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Elastic properties of $Ho_{0.5}Er_{0.5}$ single crystal

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Abstract

The results of an investigation of the Young's modulus E and the internal friction Q^{-1} of a $Ho_{0.5}Er_{0.5}$ single crystal in the basal plane in the temperature range 4.2–400 K are reported. The measurements were carried out by the method of flexural autovibrations of a thin sample with sound frequency (3 kHz). The Young's modulus at 4.2 K was measured to be 154 GPa. From the obtained data the magnetic part of the Young's modulus and the Debye temperature $\Theta_D = 375$ K were calculated. The anomalies on the Young's modulus and the internal friction temperature dependencies corresponding to magnetic phase transitions and magnetic structures present in the alloy are determined and discussed.

Keywords: Young's modulus; Internal friction; Magnetic phase transitions

1. Introduction

The present paper is devoted to an investigation of the elastic characteristics (Young's modulus E and internal friction Q^{-1}) of a $Ho_{0.5}Er_{0.5}$ single crystal. Because of the substantial magneto-elastic interaction in rare earth metals which couples the magnetic subsystems with the crystal lattice such a study enables additional information about the character of the magnetic transformations, the magnetic phase transitions, etc. to be determined.

The rare earth metals Ho and Er have complex magnetic spin structures and magnetic phase transitions [1–6]. One may expect similar behaviour in the Ho–Er alloy system. The magnetic properties of these alloys have been studied [7]. By means of magnetisation measurements in a magnetic field it was found that a $Ho_{0.5}Er_{0.5}$ single crystal has a Curie temperature of $\Theta_C = 35$ K and a Néel temperature of $\Theta_N = 104$ K [7]. In Refs. [8,9] the magnetic structure of $Ho_{0.5}Er_{0.5}$ was studied by neutron diffraction measurements. It was found that the alloy undergoes a transition at the Néel temperature to an antiferromagnetic basal plane spiral and at Θ_C a transition to a conical spiral phase with the same tilt angle of the cone from the basal plane occurs for Ho and Er [8]. The study reported in Ref. [9] confirmed the results of Ref. [8] concerning the low temperature magnetic spin structure of $Ho_{0.5}Er_{0.5}$, but it also found that, below Θ_N, instead of an ordinary basal plane spiral a complex binary phase arises which could be described as a c-axis modulated spiral with different tilt angles for Ho and Er. Below 47.5 K this phase is transformed to a basal plane antiferromagnetic spiral and below 35 K the transition to a conical ferromagnetic spiral occurs. An X-ray study which was carried out later [10] confirmed the results of Ref. [9].

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