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# Pinning enhancement in $MgB_2$ superconducting thin films by magnetic nanoparticles of $Fe_2O_3$

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## Abstract

MgB2 thin films were fabricated on *r*-plane $Al_2O_3$ (1102) substrates. First, deposition of boron was performed by rf magnetron sputtering on $Al_2O_3$ substrates and followed by a post-deposition annealing at 850 °C in magnesium vapour. In order to investigate the effect of $Fe_2O_3$ nanoparticles on the structural and magnetic properties of films, $MgB_2$ films were coated with different concentrations of $Fe_2O_3$ nanoparticles by spin coating process. The magnetic field dependence of the critical current density $J_c$ was calculated from the M–H loops and magnetic field dependence of the pinning force density, $f_p$(b), was investigated for the films containing different concentrations of $Fe_2O_3$ nanoparticles. The critical current densities, Jc, in 3T magnetic field at 5 K were found to be around $2{\bullet}7 \times 10^4$ A/cm$^2$, $4{\bullet}3 \times 10^4$ A/cm$^2$, $1{\bullet}3 \times 10^5$ A/cm$^2$ and $5{\bullet}2 \times 10^4$ A/cm$^2$ for films with concentrations of 0, 25, 50 and 100% $Fe_2O_3$, respectively. It was found that the films coated with $Fe_2O_3$ nanoparticles have significantly enhanced the critical current density. It can be noted that especially the films coated by $Fe_2O_3$ became stronger in the magnetic field and at higher temperatures. It was believed that coated films indicated the presence of artificial pinning centres created by $Fe_2O_3$ nanoparticles. The results of AFM indicate that surface roughness of the films significantly decreased with increase in concentration of coating material.