Inovative Devices Inspired by Basic Research

Achievement :
The discovery of giant magneto-resistance(GMR) and its contribution to development of innovative spin-electronics devices

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<Summary>

Computer hard discs, which store vast amounts of memory, are improving year by year and at a faster rate than ever before. Now, however, these memory storage discs are not limited to computers, but are also being used in such electronic appliances as mobile music devices and video cameras. The reason behind the great increases in memory storage capacity and the rapidly diversifying use of hard discs is the discovery of giant magneto-resistance (GMR), a groundbreaking technological innovation. The men responsible for this astonishing discovery are Prof. Albert Fert and Prof. Dr. Peter Grünberg.

The memory storage capacity of hard discs is increasing year by year and at an ever accelerating rate. Laptop computers in the early 1990s generally had a memory storage capacity of several dozen megabytes. Now, however, memory storage capacity of around 100 gigabytes (one gigabyte = 1000 megabytes) is the norm. In recent times, personal computers are able to store vast amounts of image and musical data, and hard discs are now able to store hours and hours of television programs. The reason behind the great increases in memory storage capacity of hard discs and the diverse usage of hard discs in many other types of electronic appliances is the development of a magnetic head which utilizes giant magneto-resistance (GMR) effect.

The magnetic head that utilizes GMR effect

Hard discs use a magnetic head to store data and read it. In the hard disc is a thin magnetic disc called a platter, and this records data. The platter approaches a component known as the magnetic head, and through a process of electric current transformation, the magnetic head reads bits (units of data) of stored information.

To increase the storage capacity of hard discs, it is necessary to cram a large amount of data into a small space. In order to do this, the volume of the magnetic body per bit must be reduced. However, this reduction of the volume of the magnetic body weakens the magnetic field of each bit of data, and this makes it difficult for the head to read the stored magnetic information.

What was required was a component that could read the weakened magnetic field, or more specifically, a head that could convert small amounts of data into electric signals. And this heralded the appearance of the GMR element.

In previous magnetic heads used for reading data, magneto resistance (MR) components had been used. Magneto resistance is the phenomenon of the change to electrical resistance when subject to a magnetic field. As the electrical resistance change causes the electrical current change, the data written on the hard disk can be read by detecting the electrical current. The resistance change ratio when using the MR component is at most only a few percent.

In contrast to this, when the GMR component is used resistance ratio rises to several tens of percentage. In other words, even a responsibility to a weak magnetic field leads to a vast increase in sensitivity. This means that even when a large amount of magnetic data is stored on a small sized hard disc it is easy to read, and this has resulted in the memory storage capacity of hard discs undergoing great improvements. Thanks to the development of the magnetic head which utilizes GMR effect in the late 1990s, the performance and effectiveness of hard discs is being enhanced at a faster and faster rate.

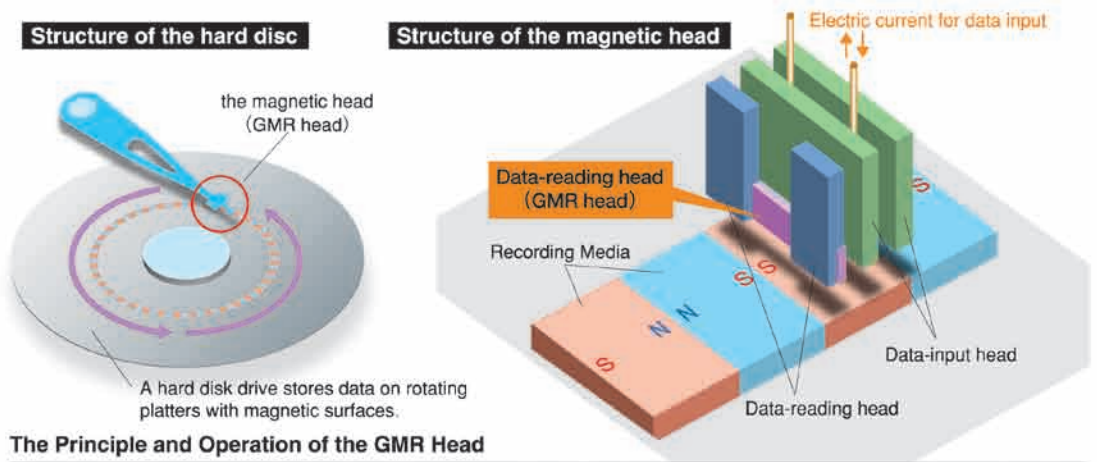
The Development of GMR and the Japan Prize Winners

The departure point for GMR, which has resulted in the high density hard discs in use today, was the discovery of Giant Magnetoresistant effect back in the late 1980s. In 1988, Prof. Albert Fert and his team at Univercity of Paris-South in France, discovered GMR by placing alternate layers of thin films of iron (Fe) and chrome (Cr) and building up a multilayered film consisting of dozens of thin film layers of both metals at the low temperature (4.2K) of liquid helium, and noticing the highly unusual results for the time of approximately 50% magnetoresistive effect.

At the same time, an independent research project led by Prof. Dr. Peter Grünberg at Research Center for solid state physics in Germany discovered approximately 1% GMR effect after placing a thin film of iron both on top and beneath a thin film layer of chrome at room temperature. The research team then found that when building up alternate thin film layers with transition metals (e.g. Fe or Ni) and nonmagnetic metals, the majority of these showed GMR effect.

The landmark GMR component which proved a major breakthrough for magnetic memory is the result of discoveries made by both these researchers (the GMR component employs the characteristics of the electron spin , and is therefore known as one of the spin electronics device, or spintronics devices).

Currently, a product that utilizes Tunneling Magnetoresistance (TMR) is under development which will further improve Giant Magnetoresistance. The discovery of GMR effect has, in a short period of time, greatly enhanced the memory storage capacity and effectiveness of the hard discs used in both computers and in many other types of electronic appliances. The fundamental research undertaken by both Prof. Albert Fert and Prof. Dr. Peter Grünberg has made a major contribution to the advancement of information technology. Their achievements are of inestimable importance and richly deserve their place in the annals of scientific discovery.



The Principle and Operation of the GMR Head

When the GMR head moves, the direction of the magnet of the GMR element is altered by the change in the direction of the magnet on the surface of the disc. As the resistance of the element changes in accordance with GMR effect, it is able to be detected as an electric signal. Thanks to the GMR element, even the slightest change to the magnetic field caused by a minute bit can be detected, and this has resulted in further advancements in the high density of hard discs.