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Fabrication of in-situ MgB2 thin films on Al2O3 substrate using off-axis PLD technique

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Fabrication of *in-situ* MgB_2 thin films on Al_2O_3 substrate using off-axis PLD technique

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CANDIDATE'S CERTIFICATION

I hereby declare that the research for this submission was carried out by the candidate at Institute for Superconducting and Electronic Materials, the Faculty of Engineering, the University of Wollongong, is wholly my own work unless other wise referenced or acknowledged. The document has not been submitted for any other academic institution.

Yi Sun Wu

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Contents

Abstract

In Chapter 1, I briefly discuss some fundamental theories and the history of superconductivity. A few examples are given for superconductor applications. At Chapter 2, a literature review of MgB_2 is presented, with some discussion on its discovery, as well as the current research on this binary superconductor. In Chapter 3, the experimental system and other types of laboratory measurement and analysis equipment are introduced, such as those used for critical temperature T_c and critical current J_c measurements, microstructural analysis using X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), etc. From Chapter 4 through Chapter 7, various ways of improving the fabrication of MgB_2 thin films are discussed along with the corresponding results.

In Chapter 4, I first report investigations on the vacuum level and background pressure in order to create an optimised environment inside the chamber for the pulsed laser deposition (PLD) of MgB_2 thin films on Al_2O_3 (Sapphire) substrates. I found that a vacuum of 9×10^{-8} Torr inside the deposition chamber was necessary before deposition to generate a stronger plasma of the ablating materials, but that a high purity argon background gas had to be introduced up to a pressure of 120m Torr to fabricate high quality MgB_2 thin films. This result was employed in the experiments in the rest of this report.

In Chapter 5, the effects of changing the annealing parameters, time (τ_{ann}) and temperature (T_{ann}), are reported. The combined results from T_c measurements and

XRD showed that the films with longer dwell times, up to 9 minutes at a moderate sintering temperature, have higher T_c and better crystal growth. We found that for films sintered at 700 °C, critical current densities, J_c, as high as 2×10^{-6} Acm^{-2} were achieved at 10K and 0.5T. However, J_c drops as the magnetic field increases. It is proposed that the improved J_c in low fields was due to the fine grains and enhanced density of the sample.

In Chapter 6, I discuss the fabrication of MgB_2 thin films with the addition of elemental Si. Silicon is a semiconductor and is very reactive with Magnesium to form Mg_2Si, which can act as a source of pinning centres in our thin films, making it possible to improve the J_c dependence in magnetic field. The drawback of this is higher resisitivity and weaker grain connectivity, so a moderate amount of Si addition must be chosen. Also, the Si was added by using a switching target mechanism which will produce thin films of partial multilayer structures. Although the time for the Si deposition was short, the Si layers embedded in between the MgB_2 layers were thin and usually broke during a high temperature sintering process. However, the defects which formed in between these layers generally had a two dimensional structure and their effect on the pinning properties due to this geometry is also discussed. A film with about 5 wt% of Si added was observed to have slightly decreased T_c and weaker field dependence.

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