ cm/μs}$, and $V_{SS} = 0.303\pm0.003 \text{ cm/μs}$, are in good agreement with the literature data.

![Figure 1](image_url)

Figure 1. (a) Schematic representation of the EMAT experiment: the magnet, direction of magnetic field, sample (yellow) with coils (green) and applied RF pulse (magenta) are shown; (b) An oscilloscope screen shot: an excitation pulse (labeled T) and ultrasound echoes in aluminum obtained on the detector coil at the field of 25 T (green) and 5 T (blue); (c) Magnetic field dependence of the signal amplitude in stainless steel, aluminum, and brass.

Acknowledgements

S. Goli is thankful to the NHMFL Research Experiences for Undergraduates (REU) program. Development of the ultrasound techniques at the NHMFL is supported by the In-House Research Program.

References