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LETTER TO THE EDITOR

Magnetoresistors based on composites

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Abstract. This Letter proposes a new magnetoresistor based on composite materials. This device exhibits characteristics comparable to that of conventional magnetoresistors but can be realised with much simpler technology.

Conventional magnetoresistors, i.e. resistors whose values of resistance change with an applied magnetic field, are usually prepared from semiconductors such as indium antimonide. In these devices, the magnetoresistance effect is enhanced by shorting the Hall voltage generated across the semiconductor due to an applied magnetic field. This is achieved either by making the sample with an annular ring shape (Corbino disc) [1] or by incorporating shorting links in the material (InSb–NiSb eutectic) [2]. The zero field resistance of the Corbino disc magnetoresistors is very small ($\sim 1\ \Omega$), and hence, it cannot be used directly in electronic circuits. Further, both the types of magnetoresistors (disc and eutectic) need special fabrication techniques like unidirectional solidification of eutectics or realisation of semiconductor films or crystals with specific geometry. Thus, there is a need to develop magnetoresistors which can be realised with simpler technology, but have a performance comparable to the conventional magnetoresistors.

It has been predicted [3] that the magnetoresistance effect can be realised by proper coupling of interactions in a multiphase composite material. When magnetic particles are dispersed in an elastic material, a magnetoelastic composite results. If a magnetic field is applied to this composite, a deformation (or strain) is produced in the composite due to the interaction between the magnetic particles. If this deformation is transferred to a thin composite elastic resistive sheet, it leads to a change in the resistance of the sheet. An attempt has been made to conceive and develop magnetoresistors based on the above-mentioned interaction in composites.

The structure of the magnetoresistor developed is shown in figure 1. It consists of an elastic magnetic cylinder in which a thin resistive sheet is sandwiched in the centre. The magnetic cylinder is made of a composite of rubber and iron powder. The resistive sheet is made of a composite of rubber and metal powder (brass). The change in resistance (in this device), as a function of magnetic field, has been measured. A typical variation is shown in figure 2. From this figure, it may be seen that the change in resistance is small at low fields. At higher fields, the change in resistance increases steeply with magnetic field and finally tends to saturate. Typical values of the relative change of resistance ($\Delta R/R_0$) for this type of magnetoresistor is given in table 1 along with the corresponding

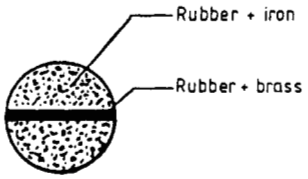

Figure 1. Cross section of the sample.

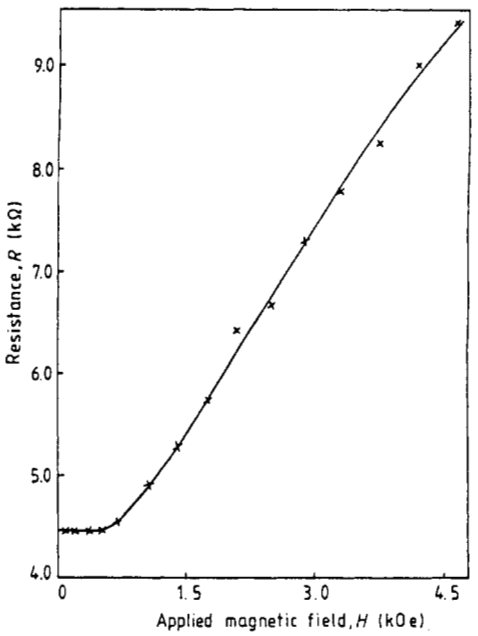

Figure 2. Measured variation of resistance with applied magnetic field for a typical sample: Volume fraction of iron, $v_f = 0.25$; length of the sample, $L = 2.0$ cm; diameter of the sample, $d = 1.0$ cm.

values for other types of conventional magnetoresistors. From this table it may be seen that the magnetoresistor based on a composite gives rise to a change of resistance comparable to that of conventional magnetoresistors.

It is well known that the zero field resistance of a composite magnetoresistor can be varied over a wide range by changing the composition of rubber and conducting particles

Table 1.

Type	$\Delta R/R_0$ at 8 kOe
Corbino disc [1]	15
InSb–NiSb eutectic [2]	
aligned	12
unaligned	2
Cd_2As_3–NiAs eutectic [4]	0.4
Present composite	1 at 4.5 kOe

in the resistive sheet. It has been found that the change in resistance in this type of magnetoresistor depends on parameters like its shape and the composition of the material of the magnetic cylinder. Detailed theoretical calculations of the magnetoresistance and its dependence on the factors mentioned above have been carried out based on a model proposed for the composite, and these are being communicated separately.

Thus, the work reported in this Letter clearly indicates the possibility of realising magnetoresistors based on composites which require relatively simpler technology, but provide a performance comparable to that of conventional magnetoresistors.

References

[1] Weiss H 1969 *Structure and Application of Galvanomagnetic devices* (New York: Pergamon)
[2] Weiss H and Wilhelm M 1963 *Z. Phys.* **176** 399
[3] Van Suchtelen J 1972 *Philips Res. Rep.* **27** 28
[4] Elliott C T and Hiscocks S E R 1969 *J. Phys. D: Appl. Phys.* **2** 1083