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Elastic properties of a high purity gadolinium single crystal

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Abstract

The temperature dependence of Young's modulus (E_c and E_b) and the internal friction have been measured in a high-purity gadolinium single crystal along the *c*- and *b*- axis in the temperature range of 4.2–350 K at the frequencies of 800–1200 Hz. At 4.2 K the values of E_c and E_b are equal to 7.25×10^{11} and 6.14×10^{11} dyn/cm^2, respectively. The lattice part of Young's modulus has been calculated. The origin of Young's modulus anomalies at the Curie temperature and in the temperature region near 140 K are discussed. © 1999 Elsevier Science B.V. All rights reserved.

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1. Introduction

The heavy lanthanide metal gadolinium reveals ferromagnetic ordering below the Curie temperature, T_C, which according to various authors lies in the interval 290.1–297 K [1–6]. Upon further cooling a spin-reorientation transition takes place at a temperature, T_{SR}, between 223 and 250 [1,4–8], where the spins deviate from the *c*-axis towards to the basal plane [7–11]. The reason for the spin reorientation is the competition between the values of crystal anisotropy constants K_1 and K_2: the spin-reorientation transition occurs when K_1 changes its sign from positive to negative (K_2 is positive over the whole temperature range). The experimental data on T_{SR} and the temperature dependence of the deviation angle ϕ (from the *c*-axis) obtained by various authors are quite different.

Elastic properties of Gd were studied in Refs. [2,12–18]. Minima were found at T_C and T_{SR} in the temperature dependencies of the elastic constant c_{33} and Young's modulus measured on polycrystalline gadolinium. Fisher et al. [13] and Klimker and Rosen [2] measured the hydrostatic pressure dependence of the elastic constants c_{ij} in gadolinium. Longitudinal ultrasound temperature dependencies reveal maxima at T_C and T_{SR} for measurements along the *c*-axis and maximum at T_C for measurements along the *a*-axis [2,18].

The magnetic field dependence of the c_{33} spin reorientation anomaly was studied in detail in Refs. [15,16]. It was found that the magnetic field made the anomaly shallower, and the field corresponding to the disappearance of the anomaly strongly depended on the demagnetization factor of the sample.

According to the studies made by Savage and Palmer [17] the value of spin reorientation anomaly should depend on the sample purity.

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