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Anomalous Magnetoresistance in $Fe_{1-x}Ni_x$ binary alloys

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Abstract : Prepared $Fe_{1-x}Ni_x$ (x=0.1, 0.4, 0.5, 0.6, 0.7, 0.9) polycrystalline alloys have been considered for resistivity measurement at zero magnetic field and 8T magnetic field. For x=0.1 and 0.4 negative magneto-resistance (MR) is observed and for other sample MR is positive. Though all the samples are ferro-magnets, due to antiferromagnetic coupling and spin-flip scattering in some samples, MR becomes negative. At low temperature region electron-electron scattering contributes to the MR whereas at room temp region electron-phonon scattering contributing to the MR. MR value is irrespective of the crystal phase possessed by all the samples.

Key Words : Resistivity, Magnetoresistance, Antiferromagnetic coupling, Spin-flip scattering.

PACS Numbers : 75.50.Bb, 75.47.-m, 75.50.Ee

1. Introduction

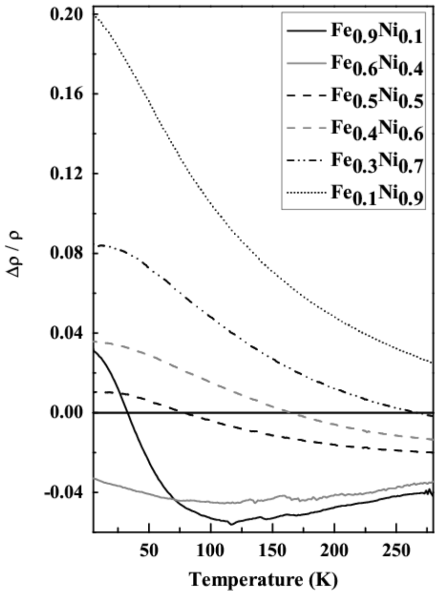
Magnetic properties of Fe-Ni alloys are anomalous due to competing exchange interactions between Fe-Fe, Fe-Ni and Ni-Ni [1]. Several theoretical studies indicated J_{FeFe} near neighbour exchange integral is negative in FeNi alloys indicating antiferromagnetic coupling between Fe atoms. Pure Fe possesses bcc structure and is ferromagnetic whereas pure Ni exhibits short range ordering and possesses fcc structure. When Fe is alloyed with Ni, it exhibits a structural phase transition from bcc (α phase) to fcc (γ phase) at around 30% Ni concentration. Magnetic moment exhibits a maximum in both bcc and fcc phases [2].

2. Experiment

$Fe_{1-x}Ni_x$ (x=0.1, 0.4, 0.5, 0.6, 0.7, 0.9) random alloys have been prepared using arc melting method. The resistivity of the samples has been measured down to 5K with zero magnetic field and 8T field applied longitudinally to the current direction using four probe method.

3. Results and Discussion

Magnetoresistance (MR) is calculated as, $\frac{\Delta\rho}{\rho} = \frac{\rho\,(H,T) - \rho\,(0,T)}{\rho\,(0,T)}$ and is shown in the figure for various alloys. Except x=0.1 and 0.4, all other alloys exhibit a nonlinear decrease of MR with temperature. The temperatures at which MR changes sign for x=0.1, 0.5, 0.6 and 0.7 are 33K, 78K, 169K and 270K respectively. For x=0.4, MR is negative throught and has a braod minimum at 120K. Temperature dependance of MR in these alloys can be explained considering metallic and magnetic contributions. Both metals and antiferromagnets exhibit positive MR whereas ferommagnets exhibit negative MR [3]. These alloys are disordered and are expected to have clusters with Fe moments aligned opposite to the field and can form noncollinear magnetic structures within the ferromagnetic matrix. Number of antiferromagnetic clusters decrease and metallicity increases with Ni concentration. Decrease of MR with temperature for x=0.1, 0.5, 0.6 and 0.7 alloys is related to the changes in antiferromagnetic coulpilng, magnetic momnet and metallicity. All these three contributions compete with one another leads to complicated but systematic temperature dependence of MR. Minima observed in x=0.1 and 0.4 alloys may be related strong spin fluctuations which tend to increase MR.



4. Conclusion

Negative MR observed in $Fe_{0.9}Ni_{0.1}$ (bcc phase) and $Fe_{0.6}Ni_{0.4}$(fcc phase) [4] is due to electron-electron scattering at low temperature, spin-flip scattering within medium temperature range and electron-phonon scattering range near room temperature. In remaining samples because of less scattering contribution MR is positive.

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