Disk Drive Contamination and Defect Sensitivity Trends

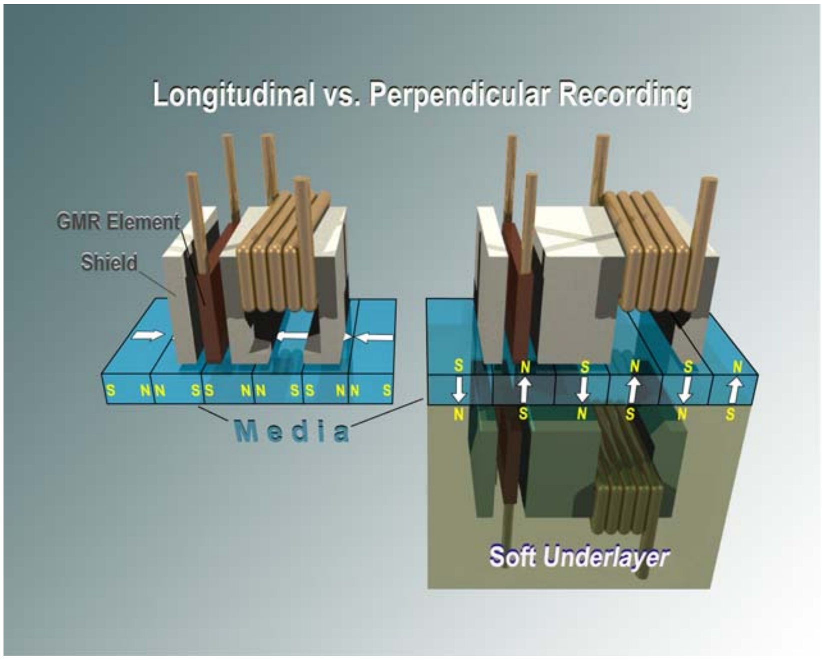
Thomas M. Coughlin
Coughlin Associates
www.tomcoughlin.com

In prior issues we have shown the areal density growth curves for public technology demonstrations as well as product announcements. Overall it appears that based on product technology announcements that product areal density increases are about 50% annually. This areal density increase is being driven by the introduction of new magnetic recording technologies, in particular perpendicular recording. **Figure 1** compares the head and media for perpendicular recording with longitudinal recording.

In perpendicular recording the magnetic bits are written normal to the magnetic disk surface. This is done with special magnetic "probe" heads that channel the magnetic field in the write head to the tip of a long soft magnetic pole. The magnetic media, in addition to a special hard magnetic layer in which the bits are written that supports perpendicular recording has a soft magnetic layer that creates "images" of the probe head and effectively doubles the head field available for writing on the media. The soft magnetic layer under the recording media layer acts as a part of the magnetic recording head. Readback in contrast uses conventional GMR or TMR head technology.

In perpendicular recording as the bits are increased in linear density along the recorded tracks on the disk the magnetic bits do not become less stable as is the case for longitudinal recording. In longitudinal recording as the bits get closer together on the track they interact with each other and make it easier for random thermal energy in the environment to spontaneously reverse magnetic grains in the disk media. This does not occur as easily in perpendicular recording. Thus perpendicular recording allows for higher linear densities than longitudinal recording and will help sustain 50% or higher annual product areal density increases.

Figure 1. Comparing Perpendicular with Longitudinal Recording (from Seagate Technology)



Perpendicular recording has its own special issues however. In order to maintain a consistent write field on the media the spacing between the head and the disk must have a lower flying height and tighter spacing loss tolerance and the write head poles require special shaping in order to prevent write fields going through the media soft magnetic layer to weaken and even overwrite adjacent track data.

Initially longitudinal recording will co-exist with perpendicular recording for some product generations since companies that don't have access to perpendicular recording components will seek to provide the same storage capacities with the same number of components as competing perpendicular recording drives. However by 2007 perpendicular recording is expected to become common place even for larger form factor hard disk drives.

Figure 2 shows the various components of magnetic spacing loss (distance between the head write/read elements and the effective centerline of the magnetic recording media) and **Figure 3** gives our projections for the development of these various magnetic spacing factors as a function of areal recording density.

Figure 2. Components in Magnetic Spacing (former IBM Web site).

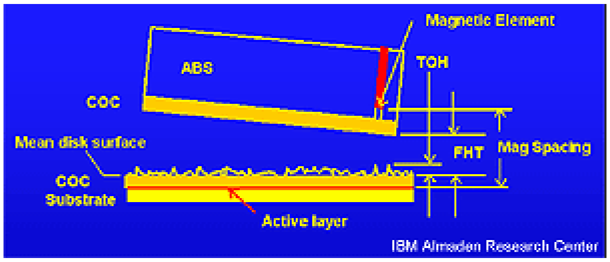
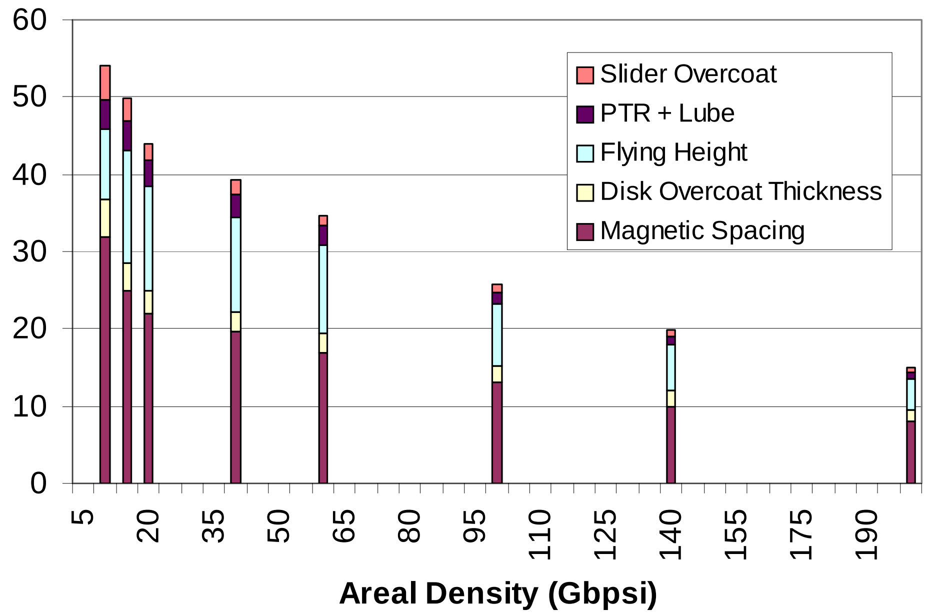


Figure 3. Magnetic Spacing Component Roadmap



A lower flying height creates greater demands on disk cleanliness and topography in order to avoid errors in reading back the information on the disk drive. In addition higher recording densities creates greater sensitivity to smaller disk defects.

- As track sizes decrease the diameter of tolerable defects on the disk gets smaller.
- This must be true for the initially tested disk and during the life of the disk drive.
- As heads fly lower to accomplish high BPI the incidence of particles becoming embedded into the substrate or damage to the media layers increases leading to growing hard defects over time and loss of customer data.

Table 1 shows the expected bit sizes for various areal recording densities. **Figure 4** shows trends for surface Ra, Rp and expected pit depth across the recorded track for a 40% signal loss. Current recording areal densities now make hard disk drives sensitive to much shallower defects than had been the case a few years ago. This makes contamination control a much bigger issue in modern disk drives. Manufacturing equipment to control contamination leading to defects and to clean contamination in the drive during operation are a prime area of research as we go into perpendicular recording products with lower flying heights and tighter flying height tolerances. Also operating shock that could induce indentations into the disk, especially for the mobile applications that perpendicular recording will initially be used for will, be a prime concern.

Table 1. Bit Size as a Function of Recording Density

Areal Density	Bit Size (micron)	kBPI	kTPI
10 Gbpsi	0.53X0.075	345	32
20 Gbpsi	0.38X0.057	445	45
40 Gbpsi	0.23X0.048	530	75
100 Gbpsi	0.18X0.021	833	120
1,000 Gbpsi	0.050X0.013	2,000	500

Figure 4. Expected Trends for Disk Surface Finish and Across Track Pit Depth for 40% Amplitude Loss