

GMR Head Technology

Increased Areal Density and Improved Performance

Giant magnetoresistive (GMR) head technology is the latest advancement in hard disk drive (HDD) storage, and is used in Western Digital EIDE and SCSI hard drives in 1999.

Anisotropic Magnetoresistive (AMR) technology is currently the primary, high-performance read head technology used in today's hard drives. AMR heads have replaced thin film inductive heads, the previous standard in the marketplace. GMR heads are projected to be the dominant head technology beyond the year 2000. GMR heads provide increased areal density, improved performance, and reliability.

Note: Magnetoresistive head technology (MR) and AMR are the same. Engineers early in the growth of MR technology dropped the 'A' from AMR. Now that other options exist, the 'A' needs to be added back in. Though the 'A' is often referred to as meaning "Advanced," it really means "Anisotropic".

History/Background

IBM has led the development of HDD technologies since the first hard drive in 1954. IBM's Winchester technology, first introduced in 1973, increased storage density by linking the head and disk permanently.

Introduced in 1979, thin film inductive (TFI) technology was another important development. The technology before thin film inductive read/write heads—wired, wrapped magnetic cores—had been the standard in the industry for a number of years.

In 1991, IBM introduced Anisotropic Magnetoresistive (AMR) technology into HDD products. Not only did AMR technology enable the storage of more data per disk, but it also reduced the number of heads and disks required per drive for a given capacity. AMR heads have

been improved since their introduction, and presently support areal densities as high as 3.3 gigabits per square inch.

Today, AMR head technology has been surpassed with the advent of giant magnetoresistive (GMR) or "spin valve" heads. This has extended the areal density to greater than 10 gigabits per square inch—more than three times the areal density supported by AMR heads—and advances in materials and process technology will extend the technology to well beyond 10 gigabits per square inch.

GMR heads have more than twice the sensitivity of AMR heads, and bring high-powered workstation capacity to the average desktop PC user. This optimizes HDD performance for storage-intensive multimedia business and entertainment programs, allowing television-like video, picture, and sound quality.

Beyond GMR, the next step in hard drive technology will be "Synthetic Spin Valve" GMR, which will be followed by Colossal MR (CMR). These developments are underway utilizing materials and layers yet to be identified or proven outside of research labs.

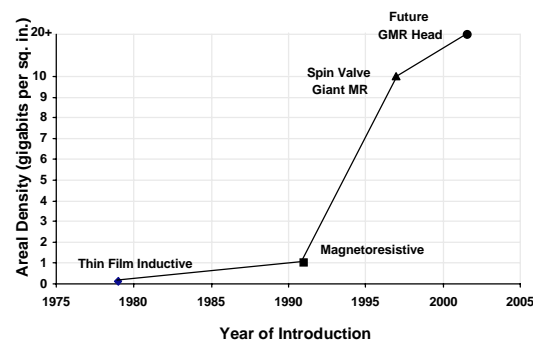


Figure 1. HDD Technology Development

Why Use GMR Heads?

As the demand for higher areal densities and data rates increases, heads of increasing sensitivity are required to maintain high quality read-back signals. The high areal densities attainable with GMR heads enable hard drive products to offer maximum storage capacity with a minimum number of heads and disks. Fewer components (i.e., heads and disks) mean greater reliability, lower power requirements, and lower storage costs. Increased signals from GMR heads also help to overcome system noise problems.

Advantages of GMR over AMR

- Ability to support areal densities of more than 10 gigabits per square inch versus 3.3 gigabits per square inch.
- Twice the sensitivity to changing disk magnetization.
- Fewer heads and disks required for the same storage capacity.
- 30 percent less mechanical spacing required for equivalent performance.
- Enhanced error rate performance and yield margins.

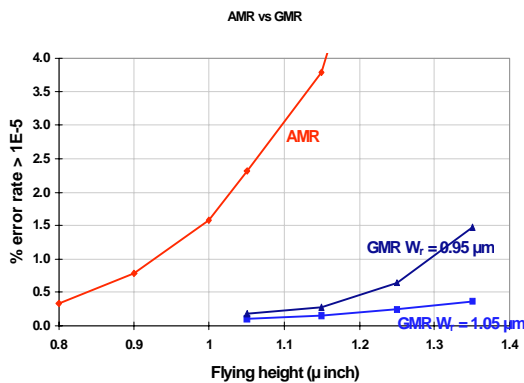


Figure 2. AMR vs. GMR Error Rate/Yield Comparison

How GMR Works

The GMR head structure, which is called a spin valve, consists of a stack of four magnetic thin films: a sensing or "free" magnetic layer, a nonmagnetic conducting spacer layer, a magnetic "pinned" layer, and an "exchange" layer. The first three layers control the resistance of the sensor in response to magnetic fields from the disk. A change in the resistance of the GMR sensor depends on the "spin" orientation of the conducting electrons and the difference in the magnetization directions of the free and pinned layers.

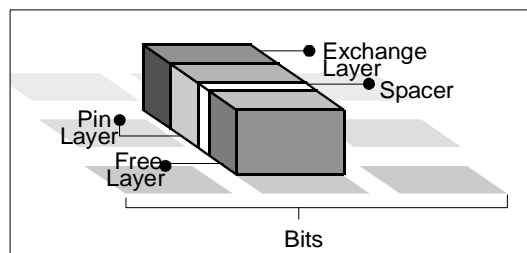


Figure 3. GMR Spin Valve Structure

Magnetic orientation of the pinned layer is fixed and held in place by the adjacent exchange layer. The magnetic orientation of the free layer changes in response to tiny magnetized regions (bits) on the disk by rotating relative to the magnetic orientation of the pinned layer when a data bit on the disk passes beneath the GMR element. This magnetic rotation generates a significant change in sensor resistance or signal.

Because the layers are close together, electron "scattering" will cause some electrons to move from one layer to the other. When an electron's spin matches the magnetic orientation of the layer in which it flows, those electrons experience lower resistance. As a result, the net resistance changes and provides a signal that can be sensed by appropriate electric circuits.

Where the resistance change in an AMR element is approximately 2 percent, in today's GMR heads, the change in resistance is typically 4 to 5 percent.

GMR Storage

As HDD areal densities increase, the magnetic field from the stored bits becomes increasingly smaller. Through this effective use of electron spin properties, GMR heads make it possible to sense the magnetic fields from stored bits even at areal densities of more than 10 gigabits per square inch. In contrast, drives using AMR head technology support only up to 3.3 gigabits per square inch. This ability to store 10 gigabits per square inch translates into a storage capacity well over 40 gigabytes per drive. Eventually, GMR heads will support areal densities greater than 10 gigabits per square inch.

Summary

Continued advancements in head technology are essential to maintain rapid areal density growth during the next decade. GMR represents the next step in HDD technology from today's AMR heads, and utilizes much of the design, production, and test experience associated with AMR technology.

GMR spin valve heads allow greater reliability than previous HDD technologies and support areal densities greater than 10 gigabits per square inch. The increased sensitivity of GMR heads ensure high quality read-back signals and meet the growing demand for higher areal densities and data rates. As areal densities continue to grow, more advanced structures beyond GMR will be required. To meet this need for the future, the development of new MR device technology is well under way.

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800.ASK.4WDC USA
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Western Digital Corporation
8105 Irvine Center Drive
Irvine, California 92618

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