ABSTRACT

Materials with large change in resistance on application of small magnetic field at room temperature are finding several applications in magneto-electronic devices like, magnetic information storage devices and sensors. This change in resistance is observed in magnetic multilayers, magnetic granular thin films and granular bulk materials. In particular, granular alloys and composites appear to be more attractive due to ease of their synthesis and cost effectiveness compared to the multilayer thin film systems. Although granular composites exhibit larger variations in electrical resistance on application of magnetic field, magnitude of MR depends on various factors, such as, magnetic to nonmagnetic constituent ratio, size and shape of the particles, inter-particle distance and the matrix etc. In addition to this, the matrix too has its role in regulating the magnetic and electrical transport behavior. For nonmagnetic metals and semiconductors, the magnetoresistance (MR) is usually negligible at 300 K at low magnetic fields. In contrast, large anomalous positive MR was also reported in nonmagnetic silver chalcogenides, inhomogeneous narrow-gap semiconductors and semimetals like, bismuth and graphite**.** Therefore, the main objective of this work is to analyze experimentally the influence of particle size, magnetic particle concentration and the influence of matrix to get large MR at room temperature in moderate magnetic fields.

From the detailed investigation on a series of semimetallic ball-milled graphite samples, it is found that micron-sized particles exhibit large MR values at room temperature as well as at low temperatures when compared to nano-sized particles. Therefore, large values of MR can be achieved by optimizing the semimetallic graphite particle size. The carbon based composites exhibit small negative MR while graphite based composites show large values of positive MR which suggest that the sign of MR is governed by matrix, but not the magnetic constituent. In the case of permalloy-graphite and cobalt-graphite composites, positive MR is exhibited in both longitudinal and transverse geometries at all applied fields. Similarly, MR increases with increasing field and does not saturate even at 50 kOe. On the other hand, MR increases with increase in annealing temperature which is due to the grain growth when the samples are subjected to heat treatment. Therefore, particles with optimum dimensions can give high MR. The matrix dependence on MR has been verified by using different semimetallic (Bi, C) and metallic (Cu, Ag) matrices. It shows a positive MR value for the case of semimetallic matrix, while metallic matrix exhibits negative MR. From the detailed magneto-transport studies, it is clear that the magnetic components play a minor role in obtaining large positive MR values. Therefore, it may be concluded that the matrix contribution to the positive MR is significant and this is due to its semimetallic behavior of the matrix itself. This conclusion refutes the earlier claims of magnetic contribution by other workers in the literature and provides a deeper insight into the physics of GMR in granular composites.

Key words- Giant Magnetoresistance, Granular Material, Graphite, Permalloy, Matrix Effect, Nano-materials.