Imation Tera Angstrom™ Technology – Nanotechnology Applications

Dr. Subodh K. Kulkarni

Imation Corporation, Oakdale, MN, USA, skkulkarni@imation.com

ABSTRACT

Imation last year introduced a revolutionary new magnetic tape technology Tera Angstrom™ that will enable high capacity and high transfer rate data cartridges for archiving and backing-up digital data. Tera Angstrom™ technology uses nanometer size magnetic metal particulate (MP) pigments and three key processes to enable these high end data storage products: in-line I-MUF technology to enable separation of these nanometer sized pigments in the dispersion used to coat the substrate; quiescent drying and in-line orientation of the pigments in the direction of the coating; in-line steel calendering using very smooth (Ra < 3 nm) rolls to enable extremely smooth (Ra < 5 nm) magnetic media. This paper describes more details about these unique processes to enable the finished properties of the magnetic media.

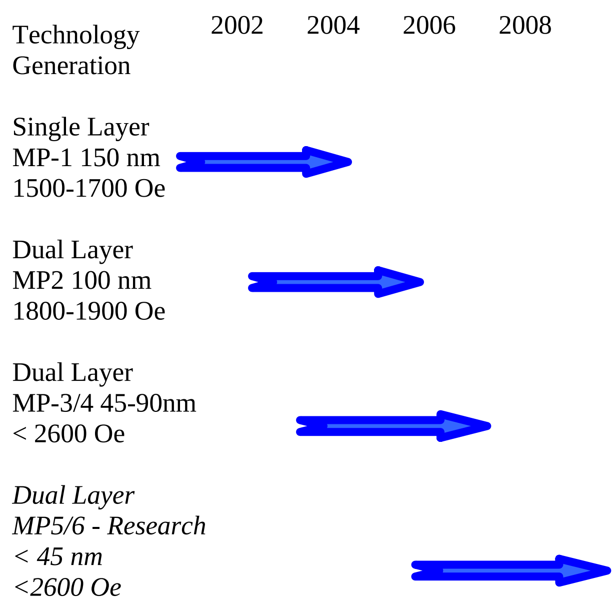
Keywords: magnetic media, metal particulate, Tera Angstrom™ technology

1 MAGNETIC TAPE TECHNOLOGY

Magnetic tape has been the dominant technology used in the last 50 years to archive and back-up digital data. Imation (at that time 3M) was the first company to offer magnetic tape products for IBM systems 50 years ago, and Imation continues to be the leader of magnetic technology today, offering the broadest portfolio of removable data storage products across all the segments – Enterprise, Mid-range, Entry level, and Consumer. Magnetic tape technology offers significant advantages over competing technologies, and current trends indicate that this will continue to be the case in foreseeable future. With increasing demand for digital data to be archived, there's great need to keep increasing capacity and transfer rate for data cartridges. This is accomplished with increasing bit and track densities on a given tape, and increasing the amount of tape in a given cartridge.

To enable the increasing bit and track densities, media companies have used increasing coercivity and smaller size acicular shaped metal particulate pigments for every successive generation of tape products. The current high end products (400 GB native capacity) are using acicular magnetic pigments that are ~10 nm in diameter and ~50-70 nm in length. In future, the particle sizes will decrease even further. This is shown in Fig. 1, where each arrow represents a generation of MP technology and the timeline over which products that have been introduced using that technology. With continuous advancements accomplished in the MP technology, we think MP technology will be the most competitive technology for the foreseeable future and 1 TB native capacity cartridges will be achieved using MP technology in the next few years.

Figure 1. Magnetic Tape Technology Migration



Along with using more sophisticated MP pigments and the formulation chemistry that goes with it, the media processes that are used to enable the media to be produced play a significant role in the end properties of the media. The higher bit and track densities needed for future products necessitate media with high signal to noise ratio (SNR). This is accomplished through a thin magnetic layer on top of a non-magnetic layer or sub-layer coated on a thin flexible plastic substrate with a conductive backside coating. The thicknesses of the substrates and the coatings on the media are depicted in Table 1. Also, in Table 1, are shown the needed smoothness of the magnetic media that is anticipated in future.

Table 1. Media Requirements Migration Path

Parameter	Units	MP 1	MP 2	MP3/4	MP4/5	MP6/7
Mag Layer Caliper	Micro-inches	40	12	8	2-4	<2
Sublayer Caliper	Micro-inches	N/A	70-90	70-90	40-60	40-60
Backside Caliper	Micro-inches	25	20-25	20	10-20	10-20
Substrate Caliper		18 -36ga	24ga	24ga	18 ga	<18 ga
Substrate Material		PEN/PET	PEN/PET	PEN/PET	PEN/PET	TBD
Mag Surface Roughness	Ra nm	6-10	4-6	4-5	3-4	2-3
Bit Density	Kbpi	80 -190	90 -180	180-220	250-300	>300
Data Tracks	in 1/2" wide	350-600	300-400	500-600	1000-2000	>2000
Write Track Width	Microns	17-36	25-30	15	7-10	<7
Read Track Width	Microns	9-20	12-15	7	3-5	<5
Tape Length	Feet	800-2200	[illegible] 2500	1500-2500	2000-3000	3500-5000

In processing of magnetic media suitable for tape products, several steps are used to end with a finished magnetic tape. The process starts with creating dispersions of magnetic, non-magnetic and backside chemistries. To create these fine dispersions, the appropriate pigments, binders and other additives are milled together. These dispersions are coated using thin film coating techniques on a moving web at high speeds and dried using high temperature ovens. After coating and during the process of drying, the magnetic particles are aligned in the direction of the moving substrate to further enhance the electromagnetic properties of the media. After drying the magnetic media is calendered in a stack of rollers to further improve the packing of the magnetic pigment and smoothness of the media, again giving a boost in the electromagnetic performance of the media. Subsequent to calendering, the media is slit into the desired format. This media is further servo-written and then wound into cartridges.

2 IMATION TERA ANGSTROM™ TECHNOLOGY

Imation has developed a revolutionary process to accomplish making the magnetic media that leads to higher smoothness and higher SNR, therefore enable the higher capacity and transfer rates for future products. The features of this process are described in this paper.

The three differentiating elements of Imation's process are:

1. I-MUF technology.
2. Quiescent drying with magnetic coil orientation.
3. In-line calendering using proprietary rollers.

In each of these areas, Imation's process provides an improvement in performance over conventional competitive approaches in the respective areas, and the combination of all the three features provides a significantly improved performance over conventional approach.

Fig. 2 shows the I-MUF schematic and Fig. 3 shows the particle size distribution achieved using conventional milling technologies such as homogenization, compared to Imation's I-MUF technology. I-MUF technology enables elimination of large size particles seen in conventional homogenization, and maximizes the separation of the nano sized MP particles. Fig. 4 shows the schematic and Fig. 5 shows the higher packing density and orientation achieved using Quiescent drying and magnetic coil orientation compared with conventional approach of using impingement drying and magnet orientation. Note the individual nanometer sized MP particles being aligned to the direction of the coating or the direction of the slit media thereby enabling higher EM performance and higher capacity/transfer rates. The effect of in-line calendering with proprietary finished calender rolls is shown in Fig. 6 where it is evident that higher smoothness can be accomplished using the new process. The smoothness of the calendar rolls used in this process is <2.5 nm.

In summary, the new proprietary Tera Angstrom™ process invented and developed by Imation is providing superior magnetic media that will enable future products for archiving and backing-up digital data. The new process has been incorporated in the new coating facility in Weatherford, OK, which is the only facility in the world to have this unique process to make advanced magnetic media. Production has commenced, and the state-of-the-art facility is producing high end tapes for the most advanced products (currently 400 GB native capacity, and in future, higher capacities will be available) used in the industry.

Figure 2. Schematic of I-MUF process

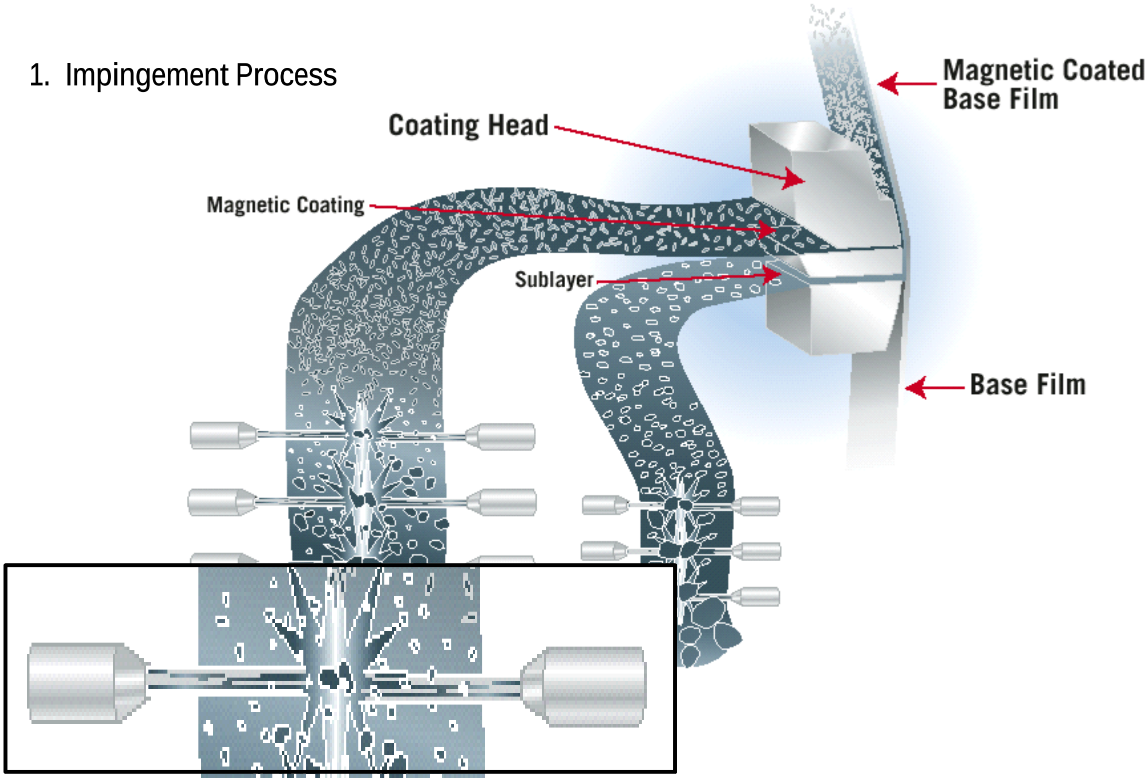


Figure 3. High Pressure I-MUF Impingement Provides More Uniformity and Smaller Particle Size

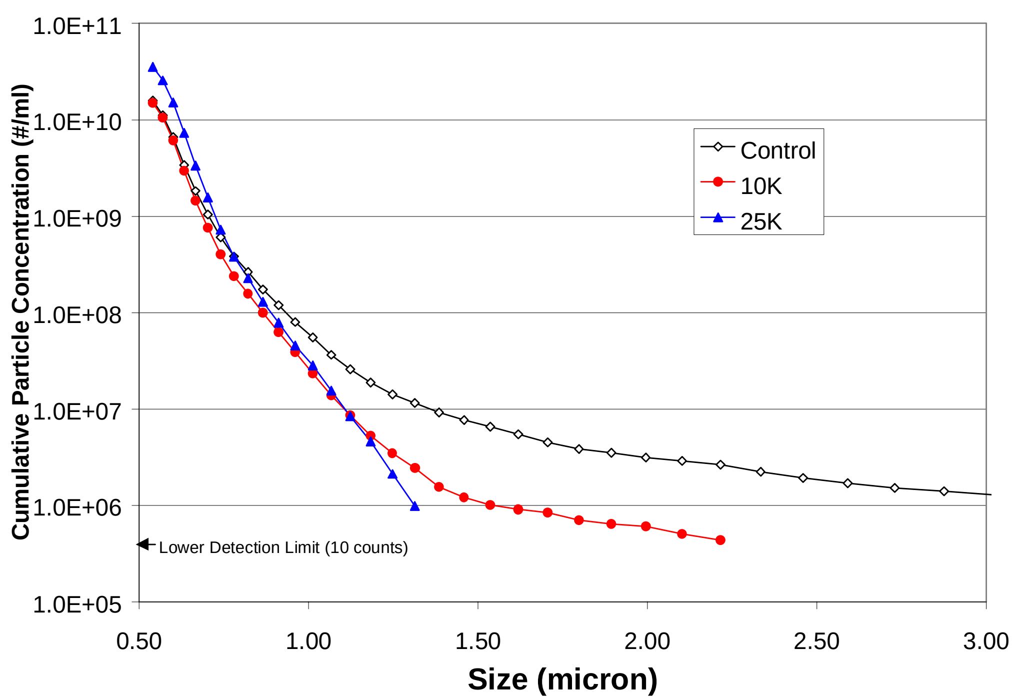


Figure 4. Schematic of quiescent drying and in-line orientation

2. Quiescent Drying Process

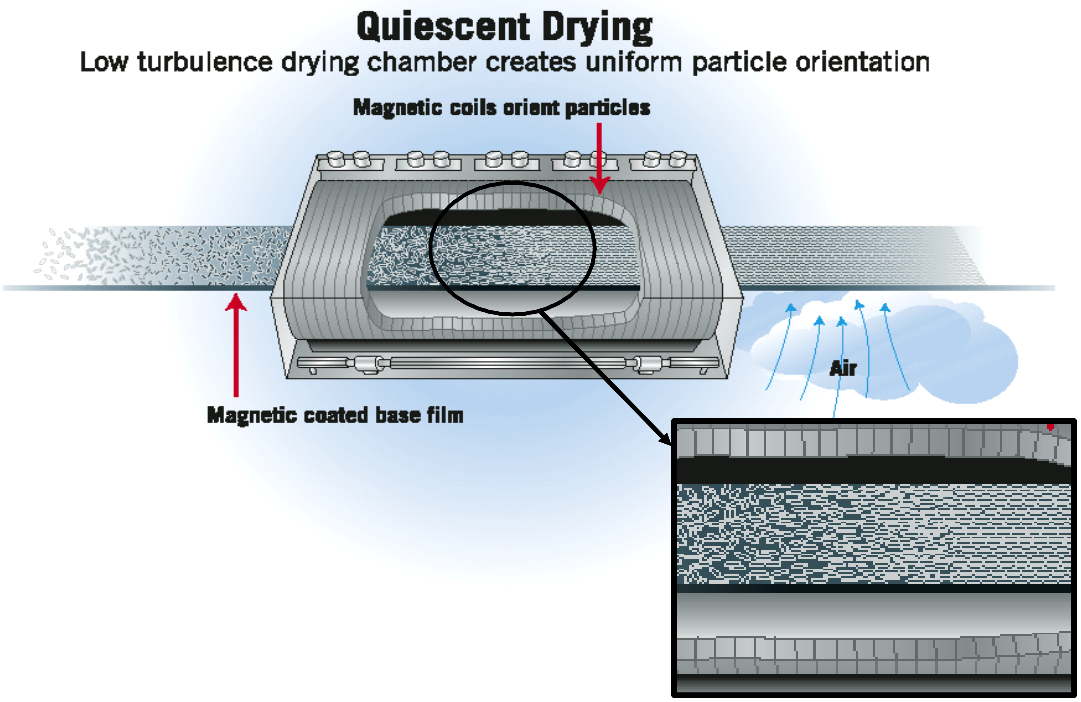


Figure 5. SEM Images at 40,000x. Left: Imation LTO2 sample with Quiescent Drying and Magnetic Coil Orientaion; Right: Competitive LTO2 product

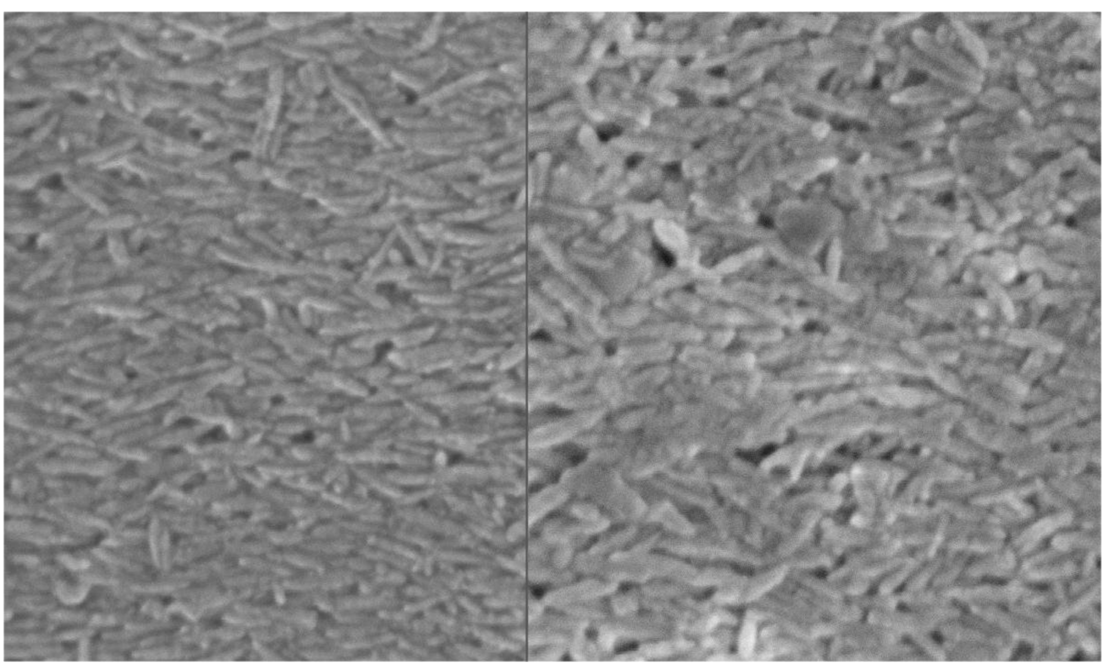
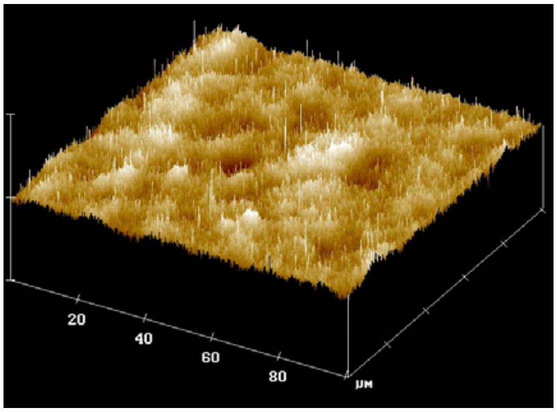


Figure 6. AFM Images of Imation and Competitive Media

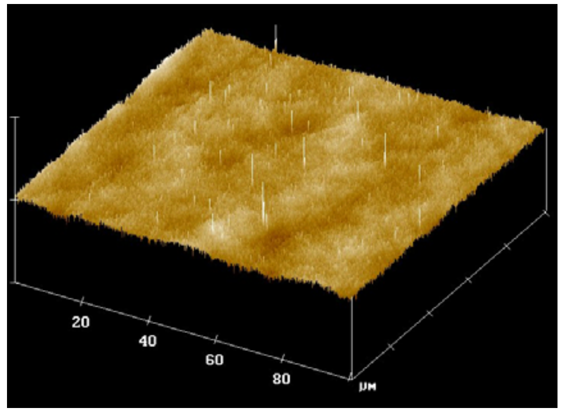
AFM Image of Imation LTO2 POR

Ra: 4.0 nm



AFM Image of Imation 1 TB target media using Advanced MP Coating Technology in Discovery pre-production facility

Ra: 2.4 nm



100 μm x 100 μm scans, vertical scale 100 nm/div