

# Perpendicular Magnetic Recording (PMR)

## WD Addresses Hard Drive Capacity Challenge with PMR Technology

For decades, the hard drive industry has focused almost exclusively on a method called longitudinal magnetic recording to record data on hard drives. In longitudinal recording, the magnetization of each data bit (i.e., the binary digit 0 or 1) is aligned horizontally, parallel to the disk that spins inside the hard drive.

In perpendicular magnetic recording (PMR), the magnetization of each data bit is aligned vertically to the spinning disk, providing the ability to store more data on a given disk than is possible with conventional longitudinal recording. PMR thus provides a platform for future expansion of hard drive densities. WD will implement PMR technology in calendar year 2006.

### The Storage Capacity Challenge

Since IBM introduced the first hard drive in 1956, the industry has increased storage capacity exponentially to meet an ever-growing need. Today, the use of consumer electronic devices that store music, photos, and video, as well as advanced applications including digital video, personal video recorders, set-top boxes, network attached storage, and RAID solutions, are driving the need to pack more and more storage capacity on hard drives of all sizes.

Historically, manufacturers have decreased the size of the magnetic grains that comprise data bits to increase storage capacity on hard drives. Through the years, the development of smaller and smaller data bits has led to higher areal density, or number of bits of data that can be recorded onto the surface of a hard drive disk.

The problem with using this method is that we are rapidly approaching the point where the microscopic magnetic grains on the disk are so tiny that they could start to interfere with one another, thus losing their ability to hold their magnetic orientations. The resulting data corruption could render a hard drive unreliable and thus unusable. This phenomenon is known as the superparamagnetic effect (SPE). Improved coercivity, or the ability of a bit to retain its magnetic charge, is needed to overcome SPE.

### The Perpendicular Recording Solution

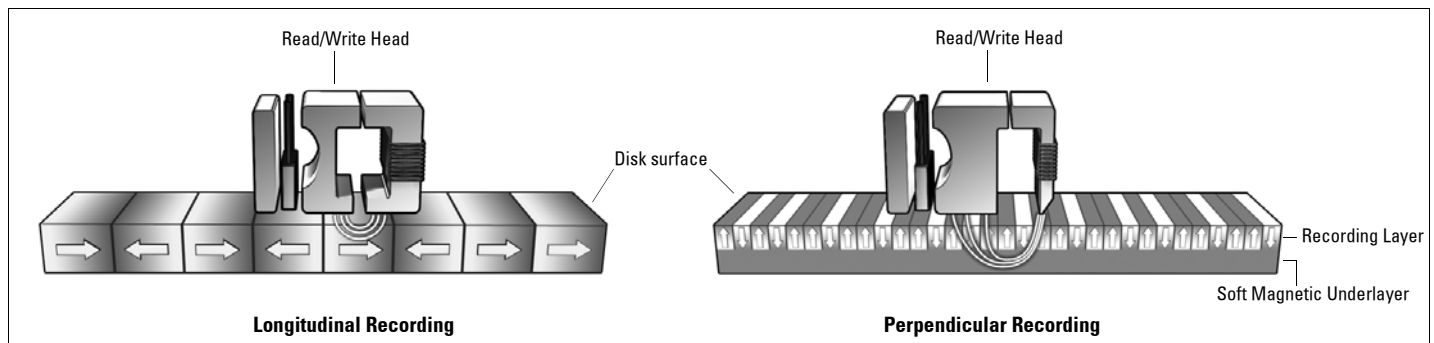
In longitudinal recording, as the bits become smaller and closer together, they experience an increasing demagnetizing field, much like two bar magnets that are placed end-to-end repel one another. Coercivity must be increased to counteract the demagnetization to keep the bits stable under thermal fluctuations; otherwise data corruption may occur over time. Higher media coercivity has pushed the recording head write field to the limit of known materials.

In perpendicular recording, the adjacent bits attract instead of repel (as with bar magnets placed side by side), creating more thermally stable bits. In addition, the media contains a magnetically soft underlayer (SUL) beneath the recording layer. This SUL allows a larger effective write field, thus higher coercivity media, enabling further increases in density. Lastly, because of the vertical orientation of the bits, the PMR recording layer tends to be thicker than that used for longitudinal recording, providing increased signal for the read heads. All of these benefits enable WD engineers to reliably pack more data on a given disk than is possible with conventional longitudinal recording.

### The Future

WD will continue to invest in PMR, and other next-generation technologies such as tunneling magneto resistive (TuMR) heads combined with proven ramp load technology. TuMR is a head design that provides greater signal output which translates into greater signal to noise ratio, enabling higher storage densities. Ramp load parks the recording head when the drive is idle and on spin up, maximizing available disk space and minimizing power usage, which results in lower heat and long-term drive reliability.

WD is committed to the transition to next-generation technologies while maintaining high standards of quality and reliability, as well as the commercial viability of WD products. PMR, TuMR, and ramp load will be key technologies during the next few years for the hard drive industry to address increasing demand for high capacity, reliable storage in existing and new applications. WD's technology implementation strategy is based on meeting customer needs as we address the hard drive industry's highest volume markets.



*Longitudinal vs. Perpendicular Recording*