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ORIGINAL PAPER

Properties of MgB_2 Thin Films Deposited on Different Substrates Prepared by Ex-Situ Annealing Process

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Abstract MgB_2 thin films were deposited on MgO (100) substrate and r-plane Al_2O_3 ($1\bar{1}02$) substrate by ex-situ annealing of boron film in magnesium vapor. The thickness of ex-situ annealed MgB_2 films is approximately 600 nm according to data observation by ellipsometer. The magnetic properties of samples were determined using a vibrating sample magnetometer. The magnetic field dependence of the critical current density J_c was calculated from M–H loops and also the magnetic field dependence of F_p was compared for the different temperature ranges from 5 to 25 K. The critical current density J_c was found to be around 1.0×10^6 A/cm^2 and 1.7×10^6 A/cm^2 in zero field at 5 K for MgB_2 films deposited on MgO and r-plane Al_2O_3 substrates, respectively. It was found that the critical current density of the film deposited on MgO became stronger than that of r-plane Al_2O_3 in the magnetic field. The superconducting transition temperature was determined by ac susceptibility measurement using physical properties measurement system. ac susceptibility measurements for MgB_2 films deposited on MgO and r-plane Al_2O_3 substrates were performed as a function of temperatures at constant frequency and ac field amplitude in the absence of dc bias field. The critical current densities as a function of temperature were estimated from the ac susceptibility data.

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1 Introduction

The discovery of the superconductive properties of MgB_2 in 2001 [1] revealed an attractive candidate for electronics applications [2], due to its relatively high critical temperature (T_c) of 39 K [1], high critical current density (J_c) [3], a large coherence length (ξ) [4] and the absence of a weak link [5]. In the last decade, there have been significant efforts to depositing MgB_2 thin films [6]. As a result of these efforts, one of the most successful techniques is annealing B or Mg–B precursor film in high Mg vapor at high temperature [7–9]. The selection of the substrates affects the film quality. The substrates generally used for MgB_2 film fabrication are r-plane Al_2O_3, c-plane Al_2O_3, Si (100), Si (111), $SrTiO_3$ (100), MgO (100), and SiC (0001) [10]. The critical current density and the critical temperature of MgB_2 dependent on the type of substrate needed to be investigated.

In this paper, we present the results of dc magnetization and ac susceptibility measurements of MgB_2 thin films deposited on MgO (100) and r-plane Al_2O_3 ($1\bar{1}02$) substrates by ex-situ annealing of boron film in magnesium vapor.

2 Experimental Procedure

For this study, MgB_2 thin films were prepared using a two-step synthesis technique and deposited on polished MgO (100) and r-plane Al_2O_3 ($1\bar{1}02$) substrates. We used the same deposition conditions for MgO and Al_2O_3 substrates. MgB_2 films with a thickness of about 600 nm determined by spectroscopic ellipsometer (Angstrom Advanced Inc-PHE 102) were prepared as described in our previous study [11].

The ac susceptibilities and dc magnetization measurements were performed with a Quantum Design Physical Properties Measurement System (PPMS), ACMS and VSM