ABSTRACT OF THE THESIS

"Synthesis and Physical Property Characterization of Pure and Nano-Magnetic Ions Doped Vacuum Annealed MgB_2 Superconductor"

The Synthesis and Physical Property Characterization of Pure and Nano Magnetic Ions Doped MgB_2 Superconductor are presented in the thesis. The samples were prepared using formula Mg + 2B and $Mg_{(1-x)}M_xB_2$ or MgB_2M_x where M = Nano Co_3O_4, Nano Fe_3O_4 and Nano NiO etc. where x can varies say (0% to 15% depending upon the system). The conventional solid-state reaction method was used to synthesize the entire samples. The high quality fine Magnesium (Mg) and Boron (B) powder were mixed thoroughly in the ratio of 1:2 and palletized using hydraulic press, which was kept inside the soft iron tube and closed the both ends and further it was sealed in a quartz tube in the vacuum environment of 10^{-5} mbar. The ampoule was sintered at 750°C for 2.5 hrs and finally quenched in the Liquid Nitrogen by broken the ampoule inside the LN_2. The surface resistance obtained in our samples is less than 1 Ω. The quenched samples were generally brittle and porous. After many efforts and trial I successfully synthesized the pure phase MgB_2 superconductor. The pure optimized MgB_2 sample that prepared by this technique was of good quality, exhibited T_c near 39K, which was reported in K.P Singh et.al in Modern Physics Letter B (2006). I studied the electrical transport properties of the pure sintered sample where the transition temperature (T_c) observed at 39K, which was in good agreement with the previous reported data. The RRR factor came out to be near at 5 times. The DC susceptibility measurement was carried out on the pure sintered MgB_2 sample that it was observed the sharp transition (ΔT_c~1K) near at 39 K. Various characterizations i.e. RT measurement, XRD, DC susceptibility, MH loop, etc. had been studied to determine the physical properties of the system I studied the resistivity effect of the pure MgB_2 sintered sample under high Magnetic field of 8 Tesla. The effect on the resistivity of the pure sample

was depicted that the transitions temperature suppressed up to 17 K for the 8 Tesla from 39 K for 0 Tesla. The transitions got broadening as the field increases. From where I could calculate the Hc_2 value of the sample and it was come out to be 22 Tesla at 0 K. The magnetization measurement was performed on the pure sintered MgB_2 sample where the magnetic J_c calculated using Bean's Critical Model and it came out near at $10^6 A/cm^2$. The standard four-probe resistivity method was used to measure the resistivity of the samples. All the samples were behaving metallic down to say 100 K and further it followed the power law. I studied the comparisons of the effect on different encapsulations pure MgB_2 samples (say Ta foil, Mo foil, Fe tube and Ta tube etc). As in overall looking, the Fe-Tube encapsulation won the race. The comparisons of the MgB_2 prepared by different encapsulation techniques were reported in K.P Singh et.al in J. Cryogenics (2007). This synthesis route was obtained after various hit and trial experiments. Room Temperature XRD measurement was taken using CuK_α radiation to study the phase formation and impurity concentration, etc. All our samples were crystallized in hexagonal structure in room temperature with single phase observed in XRD patterns whereas the small peak of MgO was observed in our sample, which I couldn't avoid from our samples. SEM measurement was taken to study the morphology of the sample where I observed the distribution of the grains and the connectivity of the grains as seen in the high-resolution magnification. I reported the synthesis and optimization of pure MgB_2 of high quality sample compared with the reported data. I also studied on the effect of various nano particles addition to the parent MgB_2 system. It was reported that the nano particles admixing to the parent pristine MgB_2 system results the critical current density (J_c) increased nearly upto $10^8 A/cm^2$ at the lower concentration of the nano contents at low temperature region that was published in Superconductor and Science Technology 2006 for the nano Co_3O_4 additions to the MgB_2 system. The optimum J_c was observed in 2% - 4% nano Co_3O_4 doped samples, which corresponded for the flux pinning in the samples at low temperature region under low magnetic field. It was depicted that the Fluxoid jumps region found in the low temperature region, which was responsible for the flux dynamics, due to which J_c got decreased. While considering the doping content in the MgB_2 system, the increases of x contents result the increase in resistivity and the suppressed the transition temperature (T_c) in our samples. Similarly, I studied the effect of nano magnetic ions Fe_3O_4 doped in MgB_2 system, it was found that the magnetic critical current density increases in low contents of nano Fe_3O_4 samples but the nano Fe_3O_4 did not substitute or enter in to the lattice site yet it acted like as impurities in the system. Upto 4% of nano Fe_3O_4 admixing, the T_c maintained at 38K and for 6% admixing of nano Fe_3O_4 results the T_c suppressed at 32K, this means that at lower concentration of nano Fe_3O_4 didn't substitute or enter into lattice site The J_c increased for the lower concentration sample at low field as observed in the nano Fe_3O_4 doped samples. The transition temperatures suppressed as the doping level increases for the nano Fe_3O_4 series and superconductivity destroyed beyond the 10% of nano Fe_3O_4 doped sample. The inclusion of nano particle acted as the impurity in the system that acted as to pin the magnetic fields as a result the J_c increased.. The optimum J_c was observed in 0.5% nano Fe_3O_4 doped sample. The work was reported in K.P Singh et.al entitled "Nano Fe_3O_4 induced fluxoid jumps and low field enhanced critical current density in MgB_2 superconductor" in Journal of Superconductivity and Novel Magnetism (2008). Moreover, I studied on the effect of nano-NiO (Magnetic ions Nickel Oxide) doping on MgB_2 Polycrystalline bulk sample, where the nano NiO doping doesn't show any improvement in the J_c whereas only 4% nano NiO doped sample show the optimum J_c in higher magnetic field at low temperature region. Here the inclusion of nano magnetic particle acted as the impurity in the system that acted as to pin the magnetic fields as a result the J_c found optimum at 4% doped NiO sample in the high magnetic field region ($H \leq 7$ Tesla). In this study I couldn't observe Fluxoid jumps regions at low field

After overall studies, I could draw many important results. It is not the end to study the hidden properties on this system. It is necessary to study more on the magnetic properties in this system with various nano inclusions, which is required to optimize the higher J_c in the higher magnetic field at low temperature /higher temperature.