ELASTIC PROPERTIES OF $Gd_5(Si_2Ge_2)$ STUDIED BY ULTRASONIC TECHNIQUE

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Introduction

A growing interest in $Gd_5(Si_2Ge_2)$ and related compounds is supported by their unique responsiveness to a variety of intensive thermodynamic triggers (e.g., temperature, magnetic field and pressure), determined by first-order magnetic-martensitic structural phase transition occurring at T ~270 K [1]. Low thermal hysteresis makes the $Gd_5(Si_2Ge_2)$ promising candidate for a new generation of energy efficient sub-room temperature refrigeration based on the magnetocaloric effect ($\Delta T / \Delta B \cong 8$ K / 2 T). The colossal strain makes this alloy a potential candidate for future use in magnetic actuators as a replacement for TERFENOL-D, whose strain is about one order of magnitude lower. In this work, for the first time, we explore the fundamental properties of acoustic phonons in single crystals of $Gd_5(Si_2Ge_2)$ by pulse-echo ultrasonic probing.

Experimental Results

The crystals for this study were grown by tri-arc crystal pulling technique from a stoichiometric mixture of the components in an argon atmosphere under normal pressure using tungsten rod as a seed. We have measured room temperature velocities of longitudinal (f = 60 MHz) and transverse (f = 40 MHz) sound waves propagating along the (100), (010) and (001) crystallographic directions. The examples of the ultrasonic signals are shown in Fig. 1 (a) and (b) respectively. These measurements allowed us to calculate the values of three diagonal elastic constants in the high-temperature monoclinic phase (the so-called beta-phase): $c_{33} = 1.36 \cdot 10^{12}$ dyne/cm^2, $c_{44} = 5.17 \cdot 10^{11}$ dyne/cm^2, $c_{55} = 3.39 \cdot 10^{11}$ dyne/cm^2, where *x* and *z* axes of Cartesian coordinate system are parallel to the crystallographic directions *a* and *c,* while the later coincides with a unique two-fold rotation axis of the monoclinic crystal.

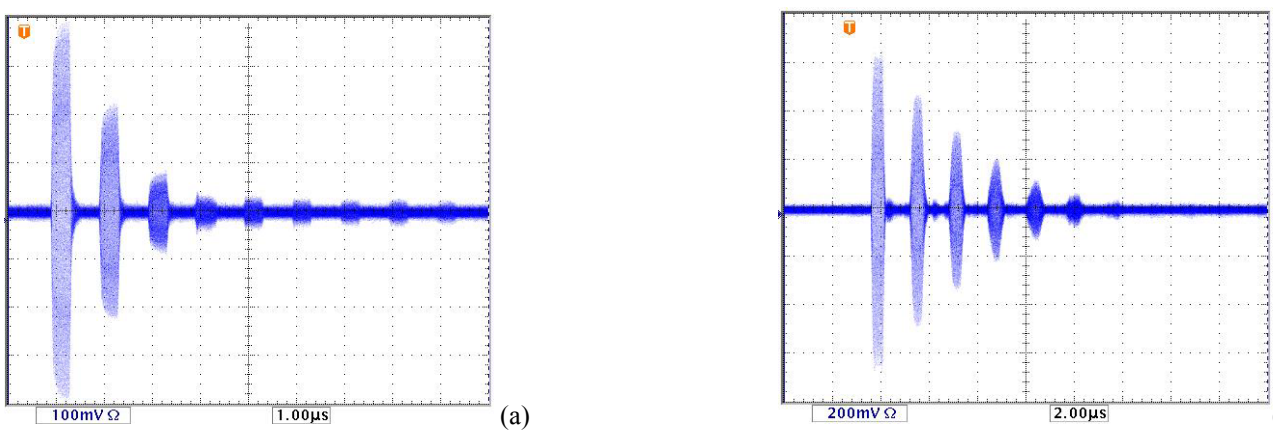

Fig.1. Examples of longitudinal (a) and transverse (b) ultrasonic signal that propagates in the $Gd_5(Si_2Ge_2)$ crystal along the *b*-axis. Red marks in the top left corners of the figures indicate the beginning of the probing pulse. Note that the time scales (horizontal axes) of these two pictures are different: 1 and 2 µsec / div for (a) and (b), respectively.

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References

[1] Pecharsky, V.K., Gschneider, K.A., Jr., Phys. Rev. Lett. **78**, 4494-4497 (1997)