

INSIGHT

International Disk Drive Equipment and Materials Association

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on the cover

Keeping pace with the competition—on the race track or in the data storage industry—is the key to a winning strategy.

Joan comments

IDEMA Executive Director, Joan Pinder



We invite you to join us at the 13th annual DISKCON USA, the world's largest technical conference and trade show devoted to data storage equipment, materials, services and technology. This year's DISKCON USA features five days of technical and business offerings, including more than 20 conference sessions, education classes, and standards committee meetings and workshops, a charity golf tournament, plus a trade show with more than 400 exhibiting companies. In these trying financial times, DISKCON USA offers a cost-effective way for companies to keep up-to-date on new technologies and to broaden education and training opportunities.

Advanced Technologies For Future Storage, scheduled for Tuesday morning, sets the tone for DISKCON USA's three-day technical conference with presentations on new types of storage beyond current magnetics. With emerging applications such as TV set-top boxes, wearable computers, and digital cameras estimated to drive growth for the data storage market, it is critical that HDD industry manufacturers educate themselves about the drive designs needed to support these exciting new applications during Wednesday's presentations. And for the first time at DISKCON USA, conference attendees will hear the integrator's viewpoint on requirements for PC and storage subsystem designs and storage capabilities for emerging applications, also on Wednesday. The conference will wrap up on Thursday with the always popular Wall Street session, covering the state of the industry as viewed by both buy and sell sides of Wall Street.

In addition to the conference, DISKCON USA offers 13 technical education classes, including new classes on Head-Disk Interface, Disk Drive Interfaces, Microcontamination, and ESD, as well as a presentation skills course to provide you with the techniques needed to get maximum impact from your technical and sales presentations. Whether you are new to the industry or a veteran, you will find that IDEMA's classes will provide a greater understanding of the components and manufacturing processes used to build today's high-performance disk drives.

Another annual DISKCON USA event is the Mark Geenen Technology for Youth Charity Golf Tournament, which will be held at the Castlewood Country Club in Pleasanton on Monday; shotgun start at 12:15 p.m. IDEMA has teamed with former San Francisco 49er Ronnie Lott's charitable organization, All Stars Helping Kids, to help complete an interactive playroom on the pediatric floor at the UCSF Medical Center in San Francisco. Last year, the tournament raised over \$50,000 in cash in support of this important and worthwhile project.

DISKCON USA's most prestigious affair, attended by the Who's Who in the data storage industry, is its Keynote Dinner, which is set for Wednesday from 6:00-9:00 p.m. at the Fairmont Hotel. This year's keynote speaker is Maxtor Corp. President and CEO Mike Cannon. Be sure to make your reservation to attend and hear why Mike thinks drive makers should change the value proposition offered to customers.

I look forward to seeing everyone at DISKCON USA the week of September 20th at the San Jose Convention Center in San Jose Calif. Take advantage of IDEMA's low-cost technical conference and classes to educate yourself, or attend the show at no cost to find out about the latest in new products serving the disk drive industry. As a not-for-profit association, IDEMA presents DISKCON USA to you as one of the best deals in the industry. Be sure to register at www.idema.org.

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marketplace

Leading trade analysts share their market perspective on the data storage industry.

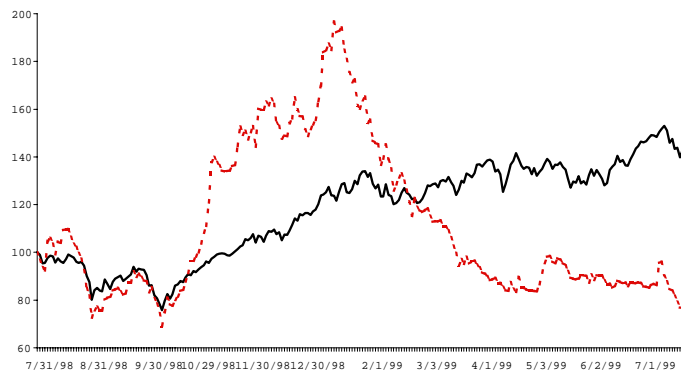
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Statistical Summary Selected Data Storage Stocks

Industry	Sector	Company	Shares Out. (MM)	Stock Price 8/2/99	Calendar Year Earnings Per Share			Price/Earnings Ratio		Market Cap (\$MM)	Cal. 99 Revs. (\$MM)	Market Cap/99 Revs	
					1997A	1998A	1999E	1998	1999				
Disk Drives		Maxtor	103.3	5.47	(4.28)	0.52	(1.45)	10.5x	NM	565	2,376	0.2	
		Quantum	173.0	23.00	2.07	0.48	0.63	47.9x	36.5x	3,979	4,742	0.8	
		Seagate Technology	230.2	27.69	1.72	0.62	0.67	44.7x	41.3x	6,374	6,678	1.0	
		Western Digital	90.6	4.56	0.83	(4.28)	(3.19)	NM	NM	413	2,788	0.1	
Components		HMT Technology	44.8	2.69	1.34	0.37	(1.17)	7.3x	NM	121	193	0.6	
		Hutchinson Tech.	30.8	25.63	1.02	(1.29)	0.69	NM	37.1x	789	579	1.4	
		Komag	64.2	3.88	0.40	(3.51)	(1.81)	NM	NM	249	371	0.7	
		Read-Rite	49.5	5.06	1.75	(2.75)	(3.49)	NM	NM	250	711	0.4	
Capital		Intevac	11.8	4.75	0.95	0.01	(0.93)	NM	NM	56	46	1.2	
Equipment		Veeco Instruments **	15.9	30.00	1.66	1.08	1.42	27.8x	21.1x	477	230	2.1	
Removable		Iomega	269.1	4.06	0.42	(0.15)	(0.08)	NM	NM	1,093	1,465	0.7	
Average:								11.5x	11.3x				0.8

**No official H&Q coverage; First call estimates. "A"= actual; "E"= estimate

Data Storage Index



The Disk Drive Market: A Period of Pain

By Danielle Levitas, IDC

Over the past two years, the disk drive market has been going through a major structural change. Gigabyte consumption and average drive capacity growth have been slowing. Areal density growth has been accelerating. The end result is that the storage industry is delivering technology at rates that exceed what end users are demanding.

How did we get here? Oversupply conditions began in the third quarter of 1997, particularly with desktop hard disk drives (HDDs). This caused aggressive price declines in order to move product. At the high end, demand for half-high (41 mm) drives has been slowing and some original equipment manufacturers (OEMs) have

been reluctant to move to the next higher capacity point, simply because it was available. More recently, the desktop segment has begun to mimic this pattern. The 4-gigabyte capacity point began to grow in popularity at the end of 1997. Although the volume for 4-gigabytes peaked in 4Q98, this capacity point has remained the largest volume capacity point through the second quarter of 1999 (Figure 1). Even in the notebook segment, we have seen the 9.5 mm high (2-platter) design point become the dominant configuration since 1H98. The 9.5 mm design has grown from less than 15 percent in 1Q98 to more than 75 percent in 2Q99. This is also in part due to areal density gains in excess of 100 percent per

year, which is outstripping end users' demand for gigabytes. The notebook market's needs to offer lower cost systems in order to expand its user base, especially in light of the desktop PC's precipitous price declines and the dramatic delta between the two types of PCs.

For the first half of 1998, builds for desktop disk drives dropped off as drive suppliers worked off the excess inventory from 2H97. Fortunately, demand was robust in the second half of 1998 and the drive market grew 16 percent over 1H98. As we entered 1999, the PC market was experiencing sustained demand, particularly for low-cost systems. Not only were \$399 PCs

being launched by several suppliers, but the "free" PC emerged. Demand for low-cost drives mushroomed and new floor price points emerged, even below \$80. Despite how unprofitable most of these products are, large volumes of drives are moving at these price points from virtually all volume desktop suppliers.

So where do we go from here? We do not expect pricing pressures to let up over the next few quarters and this means that drive manufacturers which are dependent upon the desktop portion of the market will need to evolve their business strategies so they can support ASPs of \$85 in this

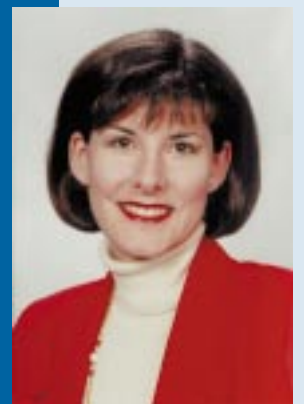
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letter from the editor

The cover of INSIGHT drives the message home that IDEMA's services help members to Keep Pace in the dynamic data storage industry. Many of these services, particularly the member benefits during DISKCON USA, are outlined by Membership Program Manager Debbie Lee on page 14. Another key benefit offered by IDEMA is high-quality technical education. In addition to classes provided on-site and to the public worldwide, IDEMA's Asia-Pacific office has developed a Certificate of Competence in Storage Technology program which has become the most recognized certification program for our industry in Singapore and Malaysia. IDEMA Asia-Pacific Executive Director S.H. Goh, on page 50, describes the association's plan for expanding the successful program into Thailand.

The feature and technical articles, address the new technologies and applications being developed to satisfy customers who want more capacity, but at lower costs. In her Marketplace article, *The Disk Drive Market: A Period of Pain* on page 7, IDC Analyst Danielle Levitas provides insight into the industry's last two years and offers new hope for struggling storage companies.

One of the new technologies being developed to increase areal density is described on page 8 by Dr. David Aziz, Veeco Metrology Group. Dr. Aziz explains that as magnetoresistive technologies mature, additional advances in areal density will focus on increasing the number of tracks per inch by decreasing the width and surface area of the writing element. Another emerging technology is solid state disk (SSD) technology. Quantum's Charlie Cassidy defines SSD technology and lists its advantages over magnetic recording in his article on page 18. Advances in disk substrate technology are also being made, and Titanium X Corp. President and COO Richard Weir provides a comprehensive comparison of substrate materials in his article *Alternative Substrates: The Real Cost* on page 44.



Nicole Flynn,
MarComm Manager
and
INSIGHT Editor

High Resolution Optical Tools for Shrinking Pole Tips

By Dr. David Aziz, Veeco Metrology Group

Over the past five years, the increase in areal density has been driven primarily by the introduction of MR and GMR read devices. As these technologies mature, additional advances in areal density will focus on increasing the number of tracks per inch by decreasing the width and surface area of the writing element. The width of the writing element produced by a number of manufacturers will soon be less than 1 micron. Additionally, these elements are often shaped during the manufacturing process, further reducing their width immediately above the write gap. This width is a key factor in determining the width of the write track. In order to keep pace with the reduction in pole tip dimensions, it is necessary to improve the lateral resolution of the optical tools used to measure these poles. This is being accomplished by increasing the numerical aperture (NA) and decreasing the operating wavelength (λ) of these optical tools.

Figure 1a shows a schematic ABS view of a pole tip; the writing element is P2. A color-coded height map of a pole tip is shown in Figure 1b (red = high, blue = low). The shields (S) and poles (P) shown in Figure 1a are readily identified in this image, while the MR element is too thin to be detected with an optical microscope. Projections for the width of P2 and the thickness of P1/S2 are shown in Figure 2. This is based on National Storage Industry Consortium (NSIC) and other industry data. The width of P2 is declining at a rapid rate, and will be well below 0.5 μm in the next few years. The thickness of P1/S2, on the other hand, is both larger than the width of P2, and declining at a more moderate rate. Production measurements of weighted pole tip recession (PTR) combine the recessions of S1, P1/S2, and P2 with respect to the air-bearing surface (ABS). Figure 2 also shows the lateral resolution roadmap for optical tools. The data presented in this article for the 0.95NA Linnik objective corresponds to the 1999 data point, while the resolution indicated by the 2000 and 2001 data points can be achieved with ultraviolet systems.

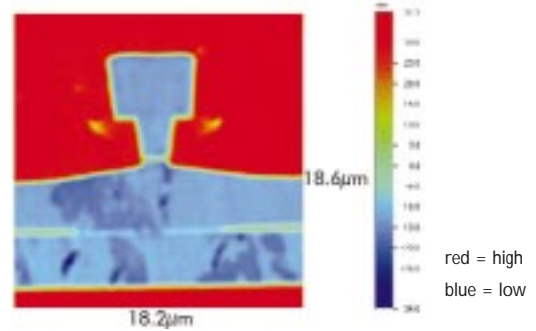
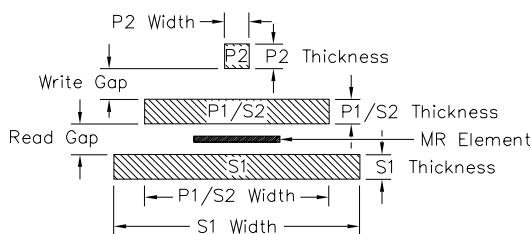


Figure 1b. Height map of a pole tip, measured with an interference microscope

The primary tool for production measurements of magnetic head topography is the optical profiler. These systems employ the technique of optical interferometry. A beam of light is split into two parts; the test beam reflects off the test surface, in this case a magnetic head, while the reference beam reflects off a high-quality internal reference mirror. The test surface and reference surface are imaged simultaneously onto a camera, with the combined beams forming an interference pattern (commonly referred to as fringes). The length of either the test beam or the reference beam is varied in a controlled fashion, which produces a change in the interference pattern. A set of images is acquired during this process, and software algorithms are used to precisely determine the topography of the test surface. Height variations of a fraction of a nanometer (nm) up to several millimeters (mm) can be

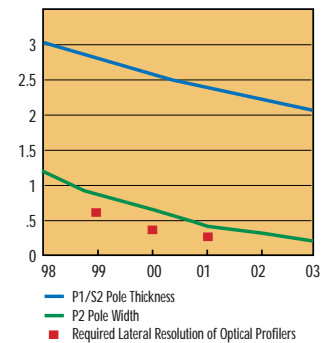


Figure 2. Projected dimensions of P1/S2 thickness and P2 pole width, as well as the required resolution of optical metrology tools

measured with this type of system.

A diagram of an interference microscope is shown in Figure 3a. The source, typically a halogen lamp, is imaged onto the sample in what is called Köhler illumination. In this case, each part of the test surface receives light from many parts of the lamp, producing even illumination across the surface. The interference microscope objective includes a beamsplitter and

VEECO Metrology Ad

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a reference mirror. The beamsplitter splits the illumination into test and reference beams as described above. The reference mirror reflects the reference beam back to the beamsplitter, which then directs a portion of it back through the imaging optics to the camera. The test beam reflects off the test surface, passing through the beamsplitter and joining the reference beam on the path to the camera. In order for interference fringes to be obtained in this type of system, it is necessary for the test and reference beams to have the same length. This is due to the broadband nature of the “white light” source, which produces interference between the test and reference beams only when their path lengths match to a precision of a few microns. Other types of interferometers use laser sources, which can produce interference fringes for large differences in the test and reference beam path lengths.

Several types of interference microscope objectives used in the magnetic storage industry are shown in Figure 3b. The Michelson objective includes a cube beamsplitter and a reference mirror mounted to the side of the beamsplitter. This design is suitable for objective magnifications of up to approximately 5X (5 times), object dimensions of one millimeter to more than one centimeter, and numerical apertures (NA) of up to approximately 0.2. The NA of a lens

describes the steepest rays of light that can be collected, and is the limiting factor on the lateral resolution of a high-quality optical system (assuming adequate sampling by the camera). The Mirau objective is typically used at magnifications between 10X and 50X, and numerical apertures of 0.25–0.55. It is suitable for samples up to 1 mm across, and offers significant improvement over the lateral resolution available with the Michelson design. The Linnik objective is suitable for any magnification, but is used primarily at high magnifications (e.g., 100X) and high numerical apertures (up to 0.95). It is common in biological microscopy to use objectives with $NA > 1.0$. This is possible only with the use of an immersion medium, such as oil or water, between the lens and sample, and has not historically been a practical (or necessary) option for magnetic head measurements.

The lateral dimensions of test samples measured with optical profilers vary from a fraction of a millimeter up to several centimeters, with most instruments providing a range of possible magnifications. Two typical cases are crown measurement systems, in which samples are typically 1 mm–2 mm across, and PTR measurement systems, in which samples are on the order of 0.1 mm–0.2 mm across. Crown measurements are typically made with Michelson objectives having an NA of 0.13, while PTR measurements

are made with Mirau objectives having an NA of 0.55.

The lateral resolution of an optical system varies directly with NA and inversely with the wavelength (λ) of light being used. One common resolution criterion states that two point sources of light can be resolved by an optical system when they are separated by a distance ΔX , where:

$$\Delta X \geq 0.5 \left(\frac{\lambda}{NA} \right)$$

In a typical optical system, such as a camera, resolution limitations produce a reduction in the contrast between bright and dark structures. For example, a photograph of a pair of bright and dark lines spaced 10 mm apart might appear much like the original object, while a photograph of bright and dark lines spaced 1 mm apart may show little or no line structure—the bright and dark regions having blurred together.

In an interference microscope, where height measurements are the main concern, lateral resolution limits take on a somewhat different meaning. In this case, the blurring of small objects (e.g., pole tips) causes the smoothing of edges at height steps, which reduces the accuracy of the height measurement. Figure 4 shows the impact of finite lateral resolution on the measured height of a set of two-level gratings with lateral dimensions on the order of those found in pole tips. The measured root-mean-square (RMS) height average is shown for three different microscope objectives:

1. 20X magnification, 0.40NA Mirau,
2. 50X magnification, 0.55NA Mirau, and
3. 100X magnification, 0.95NA Linnik.

All measurements were made with 550 nm (green) light. The RMS height,

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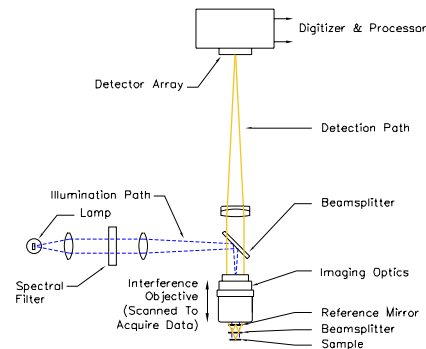
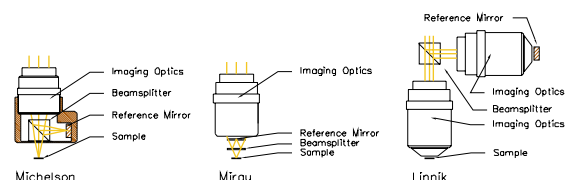


Figure 3a. Layout of an interference microscope



rather than the peak-to-valley height, is used for comparison because it allows many pixels to be averaged, rather than relying on one point each at the top and bottom. The linewidths shown here vary from a maximum of 4 μm to a minimum of 0.3 μm (corresponding to grating frequencies of 125 lines/mm to 1667 lines/mm). Each grating period is composed of a low region and a high region. The height of the gratings was verified with an atomic force microscope (AFM) to be constant across the full range of linewidths.

The data in Figure 4 show increasing underestimation of the measured height for decreasing linewidths (increasing spatial frequencies). The measurement error is inversely proportional to NA. For a 1 μm linewidth grating, the 0.4NA and 0.55NA objectives substantially underestimate the height of the grating, while the 0.95NA objective introduces minimal error. It can be seen from this data that the 0.95NA objective can be expected to perform approximately equivalently when measuring a 0.6 μm wide pole as the 0.55NA objective performs when measuring a 1.5 μm wide pole.

The effect of lateral resolution on the measurement of a moderately small pole tip is shown in Figure 5. The height of P2 along a line 1 μm above the top of the write gap is shown as measured with a 50X/0.55NA Mirau objective and a 100X/0.95NA Linnik objective. The edges of the pole are substantially less distinct at 0.55NA than at 0.95NA, and the peak-to-valley depth of the pole is noticeably reduced. The performance of the 100X/0.95NA Linnik objective was also compared with that of an AFM for the measurement of a small focused ion beam (FIB) trimmed P2. The width of P2 along a line 0.5 μm above the top of the write gap was measured, and minimal difference found between the result obtained with the two metrology tools.

Improved lateral resolution can also be obtained by decreasing the operating wavelength, as noted above. This has been exploited in semiconductor manufacturing to produce progressively smaller linewidths. Current optical profilers operate at visible wavelengths, often in the red. Green and blue light, with successively shorter wavelengths, offer modest improvements in lateral resolution. Future interference microscopes will operate at ultraviolet wavelengths, which in conjunction with high numerical apertures will maximize the lateral resolution. The lateral resolution data points in the roadmap of Figure 2 show this for future optical profilers, which will operate at progressively shorter wavelengths.

Shorter wavelengths also offer the potential for improved vertical resolution, which is typically a very small fraction of a wavelength in an optical profiler. However, there are other parameters, such as mechanical vibration and electrical noise, that impact height measurements, and these must be addressed as well in order to improve vertical resolution.

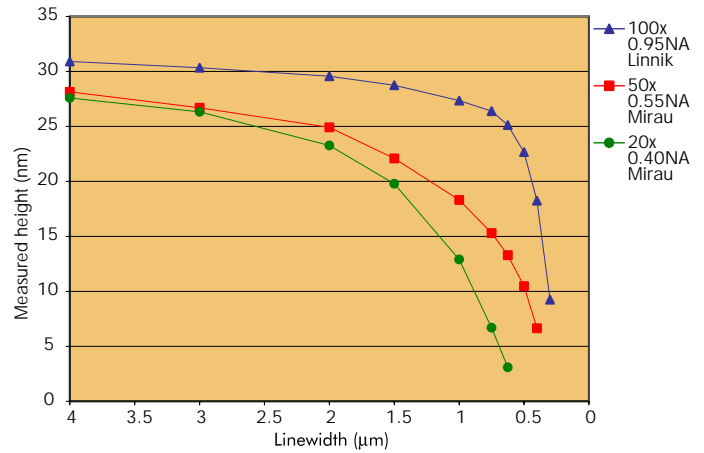


Figure 4. Effect of linewidth on measured height for several different numerical aperture objectives

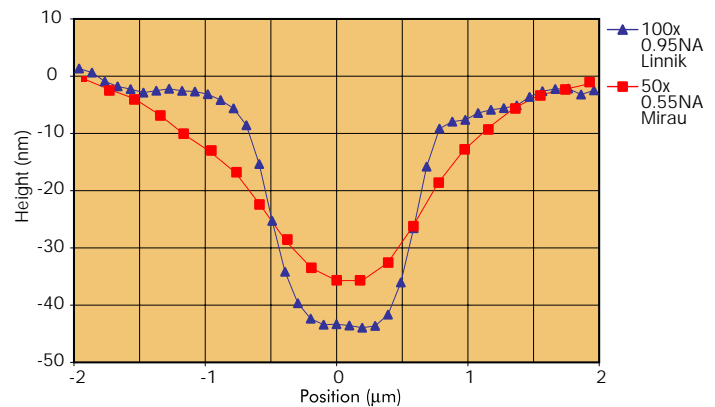


Figure 5. Effect of numerical aperture on a height measurement of P2

Another factor affecting areal density is the magnetic spacing between the media and the read/write head, of which PTR and diamond-like carbon (DLC) coatings are major contributors. As the DLC coatings, continue to get thinner, concerns such as DLC delamination will also benefit from higher resolution optical tools. The pole tip image in Figure 1b was obtained with an 0.95NA Linnik objective operating at a wavelength of 600 nm, and clearly shows the effect of DLC delamination on S1 and P1/S2.

In conclusion, the rapidly shrinking structures in magnetic heads pose

significant challenges for optical profilers. In order to continue to provide adequate metrology tools, it is necessary to increase the numerical aperture of the interference objectives used for these measurements, as well as reduce the operating wavelength of the systems. By maximizing the effect of both NA and wavelength, it will be possible to provide optical metrology tools for pole tip measurements for a number of years to come. ♦

David Aziz is a senior optical engineer at Veeco Metrology Group, where he works in the development of new interference microscope systems and components. He holds a Ph.D. in optical sciences from the University of Arizona.

KLA TENCOR AD



Like the colorful chameleon that is forever changing its appearance to adapt to its surroundings, IDEMA, too, is changing to meet the dynamic needs of its worldwide membership. Just this year, we have added new technical courses to our education program, expanded our Web site to include online registration and standards information and offered symposia in Singapore and Malaysia. For a chameleon, the ability to change is essential for survival—can't the same be said for our industry?

Members Save at DISKCON USA

IDEMA members, including the employees of corporate members, enjoy substantial savings on activities and publications during DISKCON USA. This year, take advantage of these member benefits:

- 10–20 percent discount on DISKCON booth space
- Priority points toward booth selection at DISKCON
- 30 percent discount on the technical conference and symposia
- 20 percent discount on IDEMA publications, such as symposia and conference proceedings
- 20 percent discount on technical education classes
- Extended corporate listing in the Directory of Products and Services for the Disk Drive Industry (released at DISKCON USA)
- Free copies of the Directory of Products and Services for the Disk Drive Industry
- Listing in DISKCON USA issue of INSIGHT magazine
- Exclusive advertising in INSIGHT and on the IDEMA Web site
- Company name and logo space on IDEMA's Disk Drive World Map Calendar (showcased in the IDEMA store and booth, as well as the Technical Proceedings booth at DISKCON USA)
- Speaking opportunities at conference and workshops
- Ability to participate in IDEMA's International Standards program

Members speak out about IDEMA and DISKCON USA

“Participating in DISKCON USA for the past 12 years has given VTC a unique opportunity to bring our company from Minnesota to Silicon Valley, and present it in a special way. As an important image builder for VTC, this conference not only provides a venue for us to personally visit with many customers in one place, but also to get to know other disk drive suppliers.”

*Jane Armstrong
Marketing Communications Manager
VTC Inc.*

“IDEMA's basic technical education classes, offered throughout the year and at DISKCON, provide an excellent overview of the disk drive industry. The classes are affordable and the instructors are extremely knowledgeable and experienced in the industry. They are a must for industry newcomers and non-technical professionals!”

*Sandy Taylor
Human Resources Director
MMC Technology*

“The opportunity to speak at IDEMA's world-wide events is one of the most valuable benefits of membership. By participating in DISKCON conferences and international symposia, Phase Metrics has been able to inform and educate a broader audience of equipment users regarding new production test technologies that enable better process control and higher production yields.”

*Wayne Erickson
Vice President Marketing, Head Products
Phase Metrics, Inc.*

*Membership
Program
Manager,
Debbie Lee
408.330.8108*



Praxiar AD

award

INSIGHT Wins APEX '99 Award of Excellence

The 11th Annual Awards for Publication Excellence, a competition for communications professionals, recognized INSIGHT with an Award of Excellence for Most Improved Magazine. APEX Awards are based on excellence in graphic design, editorial content and the ability to achieve overall communications excellence. Nearly 4,900 communicators submitted entries for the 1999 competition.

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Advanced Surface Technology, Inc. and AST Products, Inc. Announced Business Merge and Reorganization

Advanced Surface Technology, Inc. and its spin-off company, AST Products, Inc. announced their business merge and reorganization. The new organization will keep the name AST Products, Inc. with three strategic business groups focusing on different product and market development: Plasma Science Group, Analytical Technology Group and Advanced Surface Technology Group. Visit www.astp.com.

CERAC, inc. Releases New Specialty Inorganics Catalog

CERAC, inc. has released a completely updated catalog featuring more than 350 pages of today's most widely used materials for processes ranging from vacuum deposition and sputtering to ceramic and flame spray applications. Researchers involved in optics and ophthalmics, aerospace, photovoltaics and other high-tech industries will benefit from the wide variety of specialty products. The free catalog is available in print and on the Internet at www.cerac.com.

Circuit Assembly Corp. Announces New MTSL™ Series Connector

Circuit Assembly Corp. released its new MTSL Series connector, a board mount insulation displacement slim line transition connector. The MTSL was developed for use in cable mounted internal 68-pin SCSI-3 and 80-pin SCA-2 type applications. The connector can also be used on SCSI-3 terminators. The series is available as individual connectors in 68 and 80 positions, or as custom cable assemblies. Visit Circuit Assembly Corp. at www.circuitassembly.com.

CMI Introduces the CMI 900 Series X-ray Fluorescence System

CMI International announced that its new CMI 900 Series represents a significant leap forward in CMI coating thickness measurement and material composition analysis technology. The new CMI 900 Series can now perform assay of gold or other precious metals. Measurement of extremely thin immersion coatings and or films, are now possible. Material sorting and measurement of titanium nitride layers can now be performed. Printed circuit board and

electronic component manufacturers, as well as metal finishing professional will also benefit from this technological advancement. Contact CMI at 847-439-4404.

Facility Monitoring Software for Cleanroom Environments

Particle Measuring Systems has developed Facility-View, a software package that provides a comprehensive account of all environmental conditions within a cleanroom. Facility-View is a Windows™-based program that enables the user to view simultaneously tabular displays, real-time or retrieval time plots, three-dimensional histograms, status conditions, event logs and a facility map for every monitoring instrument. Networking capabilities are available and allow communications with other computers using the TCP/IP protocol to distribute data among many users. Contact Particle Measuring Systems Inc. at 303.443.7100.

New Cymetra® II Planetary Vapor Deposition (PVD) System

Veeco Instruments Inc. introduced the new Cymetra II Planetary PVD System. The Cymetra II allows deposition of up to six materials with leading planetary technology that enables the industry to exceed areal densities of 10 Gb/in². The system provides precise sub-angstrom thickness control, maximum uniformity and repeatability. Its cluster tool platform allows the combination of Veeco's ion beam etch, ion beam deposition and physical vapor deposition for advanced GMR manufacturing. Contact Veeco Instruments Inc. at 516.349.8300 or visit www.veeco.com.

SSEC Combines Single Wafer and Immersion Processing

Solid State Equipment Corporation (SSEC) has announced the Evergreen Model 203 Solvent Processor for applications in metal lift-off, flux removal resist strip, polymer removal, solvent cleaning, and other solvent processes. Embodying SSEC's advanced spin tool wet processing system technology, the Model 203 combines the best of single wafer processing with batch immersion solvent processing. This versatile system is built to meet stringent requirements on ergonomics, safety, and chemistry economy and disposal. Contact SSEC at 215.328.0700.



Strasbaugh AD

Tosoh SMD Approved to Supply Applied Materials Vectra™ IMP Coil Components

Tosoh SMD is now authorized to supply high-purity, titanium coil components directly to users of Applied Materials Vectra Ionized Metal Plasma (IMP) chambers. Field tested and approved, Tosoh SMD coil components feature uniform grain size and metallurgy, specifically engineered surface roughness and are sealed in non-contact cleanroom compatible packaging. Contact Tosoh SMD at 614.875.7912.



Ultratech Introduces New Breakthrough Broadband Stepper Lens

Ultratech Stepper, Inc. has announced the introduction of a breakthrough broadband 1X stepper lens. The new lens, the first of its kind capable of exposing both g-line and i-line photosensitive films on the same stepper, is designed to meet the varied lithography needs for a number of Ultratech's served markets. Among the unique features of the lens is a

high wafer plane irradiance that results in low exposure time and increased throughput at high-dose exposures. Visit Ultratech Stepper, Inc. at www.ultratech.com.

AccuTip Diamond Indentation Tips Bring New Level of Precision and Reliability

MTS Systems Corp. has introduced the AccuTip family of diamond tips for nanoindentation and scratch testing. With a tip radius of less than 50 nanometers, AccuTip indentation tips are sharper by a factor of 2 to 3 compared to standard tips now on the market. The indentation tips are well-suited for testing the hardness and modulus of ultra-thin films and small volumes of material. Call MTS Systems Corp. at 612.937.4000.

MicroE Colorado moves into a larger office space in the Denver/Boulder area

The new MicroE location provides a much larger lab area for performing critical servo track writer development work and includes expansion room for additional human resources. The new office address is 3170 Miner's Drive, Suite 101, Lafayette, Colo. 80026. The new phone number is 303.665.9870.



article

Solid State Disks

By Charlie Cassidy, Quantum Corporation

What is a solid state disk?

A solid state disk (SSD) is a storage peripheral that uses semiconductor storage instead of magnetic platters as the media. There are two basic types of solid state disks available today, targeted at different uses. Small form factor SSDs, which use non-volatile flash memory and are generally designed to various off-shoots of the Personal Computer Memory Card International Association (PCMCIA) standard. They are used for portable equipment, such as digital cameras and personal digital assistants which value low-power and ruggedness. High-end solid state disks, used on UNIX and Windows NT systems, tend to be packaged in standard disk form factors (3.5", 5.25" and 19" racks) and are designed around standard disk interfaces such as Small Computer System Interface (SCSI). Figure 1 shows a typical high-end SSD. Here the main focus is on performance, hence these high-end SSDs tend to be made of faster Digital Random Access Memory (DRAM) technology. The lack of mechanical components leads to very fast, predictable access time. Since DRAM loses its contents when power is removed, sophisticated data retention systems with rechargeable batteries and hard disk drives are often included in high-end SSDs. Use of standard interconnects and form factors allow solid state disks to be added to systems just like magnetic disk drives.

The controller architecture of SSDs is very similar to that of magnetic hard disk drives. Instead of a serial analog channel, the media interface in an SSD is a parallel memory interface. A central buffer controller Application Specific Integrated Circuit (ASIC), similar to the digital ASIC in a hard disk drive (HDD), is the central data and control path for access to the memory media. The ASIC also provides powerful on-the-fly error correction. This, combined with bad block reassignment techniques like

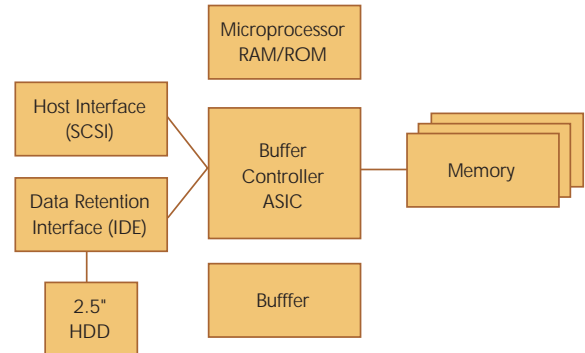


Figure 2. Solid State disk block diagram.

those used in HDDs, provide high levels of reliability and data integrity, while maintaining superior levels of performance.

The convergence of open standards (SCSI and PCMCIA), new memory technologies (16 and 64 Mb DRAM and flash memory) and higher capacity magnetic disks has brought SSD to the workstation and server market. What in 1989 cost over \$1000 per megabyte and was the size of a refrigerator, now sells to end users for less than \$20 per megabyte and fits in the palm of your hand. In the case of a compact flash card, it is not much bigger than a postage stamp.

What are the advantages of high-end solid state disks? Solid state disks are used in a variety of industries and applications to improve system responsiveness and increase system throughput. When you call a 1-800 telephone number, use a credit card or trade stock or stock options, chances are your transaction is being sped along with a solid state disk.

The main advantage of SSD is fast access time. As seen in Figure 3, this leads to data access times up to 15 times faster than magnetic disks.

The timing of the rest of the command processing and data transfer is like that of magnetic disks. Solid state disks, then, have their greatest advantage for small I/Os where the mechanical access time is a significant portion of the total time to complete the I/O on a magnetic disk. The access time advantage of SSD decreases as the I/O request size grows, because data transfer time becomes the dominant component of I/O completion time. However, modern solid state disks designed for SCSI



Thot Technologies AD

Ultra and Ultra² interfaces can sustain transfers near the full bus speed and can significantly outperform magnetic disk drives even for purely sequential workloads.

When to use a SSD?

Solid state disks are aimed at applications whose performance is limited by I/O performance. They are particularly effective in write-intensive applications, or applications where data locality is poor. Caching tends to be ineffective in those applications.

Solid state disks are frequently used in commercial processing, database and online transaction processing applications. Although

solid state disks have sustained bandwidths twice that of high-performance magnetic disks, they still may not be the optimum choice for applications that require high bandwidth for large, sequential I/O requests. Striping of high-performance magnetic disks may be a lower cost method to meet high bandwidth requirements.

Some examples of SSD use and the performance benefits obtained are:

- *Putting journal files and key parts of an options trading database on SSD reduced the response time in a financial trading environment from 24-62 seconds to 2-4 seconds.*

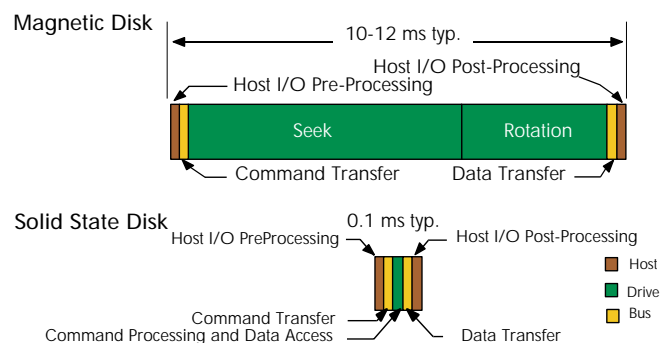


Figure 3. Solid state disk lack of mechanical latencies lead to fast, predictable performance

- *Moving active operating system files, such as job and security databases, to SSD reduced login time by 75 percent and essentially eliminated waits during batch and print-queue operations.*
- *Using SSD to hold chemical modeling data reduced job run time by 26 percent.*

This type of performance boost can be important to system providers in demonstrating the full potential of their products on workloads such as TPC-A and AIM.

How is high-end SSD used?

High-end SSDs can be connected directly to the host SCSI interconnect for minimum latency, or they can be integrated into subsystems exactly like hard disk drives. As SCSI devices, the SSDs conform to the same rules that apply to magnetic disks. They can be mirrored, striped, and bound in volumes. Information is recorded using the same SCSI commands as magnetic disks. SSDs can be integrated into Redundant Arrays of Independent Disks (RAID) subsystems in several different ways. They can provide significant performance boosts and shorten

RAID subsystem development time. Specifically, SSDs can be:

- *Integrated in RAID subsystems as discreet devices to contain the files with very high access rates.*
- *Configured as a RAID rack for the ultimate in performance and reliability.*
- *Used by RAID subsystem designers as a read cache to upgrade RAID controllers that do not support caching or have only limited cache capacity (typically 32 to 64 MB).*
- *Used by subsystem designers as a non-volatile write cache alternative (write to cache with logging to SSD) to improve write performance in RAID-5 implementations.*

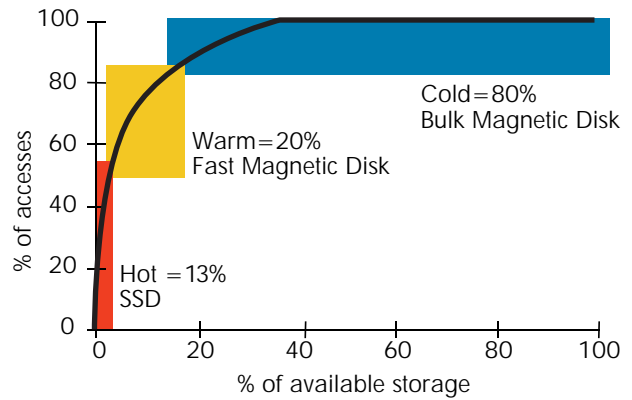


Figure 4. Adding just 3% SSD can lead to significant performance gains

Because of their access frequency, hot files will tend to reside in cache a large portion of the time. If the size of this set of frequently accessed data is larger than the cache, “thrashing” (constant purging and reloading of

data into the cache) will result, leading to lower performance. Moving these files to SSDs—where they can always be accessed near-instantaneously—can dramatically improve user-level response time and eliminate many of today’s

LSI DESIGN Ad

most common storage bottlenecks. Some examples of these hot files are:

- *Database files such as root, snapshot, index, and frequently accessed data files.*
- *Operating system files such as user rights and authorization files, job controller control files, common code libraries and the executable images of frequently used operating system commands.*

How much SSD is needed?

The biggest hurdles to overcome when comparing SSD with these other technologies are in the area of cost. Part of the issue is that for technologies such as caching, the customer naturally amortizes the cost over their entire disk farm. This amortization applies to SSD as well, but as a storage device, the natural tendency is to compare SSD cost with magnetic HDD cost. This comparison is invalid, since the entire HDD disk farm will not be replaced by SSD.

University and system vendor studies have profiled the I/O activity of a wide range of applications. Isolating and placing this small amount of “hot” storage on solid state disk means over 50 percent of the I/O requests performed by the system will see the very fast access time of solid state disk.

As shown in Figure 4, 1–3 percent of the total online data receives 50 percent of the I/O requests. I/Os to this small amount of data tends to:

- *Be small in size, averaging less than eight blocks. This means that seek and rotation times are a significant factor.*
- *Exhibit poor locality, which means caching may be ineffective in improving access times.*
- *Are critical to the application and to the business (e.g., control files, indexes and log files).*

Slow access to the 1–3 percent of data significantly impedes the performance of applications. Placing that data on SSD literally unleashes application performance. ♦

Charlie Cassidy is vice president and manager of the Solid State Business Unit at Quantum Corporation, which is part of the DLT and Storage Systems Group. Charlie has been a leader in the design and development of solid state disk technology since 1986. He is a frequent author and lecturer on system and storage performance issues.

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IDEMA has an active Standards Program with more than 20 worldwide committees, subcommittees and taskforces covering critical issues facing the data storage industry today. Members are encouraged to take an active role in the development of industry standards by attending meetings and participating in technical symposia offered throughout the year.

If you have questions contact Standards Program Manager, Kristen Montau. Check the IDEMA Web site, www.idema.org, for upcoming standards meetings, agendas and directions. All meetings are held at the IDEMA office (unless otherwise indicated).

Disk/Substrates Committee

The committee is in process of balloting revisions to both the 84 mm and 95 mm Rigid Disk Standards. A definition for disk waviness and a set of terms and definitions for lube thickness, CSS, and laser bump heights is in the balloting processes.

Lube Thickness & Contact Stop Start (CSS) Testing Subcommittee

The subcommittee is reviewing two lube measurement proposals: 1) FT-IR and 2) ESCA. These proposals are expected to be out for ballot by mid-September. To review these proposals, visit www.idema.org.

Disk Magnetics Subcommittee

The subcommittee is currently performing a Disk Magnetometer Pilot Study. The Study has three goals: 1) Determine single-lab and multi-lab correlation of magnetometers on selected samples among a limited number of laboratories, 2) Support development of an IDEMA magnetometer test method for magnetic remanence, coercivity and remanent coercivity, and 3) Determine need for full-scale round robin test using the new test method.

Emitted Shock & Vibration Committee

Next Meeting: Sept. 21, 8:30 a.m.—11:30 a.m.

San Jose Convention Center, Room M

The committee is developing a useful specification which defines the vibration and shock energy emitted by a storage device and transmitted to the housing supporting the device.

Environmental, Health & Safety (EHS) Committee

The committee is working to establish standards that will address water recycling and usage.

Energy Efficiency Subcommittee

The subcommittee is developing a proposal for measuring power consumption of a hard disk drive (i.e., watts per gig). The first meeting was held on June 17.

HDD Reliability Committee

The committee is working on developing Benchmark Reliability Tests for HDDs used in the desktop and portable computer market. They are also developing an AFR Summary document that contains philosophy and mathematics regarding AFR, AFP and ARR. Once completed, the document will be published on the IDEMA Website.

Heads Committee

The committee has developed two standard proposals: 1) Femto Transducer and 2) Femto Bond Pad Location. The proposals were balloted last month and the results were reviewed at the Aug. 26 meeting.

ESD Subcommittee

Next Meeting: Sept. 21, 8:00 a.m.—12:00 p.m.

San Jose Convention Center, Room L

The subcommittee has recently balloted its first standards proposal—General Practices with GMR/MR Heads. Ballot results were discussed at the August meeting. The subcommittee continues to work on four other proposals: 1) MR and GMR Heads—ESD Testing, 2) Tweezers, 3) ESD Materials for MR and GMR Heads, and 4) Packaging for Disk Drive Components. These proposals are available for review at www.idema.org.

Microcontamination Committee

Next Meeting: Sept. 30, 9:00 a.m.—2:00 p.m.

The committee has recently balloted the following proposal “Measurement of Extractable/Leachable Cation Contamination Levels on Drive Components by Ion Chromatography (IC)”. This ballot and the following new proposals will be discussed at the September meeting, 1) Online Measurement of Ionic Contamination on Sliders by Ion Chromatography, 2) Particulate Clean-up Test For

NRD AD

Hard Disk Drives, 3) Dynamic Headspace/ Cryogenics, 4) ICP-MS (Metals), and 5) Drive Level Outgassing. These new proposals will be available for review at www.idema.org in the near future.

Cleanroom Contamination Subcommittee

The subcommittee has begun working on a proposal for "Guidelines for Contamination Control in Disk Drive Cleanrooms and Controlled Environments." This proposal will outline how to build, use, operate and monitor disk drive industry cleanrooms.

Lab Correlation Subcommittee

Next Meeting: September 30, 2:00 p.m.–4:00 p.m.

The subcommittee has been formed to develop a program to check the accuracy and reliability of Materials Science Labs. The goal is to recommend a method to assure adherence to sound quality practices by independent scrutiny and assessing reliability of measurements.

FREE standards workshops at DISKCON USA

Future Suspension Designs & Performance Requirements

Sept. 20, 9:00 a.m.–12:00 p.m.

San Jose Convention Center, Room K

The goal of the workshop is to discuss future suspension designs and performance requirements that are needed to continue the 100 percent annual growth rate in areal density.

Topics of discussion will include: Dual stage actuators, Flex on suspension, Chip on suspension, and New suspension materials, Other topics related to the growth of high-areal density magnetic or optical recording.

ESD Issues Facing MR & GMR Heads

Sept. 20, 1:00 p.m.–4:00 p.m.

San Jose Convention Center, Room K

Space is limited so reserve your space by registering with Trudy Gressley at tgressley@idema.org.

symposium

Enabling Technology for Higher Areal Density Symposium

Oct. 20, Tora-no-mon Pastoral Building, Tokyo, Japan

Oct. 22, Sheraton Towers, Singapore

Oct. 23, Equatorial Hotel, Penang, Malaysia

IDEMA offers its corporate members several opportunities to promote their company and build awareness within the data storage community. Call Debbie Lee at 408.330.8108 to learn more about IDEMA's high-impact corporate sponsorships.

The widely reported greater than 100 percent areal density growth and recent achievements of 20 Gb/in² have put the information storage industry into a feeding frenzy for technology. Despite the industry's continued growth and recent success in areal density, several challenges loom large and threaten future growth in storage capacity. Challenges such as manufacturing yields, GMR heads and media, and non-repeatable run out lead the industry to ask: What technologies will enable the storage industry to continue its dramatic growth in capacity? And what challenges threaten future growth?

More than 700 data storage professionals are expected to attend the three-country tour of Enabling Technology for Higher Areal Density Symposium to hear industry innovators and visionaries discuss the latest technologies for higher areal density growth.

Register today to attend the Enabling Technology for Higher Areal Density Symposium and learn how to meet the challenges which threaten future storage capacity growth. To register and pay in U.S. currency, visit www.idema.org. Contact IDEMA Japan at 81.3.3539.7071 to register and pay in yen, or IDEMA Asia-Pacific at 65.226.3412 to register and pay in Singapore dollars or Malaysian ringgit.

wanted

Focus Group Participants

IDEMA is seeking industry professionals who are interested in participating in one or more focus groups. **Our aim is to learn more about members' perception of IDEMA** and their needs in the areas of education, standards, promotion, and communication. Anyone who is an employee of a member company is qualified to participate. If you are interested in helping IDEMA in this important effort, please contact Nicole Flynn at 408.330.8107 or send e-mail to nflynn@idema.org.

Speakers and Topics

Masaaki Futamoto, Hitachi

Possibilities and Problems of Perpendicular Magnetic Recording

Akira Kakehi, Fujitsu

GMR Head, Media and Slider Technology Demonstration

Joel Weiss, Seagate Technology

Alternative Substrates

David James, Xyratex International

Integration and Testing of Disk Drives: Mechanical and Servo System Issues

Guoxiao Guo, Data Storage Institute

Actuators to Support High TPI

Bernhard Cord, BPS Balzer Processing Systems

Process Characterization of a High-Speed Multi-Chamber Hard Disk Sputtering System

Dennis Speliotis, ADE Technologies

Advanced Magnetic Metrology for Media and Heads

Alan Armstrong, Marvell

The Role of HDD Electronics in Increasing Areal Densities**

NEC

Spin Dependent Tunneling GMR Head Technology*

Don Perettie, Ad Mat International

Advanced Tribochemistry for High Areal Density Recording**

* Japan only

** Singapore and Penang only

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DISKCON USA

September 20–24

San Jose Convention Center, San Jose Calif.

register on-site or online (before Sept. 14) at www.idema.org

4th Annual Mark Geenen Technology for Youth Charity Golf Tournament

Enjoy a full day of championship golf and help support former San Francisco 49er Ronnie Lott's charitable organization, All Stars Helping Kids, by participating in IDEMA's annual golf tournament at the Castlewood Country Club in Pleasanton Calif. on Sept. 20.

Standards Workshops

Volunteers from IDEMA's Standards Committees are hosting two free workshops. Space is limited. E-mail your reservation to tgressley@idema.org.

Monday, 9:00 a.m.–12:00 p.m.

Future Suspension Designs and Performance Requirements

Monday, 1:00 p.m.–4:00 p.m.

ESD Issues Facing MR and GMR Heads

Trade Show

View product demonstrations and explore hands-on exhibits from among the more than 450 companies showcasing their latest offerings for the storage industry.

Welcome Reception

Enjoy complimentary gourmet hors d'oeuvres and cocktails as you visit with colleagues, clients and customers at the DISKCON USA Welcome Reception on Sept. 21 at 5:00 p.m. in the concourse area.

Keynote Dinner

Attend the Keynote Dinner at 6:00 p.m. on Wednesday, Sept. 22, at the Fairmont Hotel, featuring Maxtor Corporation's President and CEO Mike Cannon, and learn why he thinks drive makers should change the value proposition offered to customers by promoting the dramatic system performance benefits of higher RPM drives.

University Forum Luncheon

IDEMA Fellowship Award winners will present details about their research findings at 12:00 p.m. on Wednesday, Sept. 22 at the San Jose Convention Center, Room M.

Technology Showcase

The history of the disk drive industry is captured in IDEMA's Technology Showcase. It features the world's largest collection of milestone disk drives and industry memorabilia, combined with unique educational exhibits created to explain the industry's technology.

Disk Drive Pavilion

See the latest in disk drive products from companies like Seagate, Quantum, IBM, Fujitsu and others. A wide range of drives will be showcased, including compact 1-inch drives storing 340MB to 3.5-inch drives with 25GB capacity.

Monday, Sept. 20

12:15 p.m. shotgun start—Charity Golf Tournament

8:00 a.m. – 12:00 p.m.

- The Head-Disk Interface: First Contact
- Understanding and Solving ESD Problems in Magnetic Recording

8:00 a.m. – 5:00 p.m.

- Analytical Techniques for the Evaluation of Molecular Contamination
- Leveraging Your Presentations

9:00 a.m. – 12:00 p.m.—Standards Workshop

1:00 p.m. – 4:00 p.m.—Standards Workshop

1:00 p.m. – 5:00 p.m.

- An Introduction to Disk Drive Interfaces
- Microcontamination

Tuesday, Sept. 21

8:00 a.m. – 12:00 p.m.

- An Introduction to GMR Head Technology
- Understanding Thin Film Media Manufacturing

1:00 p.m. – 5:00 p.m.

- Disk Drive Basics
- Understanding Thin Film Head Manufacturing

8:30 a.m. – 12:00 p.m.

Session I: Advanced Technologies for Future Storage Symposium

10:00 a.m. – 5:00 p.m.—Exhibit Hall Open

2:00 p.m. – 4:00 p.m.

Session II: Magnetic Component Technologies—An Industry Analysis

5:00 p.m. – 6:30 p.m.—Welcome Reception

Wednesday, Sept. 22

8:00 a.m. – 12:00 p.m.

- The Head-Disk Interface: First Contact

8:30 a.m. – 10:30 a.m.

Session III: Evolving HDD Design

1:00 p.m. – 5:00 p.m.

- An Introduction to Disk Drive Design

10:00 a.m. – 5:00 p.m.—Exhibit Hall Open

12:00 p.m. – 2:00 p.m.—Lunch

2:00 p.m. – 4:00 p.m.

Session IV: The Design of an IDEMA Award-Winning Drive

6:00 p.m. – 9:00 p.m.—Keynote Dinner

Technical Conference

As the millennium approaches, magnetic hard disk drive performance and capacity increases have continued at a furious pace with product areal densities exceeding the historical 60 percent CGR curve; GMR heads announced at greater than 20 Gbits/in² in laboratory demos, head disk spacings below 20 nm using super-smooth disks employing load/unload ramps or specially designed slider ABS; and finally with E2PRML data channels which enable internal rates to exceed 50 Mbytes/s at 10,000 RPM. Although threatened by superparamagnetism, the potential for further technological progress is excellent.

This year's DISKCON USA technical conference will feature presentations by key representatives from both the academic and industrial worlds to address advanced storage technologies for future magnetic hard disk drives; disk drive integrators to discuss design requirements for computer as well as new, emerging applications; and finally business leaders to analyze the storage industry and its financial growth potential. The three day conference will provide a forum for discussion on the following session topics:

Session I: Advanced Technologies for Future Storage Symposium

Chair: Jon Fields, Lucent Technologies

Tuesday, 8:30 a.m.–12:00 p.m.

- *New head and media structures; the road to 100 Gbits/in², 10 nm spacings, 100 Mbytes/s, addressing superparamagnetism*
- *How new measurement concepts will support future HDD progress*
- *Magnetic storage beyond disk drives*
- *Advanced non-magnetic storage; holography, magneto-optical and phase change recording directions, exploratory progress in storage at universities*

Session II: Magnetic Component Technologies—An Industry Analysis

Chair: Mike Covault, Seagate Technology

Tuesday, 2:00 p.m.–4:00 p.m.

- *MR to GMR evolution and the impact on disk drive design*
- *Slider manufacturing techniques for ultra low flying heads*
- *Dual suspension and microactuator designs for greater than 30,000 TPI*
- *Component technology and drives trends—an industry analysis*

Session III: Evolving HDD Designs for the Millennium

Chair: Bill Moon, Quantum Corporation

Wednesday, 8:30 a.m.–10:30 a.m.

- *New drive designs for emerging applications; consumer based products such as set-top boxes, digital cameras, palm computers*
- *Trends in HDD designs for future server, desktop and mobile applications*
- *New data channel and AE module designs to support higher densities and performances*

Session IV: The Design of an HDD—An Integrator's Viewpoint

Chair: Bill Healy, IBM Corporation

Wednesday, 2:00 p.m.–4:00 p.m.

- *What PC and storage subsystem designers want in ideal HDD designs for capacity, performance and \$/MB*
- *What new applications developers want in storage capabilities for emerging products*
- *How future HDD designs could impact new computer applications*

Session V: Wall Street Perspective

Chair: Bob Blair, Western Digital

Thursday, 8:30 a.m.–11:30 a.m.

- *The present business status and future of the HDD and storage component industries*
- *An analysis of industry revenue and future opportunities*
- *Progress in specific segments of the storage industry*

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hibit Hall Open

niversity Forum Luncheon

HDD—An Integrator's

ote Dinner

Thursday, Sept. 23

8:00 a.m. – 12:00 p.m.

- *Understanding and Solving ESD Problems in Magnetic Recording*
- *An Introduction to CD-ROM Technology*

8:30 a.m. – 11:30 a.m.

Session V: Wall Street Perspective

10:00 a.m. – 3:00 p.m.—Exhibit Hall Open

1:00 p.m. – 5:00 p.m.

- *Microcontamination*
- *An Introduction to PRML*

Friday, Sept. 24

8:00 a.m. – 12:00 p.m.

- *An Introduction to Disk Drive Interfaces*
- *An Introduction to GMR Head Technology*
- *Understanding Thin Film Media Manufacturing*
- *Cleanroom Operations*

1:00 p.m. – 5:00 p.m.

- *The Head-Disk Interface: First Contact*
- *Disk Drive Basics*
- *Understanding Thin Film Head Manufacturing*

Polytech PI AD

Technical Education Classes

Industry newcomers and veterans alike will find value in IDEMA's basic technical education classes. These classes are designed to provide students with a general understanding of the components and manufacturing processes used to build today's high performance disk drives. Thirteen classes will be offered at DISKCON USA, including new classes on Head-Disk Interface, Disk Drive Interfaces, Microcontamination and ESD. Register onsite or online (before Sept. 14) at www.idema.org.

Analytical Techniques for the Evaluation of Molecular Contamination

Monday, 8:00 a.m.–5:00 p.m.

Leveraging Your Presentations

Monday, 8:00 a.m.–5:00 p.m.

The Head-Disk Interface: First Contact

Monday and Wednesday, 8:00 a.m.–12:00 p.m.

An Introduction to Disk Drive Interfaces

Monday and Wednesday, 1:00 p.m.–5:00 p.m.
Friday, 8:00 a.m.–12:00 p.m.

Understanding and Solving ESD Problems in Magnetic Recording

Monday and Thursday, 8:00 a.m.–12:00 p.m.

Microcontamination

Monday and Thursday, 1:00 p.m.–5:00 p.m.

An Introduction to GMR Head Technology

Tuesday and Friday, 8:00 a.m.–12:00 p.m.

Understanding Thin Film Media Manufacturing

Tuesday and Friday, 8:00 a.m.–12:00 p.m.

Disk Drive Basics

Tuesday and Friday, 1:00 p.m.–5:00 p.m.

Understanding Thin Film Head Manufacturing

Tuesday and Friday, 1:00 p.m.–5:00 p.m.

An Introduction to CD-ROM Technology

Thursday, 8:00 a.m.–12:00 p.m.

An Introduction to PRML

Thursday, 1:00 p.m.–5:00 p.m.

Cleanroom Operations

Friday, 8:00 a.m.–5:00 p.m.



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DISKCON USA KEYNOTE DINNER

Wednesday, Sept. 22

Fairmont Hotel, San Jose

No-Host Reception 6:00 p.m.

Dinner 7:00 p.m.

Attend the DISKCON USA Keynote Dinner and learn why Maxtor Corporation President and CEO Mike Cannon believes drive makers should change the value proposition offered to customers by promoting the dramatic system performance benefits of higher RPM drives.

Mr. Cannon has 20 years of data storage industry experience in key leadership positions. He joined Maxtor in July 1996 from IBM, where he held several senior management positions in the Storage Systems Division, including vice president, mobile and desktop disk drive business unit; vice president, product design; and vice president, worldwide operations.

Under Cannon's leadership, Maxtor has seen a dramatic improvement in growth and profitability during the most difficult period the industry has seen in the last ten years. Maxtor's time-to-market leadership of its new products and relentless focus on continuous improvements in quality and flexible manufacturing has won the business of the top PC OEMs. Maxtor (Nasdaq: MXTR) became a publicly traded company on July 31, 1998 and was one of the largest technology IPOs of the year raising \$348M.





Conference Committee

*An Interview with Ed Grochowski, IBM, DISKCON USA
Technical Conference Committee Chairman*

Q. How does the Committee determine which topics to address at DISKCON USA? Describe the selection process for the technical conference.

A. A technical conference has always been a key part of every IDEMA-sponsored DISKCON event having an objective of providing the latest in-depth information on storage technologies. This information is presented by the foremost industry experts in storage components, heads and disks, disk drives, as well as the overall industry from a business standpoint. The latter is presented by storage industry analysts who add a unique perspective to the conference. The primary field of interest is magnetic storage, components and hard disk drives, but technologies beyond magnetic storage are of interest. IDEMA also sponsors a number of technical symposium events throughout the year to address specific subjects within the storage industry.

The responsibility of identifying the topics for presentation and prospective speakers for as many as four sessions in the three-day conference is managed by IDEMA's Technical Conference Committee. The members of this group are representatives of storage companies, industry consultants and IDEMA staff. The membership is a blending of industry veterans and newer participants in storage with research, development and manufacturing backgrounds, as well as management and engineering responsibilities. Selecting topics for the conference follows a general framework for the sessions to address technologies current to storage products today with an eye to the future developments. The Committee members draw on their own experiences in the industry as well as within each representative company to propose the topics which, based on the Committee's judgment, would be most interesting for a storage audience and have the greatest impact in advancing technological progress. Committee discussions for the topics and format begin at least six months prior to the scheduled conference date, and these discussions are usually a lively exchange of ideas and recommendations, which conclude with assignment of each

session to sessions leaders. These members are responsible for identifying a chairperson who will introduce the session and enlist presentation support from the industry. The members usually draw from their knowledge of storage speakers and topics from within their own companies and throughout the industry. Based on prior announcements of the conference through technical brochures and the IDEMA Web site, a number of presentations are independently submitted to the Committee and are selected on the basis of the session theme, timeliness and technical content of the submission, and overall general interest. Each session leader, working with the respective chairperson, decides on the selection.

Q. The Committee has added a new session on emerging applications to the conference this year. Explain why these applications are important.

A. This year's DISKCON USA will include a new session in which presentations from PC and storage subsystem designers will address the design of a hard disk drive from an integrator's viewpoint. The intent is to have the audience hear what these designers want in HDD products for capacity, performance and price per megabyte. In addition, this session will have presentations on how future HDD designs could impact new computer applications. This new session, combined with an updated drives session, will present how new applications will influence storage capabilities for emerging products, including consumer based products such as TV set-top boxes, digital cameras, personal communications devices and palm computers. Our objective is to broaden the participation in DISKCON USA to include these drive integrators as well as drive producers. In addition, a technical symposium has been recently integrated in the technical conference as a session to address specific advanced storage subjects. This session is intended to function as a complimentary technical addendum to the conference with presentations on future storage, both magnetic and non-magnetic.

Texas Instruments Ad

GINITIC AD

The Data Revolution: Back to Centralized Computing

Storage professionals who attended IDEMA's 3rd Quarter Dinner Meeting on July 22 were presented with a focused and straightforward talk about industry market trends by system's giant, Rick Belluzzo Chairman and CEO of SGI.

Belluzzo opened with a brief description of SGI and identified his company's two focus areas: Graphic and Visual Computing and Scalable Server Systems. Although SGI is primarily known for its powerful graphic and visual system capabilities, as evidenced by movie blockbusters Jurassic Park and Titanic, the company is now earning a reputation for providing server and storage solutions for applications that are performance and data intensive, such as warranty and insurance information. These types of applications require the ability to store, process, analyze and transfer large amounts of data quickly and securely.

Belluzzo noted three market trends which have emerged from these requirements: 1) price-elastic storage demand; 2) storage re-centralization; and 3) bandwidth explosion. In regards to the price-elasticity of storage demand, he explained that most customers are operating with fixed budgets and have large amounts of information that they need to access. Therefore, when the storage industry drops the price per gigabyte, customers respond by purchasing as much storage as they can afford. The shift to re-centralization speaks to the customers concern about database management. Valuable information has been collected and stored by companies for years, said Belluzzo, but only now are they looking at exploiting this data. Re-centralization is leading to the growth of storage area networks and clustered file systems. And finally, the explosion in bandwidth with the digital delivery channel will "make the Internet more powerful," provide an opportunity for new applications to emerge, and "put more emphasis on storage, I/O, and on moving information through a system and a system environment."

One opportunity that SGI believes will be "absolutely huge" in the next several years is strategic business analysis or business intelligence. This opportunity builds on the trend that companies are building very large databases—storing large amounts of information—to which they can analyze their customers needs and target their services accordingly. Another opportunity is the movie business and the distribution of movie content. These processes are changing dramatically, and Belluzzo foresees a point where all production and distribution will be done digitally.

He then noted four key market needs: high performance as well as capacity drives, interoperability across multiple generations, fabric media independence, and manageable storage networks. He emphasized that the market requires high-performance as well as high-capacity storage—and that system and data access are becoming increasingly important.



Tom Porter

Executive Vice President
and CTO, Seagate Technology
November 11, 1999, The Westin, Santa Clara
6:00 p.m. No-Host Cocktails, 7:00 p.m. dinner

Technology: A Supply Chain Problem?

In the face of accelerating technology transitions, increasing drive volumes and rapidly declining prices, the storage industry needs to chart a new course that improves efficiencies and enhances opportunities for success. In the future, technology development must encompass supply chain-like models in order to build seamless links and handoff points between technology providers, product developers, suppliers and vendors. IDEMA's November Quarterly Dinner Meeting speaker, Seagate Technology Chief Technology Officer Tom Porter, will discuss a supply chain approach to technology staging that can improve efficiency and accelerate product time-to-market in today's challenging business environment.

Tom Porter is charged with the global responsibility for product and technology development at Seagate's product centers and at its world-class research and development groups, including the Advanced Concepts Labs and Seagate Research. Porter joined Seagate in June 1997 and in September 1997, he assumed the additional role of executive vice president.

Porter has worked in the digital magnetic recording field for over 25 years, holds six patents in disk drive technology and has been published 11 times for technical disclosures relating to hard drive electronics. In addition, he has garnered numerous industry awards and recognition for disk and tape drive development, and was elected to the "IBM Academy of Technology."

Visit www.idema.org to make your reservation. IDEMA has reserved a block of rooms at The Westin, Santa Clara at the rate of \$209. Call 408.986.0700 to make your reservation.

Belluzzo concluded his presentation by stating that "disk farms are turning into ranches." This means that companies are collecting more and more information, which is to the benefit of the storage industry. "Data access is becoming more important than ever before because of the need to have access to information quickly for these real-time applications," he said, "and this analysis of data is a strategic resource, and therefore requires storage, management, protection and performance like never before."

Avery Dennison AD

continued from page 7

segment by 2001. This in part means developing lower cost products (e.g., Fujitsu's XV8), as well as diversifying their product lines and exploring new market opportunities (e.g., Western Digital's acquisition of "Connex" and Quantum's establishment of its consumer storage group). Single-platter and even single-headed disk drives are where the growth in the drive market is today. Revenue for the overall drive market will not likely grow over the next few quarters as prices continue to drop and as low-end capacity points continue to dominate. However, once price points and head counts begin to stabilize (can't get less than one head per drive...), unit growth will be strong enough, such that revenues can then begin to grow again.

Small form-factor PCs are now available from many PC OEMs. And although the price points are relatively high to traditional desktops, their slick style is selling into markets where users will pay up for the cosmetic improvement. Generally, these systems today are integrating 2.5" HDDs. It is reasonable to believe that if the vast majority of the desktop market's gigabyte demand truly stalls and this large segment only purchases single-headed disk drives, the market for 3.5" and 2.5" could intersect, and the desktop market could move to 2.5" once volumes are large enough to support very low price points.

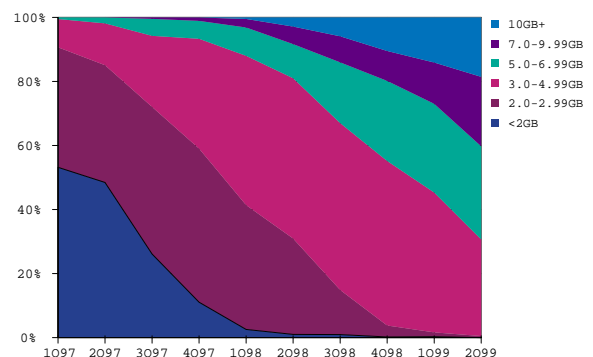
On the bright side...A growth area for hard disk drives is in the server segment. Entry servers are the most rapidly growing systems within the

multi-user system space. Although we can argue that improved bandwidth will help to drive end-user storage needs, we also are seeing multi-user systems deployed for Internet-related businesses, whether it be eCommerce or even rented-out storage space at ISPs. As more users come online via PC or Internet access devices like WebTV, demand for gigabytes at the server level will swell. NAS and SANs (network-attached storage and storage area networks) will also experience huge growth over the next several years. In addition, NAS devices may often utilize ATA (desktop) disk drives and not necessarily SCSI, and SANs may help to drive Fibre Channel HDDs.

Even brighter may be the burgeoning of emerging markets. Many of these markets require high capacity and relatively high performance, which in many cases, hard drives can often deliver at a reasonable price point. Perhaps the brightest spot is the DVR (digital video recorder) market. This market will begin to flourish once the storage market can deliver a more sizable number of gigabytes per platter at very low price points (e.g., 20 gigabytes on a single platter for about \$70); and this technology will be achieved by the beginning of

2001. This consumer device can easily consume 100 gigabyte drive (that would be 33 to 50 hours of recorded programming, depending upon the compression technology used) and with HDTV, the demand for gigabytes in these types of devices will likely quadruple. It is reasonable that over the next 4 to 7 years, every TV that is connected to a VCR will soon be connected to a DVR.

When looking at smaller form factor disk drives, particularly the 2.5" disk drive, one large potential market is the automobile market. Whether it is an auto PC which can access the Internet or the car's Global Positioning Systems that runs off of a disk drive, this segment represents another large opportunity. Even for cars which cost under \$20,000, a \$90 storage device with a high level of functionality is quite insignificant to the overall cost of the automobile. Looking to even smaller HDDs, IBM's microdrive can enable highly functional handheld devices, like personal digital assistants, MP3 players and cell phones—especially if the end-user price for the storage device declines to less than \$100. And if one really wants to reach for pie-in-the-sky opportunities, there are always wearable PCs. ♦



Phase Metrics Ad

spotlight volunteer



Russ Krapf, *Western Digital*

Russ' keen understanding of the industry and his vision for the association has enabled IDEMA to grow into a solid trade organization with 800 members worldwide.

With more than a decade of volunteer service at IDEMA, there is little that Western Digital's Russ Krapf has not helped the association to achieve. Russ was elected to the board of directors in 1989 and became an active participant in the membership committee, where he helped to launch a year-long campaign to build upon IDEMA's base of 65 worldwide members. After one year, the committee doubled its membership and elected Russ chairman; a post he held until 1994. Under Russ' leadership, IDEMA member services grew to include the Directory of Products and Services for the Disk Drive Industry, symposia events and education classes. The membership committee also lobbied for expanded content in INSIGHT, as well as more promotional and advertising opportunities for corporate members.

Pleased with the increases in membership and expanded services, the board of directors elected Russ as their chairman in 1990. He was also elected chairman of the finance committee that same year. Russ led the board of directors, membership and finance committees until 1994.

One of his first orders of business as board chairman was to convert IDEMA from a 100 percent volunteer-run organization to one with a full-time staff to manage IDEMA's daily activities and services (IDEMA now has a worldwide staff of 16). With dedicated staff in place, interest in IDEMA's standards program grew and symposia on key issues facing the industry were presented. The typewritten INSIGHT newsletter was also transformed into a professional technical journal, which offered full-length articles on a variety of storage topics and advertising opportunities for corporate members.

The most significant development during his tenure was the international expansion of IDEMA's services into Japan and Asia-Pacific. Russ said, "The disk drive industry has its major segments located in three areas of the world, and IDEMA is now serving all three of those with strong activities, combined with staff and industry leadership in the United States, Japan and Asia-Pacific."

After fulfilling his term as chairman in 1994, Russ remained an active officer of the executive committee and now serves as its treasurer. In addition, he is the chairman of the finance committee; a post he was re-elected to in 1998. After 10 years of service, Russ will be named director emeritus at IDEMA's board of directors meeting this fall. He plans to remain active in IDEMA because of the people, and he says, "It is a lot of fun."

Russ believes that IDEMA, through its standards program and various international events, has facilitated the exchange of information which has allowed the industry to grow and make improvements at a record pace. "Now," he said, "we need to utilize this information to create new markets for our technology and manufacturing capabilities."

Russ Krapf's keen understanding of the industry and his vision for the association has enabled IDEMA to grow into a solid trade organization with 800 members worldwide. In addition, his leadership has helped IDEMA to develop an international standards program which has fostered communication and cooperation within the industry and has increased awareness about magnetic recording technologies.

Dupont Ad

Dover Instrument Ad

calendar

Do you know of a storage event or meeting that would be of interest to INSIGHT's readers? Send your industry calendar items to nflynn@idema.org.

September 1999

7-9

DISK/TREND, Inc., and FREEMAN ASSOCIATES, Inc. presents

DataStorage99

Fairmont Hotel, San Jose, Calif. Industry leaders will assess critical changes underway in technology, products and markets. For more information, visit www.dsforum.com.

20

4th Annual Mark Geenen Technology for Youth Charity Golf Tournament

Castlewood Country Club, Pleasanton, Calif. Help critically ill children while you enjoy a full day of championship golf on one of two beautiful 18-hole courses. Space is limited, register online today at www.idema.org.

20

IDEMA Technical Education Classes

San Jose Convention Center, San Jose, Calif. Visit www.idema.org for full class descriptions and to register online.

20

IDEMA Standards Workshops

San Jose Convention Center, San Jose, Calif. *Volunteers from IDEMA's Standards Committees are hosting two free workshops. Visit www.idema.org for additional details. Space is limited so reserve your space today. E-mail your reservation to tgressley@idema.org.*

20-24

13th Annual DISKCON USA

San Jose Convention Center, San Jose, Calif. DISKCON USA, the world's largest technical conference and trade show dedicated to the data storage industry, offers over 400 exhibitors, five information-packed conference sessions, standards workshops, educational classes, Keynote Dinner, university forum, Technology Showcase, and Disk Drive Pavilion. Visit www.idema.org for schedules, speaker listings and to register online.

21

Silicon Valley EOS/ESD Society Membership Meeting

Ramada Inn, Sunnyvale, Calif. No Host Cocktails 4:30 p.m. Buffet Dinner 5:30 p.m. Meeting 6:00 p.m. to 8:00 p.m. For more information, visit www.esdsv.org.

22

University Forum Luncheon

San Jose Convention Center, San Jose, Calif. IDEMA Fellowship Award winners will present details about their research findings. Visit www.idema.org for more information and to register online.

22

Keynote Dinner, University Forum Luncheon, Technology Showcase and Disk Drive Pavilion.

Visit www.idema.org for more information and to register online.

24

IDEMA Technical Education Classes

San Jose Convention Center, San Jose, Calif. Visit www.idema.org for full class descriptions and to register online.

30

Deadline

IDEMA's Future Component Technology Symposium Call for Papers. Contact Kristen Montan at 408.330.8109 for more information.

new

calendar

October 1999

6
IDEMA Future Component Technology Symposia presenters notified.

14-15
NSIC Network Storage Symposium
Seattle, Wash. For more information, contact General Chairman Micah Beck at beck@cs.utk.edu.

14-15
Particle College: Fundamentals of Particle Counting and Applications Seminar
Particle Measuring Systems, Boulder, Colo. This seminar is

designed for engineers, technicians and facility personnel responsible for process improvement or contamination control operations and related areas. Through presentations and hands-on experience at Particle College, participants will learn about particles...what are they, how are they detected and what type of instruments are used to qualify these critical contaminants. Cost is \$450.00. Contact Michelle Longey at 1.800.238-.1801.

19
Silicon Valley EOS/ESD Society Membership Meeting
Ramada Inn, Sunnyvale, Calif. No Host Cocktails 4:30 p.m. Buffet Dinner 5:30 p.m. Meeting 6:00 p.m. to 8:00 p.m. For more information, visit www.esdsv.org.

20
IDEMA Enabling Technology for Higher Areal Density Symposium
Tora-no-non Pastoral Building, Tokyo, Japan. For more information visit www.idema.org.

22

IDEMA Enabling Technology for Higher Areal Density Symposium
Sheraton Towers, Singapore. For more information, visit www.idema.org.

23
IDEMA Enabling Technology for Higher Areal Density Symposium
Equatorial Hotel, Penang, Malaysia. For more information, visit www.idema.org.

25-29

The American Vacuum Society 46th International Symposium
Washington State Convention and Trade Center, Seattle, Wash. The International Symposium will feature four topical conferences, three technical group programs, more than 50 short course, and an equipment exhibition. For more information, visit www.vacuum.org.

November 1999

11
IDEMA Quarterly Dinner Meeting
Executive Vice President and CTO, Seagate Technology, Storage Products Group, Tom Porter, The Westin, Santa Clara, Calif. For more information or to register online, visit www.idema.org.

15
Call for Papers, Off the Desktop Symposium
Send abstracts to kmontan@idema.org before Dec. 17 deadline.

15-18
44th Conference on Magnetism and Magnetic Materials
San Jose, Calif. For more information, visit www.magnetism.org.

16
Silicon Valley EOS/ESD Society Membership Meeting
Ramada Inn, Sunnyvale, Calif. No Host Cocktails 4:30 p.m. Buffet Dinner 5:30 p.m. Meeting 6:00 p.m. to 8:00 p.m. For more information, visit www.esdsv.org.

EASTMAN AD

1999 members

as of 8/1/99

IDEMA members represent the innovators of the data storage industry. For detailed information about any of the companies listed, visit IDEMA's online Directory of Products and Services for the Disk Drive Industry at <http://www.idema.org/directory>.

Corporate Members

3M Singapore Pte. Ltd
3M Storage Systems Business
Abbie Gregg, Inc.
Ableslik
AccuCorp Technical Services, Inc.
Accu-Fab Systems, Inc.
ACI Industries Pte. Ltd
Acorn Technologies, Inc.
Active Control Experts, Inc.
Adaptec Japan Ltd
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ADE Phase Shift
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Advanced Imaging, Inc.
Advanced Materials Technologies Pte. Ltd
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Air Bearing Technology, Inc.
Aiwa Research & Development, Inc.
Akita Sumitomo Bakelite Co., Ltd.
Alcatel Comptech, Inc.
ALCOA Memory Products, Inc.
Alexandria Extrusion Company
Allied Signal, Inc./Electron Vision Group
ALMA, Inc.
Alpha Microelectronic Packaging Materials
Alps Electric Corporation Ltd.
ALS Technichem (S) Pte. Ltd.
Alta Group
Alyn Corporation
Amerimade Technology
Amtek Engineering Limited
AnA Mechatronics (S) Pte. Ltd.
Anelva Corporation
Anorad Corporation/A Rockwell Automation Business
Ansell Protective Products
Anza Technology, Inc.
Applied Kinetics, Inc.
Applied Magnetics (Singapore) Pte. Ltd.
Applied Magnetics Corporation
ARC Processors
Armstrong Industrial Corporation Limited
Asahi Komag Co., Ltd.
Asian Micro (S) Pte. Ltd
ASM Lithography—Special Applications
AST Products, Inc.
ASTeX
Atcor Corporation
Automation Controls Group, Inc.
Automation Tooling Company
AV Industries Sdn Bhd
Avery Dennison Corporation
Avery Dennison Singapore Pte. Ltd.
Baikowski International Corporation
Balazs Analytical Laboratory
Balzers and Leybold Singapore Pte. Ltd
Balzers-Hakuto Co., Ltd.
Bay Advanced Technologies
BayTech Group
Bell Technologies, Inc.
Belton Industrial (International) Limited
Berg Electronics
Berkshire Corporation
BF Goodrich Static Control Polymers
Bi-Link Metal Specialties

Birkenstock
BOC Edwards
Bondline Electronic Adhesives, Inc.
BPS
Bradford Company
Brady Corporation
Brandon International
Branson Ultrasonics Corporation
Burlytic Systems
C. Uyemura Co., Ltd.
Cabot Corporation
Cairnhill Metrology Pte. Ltd
Caleb Technology
Calluna Technology Ltd.
Campbell and George Company
Camstar Systems, Inc.
Candela Instruments
Canon U.S.A. Inc.
CBL Data Recovery Technologies, Inc.
CDS Analytical, Inc.
Ceiba Asia-Pacific Pte. Ltd.
Ceiba Technologies
Center for Tribology, Inc.
Central Corporation
CERAC, Inc.
Ceradyne, Inc.
Chapman Instruments
Charles Evans and Associates
Chemetal Inc.
Chemready Filter Corporation
Cianfone Scientific Instruments Corporation
Cintas Corporation
Circuit Sales International Pte. Ltd
Cirrus Logic, Inc.
Citizen Watch Co., Ltd.
Citron Technology Group
Classic Manufacturing, Inc.
CleanLink
CME, Inc.
CMI Technology, Inc.
Comdisco Electronics Group
Commonwealth Scientific Corporation
Compaq Computers, Inc.
Compart Asia Pte. Ltd
Computerrepairs
Conner Technology, Inc.
Contamination Prevention Services
Contec, Inc.
Controlled Kinematics
Coors Ceramics Co.
Coral Chemical Company
Covarian Solutions, Inc.
Cowan Alexander
Cranfield Precision
Crest Ultrasonics Corporation
Cro-Bar, Inc.
CTI-Cryogenics
CVC Products, Inc.
Cymatix, Inc.
Daido Steel Co., Ltd.
Data Recovery Labs
DATA2
Datacom SAE Pte. Ltd
DataPath Systems, Inc.
Dataquest/Gartner Group
datatech
Dave Knox Plastics, Inc.
DELL Computers
DESCO Charleswater
Despatch Industries, Inc.
DevTek Engineering & Manufacturing

DeWeyl Tool Co.
Dexter Magnetic Technologies, Inc.
Diamond Scientific Inc.
Diamonex, Inc.
Digital Instruments
Veeco Metrology Group
Dionex Corporation
Disco Hi-Tech America, Inc.
Disk Precision Industries Pte. Ltd
Disk/Trend, Inc.
Display Inspection Systems, Inc.
Donaldson Company, Inc.
Dou Yee Enterprises (S) Pte. Ltd
Dove Brothers LLC
Dover Instrument Corporation
Dow Chemical Company
Drex-Chem Technologies Pte. Ltd
DRS Ahead Technology, Inc.
Dupont Fluoroproducts
DuPont Korea
Dymax Corporation
Dynamics Research Corp.
Dynateq Pte. Ltd
E&M Electric and Machinery
E-A-R Specialty Composites
Eastman Chemical Company
Eco-Snow Systems, Inc.
EFD, Inc.
EFOS Canada, Inc.
Electronic Materials Inc.
Empak (Malaysia) Sdn Bhd
EMPAK, Inc.
Endela Trading & Mfg. Pte. Ltd.
Eng Teknologi Sdn Bhd
Engis Corporation
ENI
Enthone-OMI, Inc.
Epion Corporation
Errigo Executive Search Group
Escort Memory Systems
Exclusive Design Company, Inc.
F&K Delvotec Inc.
FANUC Robotics North America, Inc.
FEI Company
Ferro Electronic Materials
Ferrotec America Corporation
Ferrotec Corporation
Fine Components Pte. Ltd.
Fine Glass Technology Co.
Fineglass Technology Co., Ltd.
Fisher Container Corporation
Flexcon
FlexLink Systems Pte. Ltd.
FlexLink Systems, Inc.
Fluoroware Inc
Forward Technology Industries, Inc.
Fostex Corporation
Foxconn Singapore Pte. Ltd.
Fremont Industries, Inc.
FSI International-Fremont Operations
Fuji Electric Company, Ltd.
Fuji Electric Corporation of America
Fuji Electric Singapore Pte. Ltd
Fujikoshi Machinery Corporation
Fujimi America Inc.
Fujimori Kogyo KK
Fujitsu Computer Products of America
Fujitsu, Ltd.
Furukawa Electric—Computer Memory Disk
Furukawa Electric Co., Ltd.
G&W Machine Company, Inc.

Gage Applied Sciences Inc.
GE Micron Products, Inc.
GE Plastics
Gel-Pak LLC
General Disk Corporation
General Scanning Japan K.K.
Gerstel, Inc.
GHI Systems, Inc.
Gintic Institute of Manufacturing Technology
Glide/Write
GMW Associates
Greatch (Malaysia) Sdn Bhd
Greenleaf Corporation
Gregory Associates, Inc.
GSI Lumonics (View Engineering)
GSI Lumonics (Industrial Laser)
Gul Technologies Singapore Limited
Guzik Technical Enterprises
H.P. Reid
H.P. Gartrell & Company
Hakuruma Technology
Hal Sharpe Associates, Inc.
Halma Asia Pte., Ltd.
Halo Data Devices, Inc.
Hamai Co., Ltd.
Harada Corporation
Hardisk Technology
HDI Instrumentation
Headway Technologies, Inc.
Heidenhain Corporation
Heraeus Inc.—Materials Technology Div.
Heraeus Precision Engineering Pte. Ltd.
Herald Engineering Services, Inc.
Hewlett-Packard Company
Hewlett-Packard Japan Ltd.
Hi-P Tool & Die Pte. Ltd.
Hitachi America, Ltd.
Hitachi Denshi Ltd.
Hitachi Electronics Engineering (America), Inc.
Hitachi Electronics Engineering Co., Ltd.
Hitachi Maxell, Ltd.
Hitachi, Ltd.
HMS Compounds, Inc.
HMT Technology Corporation
Hologenix
HOYA Corporation
HOYA Corporation USA
HOYA Magnetics Singapore Pte. Ltd.
H-Square Corporation
Huettinger Electronic, Inc.
Hutchinson Technology Asia Inc.
Hutchinson Technology Inc.
HVA
HYAC Corporation
Hybond, Inc.
Hyperion Catalysis International Inc.
Hysitron, Inc.
IAI America, Inc.
Ibas AS
IBM Japan, Ltd.
IBM Singapore Pte. Ltd.
IBM/Storage Systems Division
ICOM Mechanical, Inc.
ID Technologies Pte. Ltd.
IGC-Cryogenics Business Group
IGC-Polycold Systems, Inc.
Imtec Acculine, Inc.
Industrial Tools Incorporated
Innotec Group, Inc.
Innovative Instrumentation, Inc.
Innovative Organics, Inc.
Innovex, Inc.
Integral Solutions International
International Data Corporation
Intevac Asia Pte. Ltd
Intevac, Inc-Vacuum Systems
Intraco Technology Pte. Ltd.
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Alternative Substrates: The Real Cost

Richard D. Weir, President and COO, Titanium X Corporation

The past thirty years has seen major advances in areal density and rotational speed of conventional electroless-nickel-coated aluminum-alloy (Al-Mg/Ni-P) substrate for the disk drive industry. Areal density has increased from 10 Mb/in² in 1980 to 5 Gb/in² in 1999, while rotational speeds have increased from 2,400 RPM in 1980 to 10,000 RPM in 1999¹. Over the same period, the manufacturing cost and pricing of conventional substrates has decreased. Recent performance improvements, however, have been increasingly difficult to achieve and have been accompanied by significant yield reductions and configuration penalties. The time is approaching when this conventional substrate will reach its limit and cost-effective alternatives will begin to dominate the disk drive markets. Currently, the industry focus is also on comparative “costs” or “prices” as well as performance of the alternative substrates.

Comparison of Alternative Materials

Two promising alternative substrate materials are a chemically strengthened aluminosilicate glass and a plasma-nitrided titanium-alloy metal. Disks of the former are in production for 65 mm drives and disks of the latter are in the testing phase. Table 1 shows the physical/mechanical parameters for each material.

The Glass Substrate

The glass disk substrate is in volume production and, until recently, has been used primarily in 65 mm drives for the portable computer market. IBM is currently introducing a 10,000 RPM drive with a 84 mm glass disk. The principal advantage of glass over conventional disks is a higher impact resistance: 350 G vs. 250 G. Like “ultra-superpolish” conventional disks, glass substrates can be finished to supersmooth, flat surfaces with very low flaw counts, thus improving yields for both media and head disk assembly (HDA) manufacturers.

All glasses, however, are hard, brittle materials with very low fracture toughness values and the Young’s modulus is near that of aluminum alloy and electroless nickel. (The Young’s modulus is defined as the ratio of the tensile or compressive stress to the resulting tensile or compressive strain. It is a measure of the elasticity applicable to the stretching or bending of material.) Thus, the use of any glass for disks of larger diameter, smaller thickness, and/or at high rotational velocities could be potentially hazardous.

magnification of the applied stress by a crack in the body, large enough to set off rapid crack propagation, and subsequently failure by fast fracture². The high mechanical stresses transmitted to the substrate could be sufficient to limit the use of the glass substrate due to fracturing. Transmission media include bearing runout, airflow turbulence and high energy vibrations due to resonance peaks during spin-up of the high-RPM server drives.

Finally, glass disks may present a slight improvement in stiffness and vibration over conventional disks. The Young’s modulus is comparatively low and the glass material may lack internal damping characteristics. Therefore, this material will probably be unable to contribute to reducing track misregistration and increasing tracks per inch, or meeting the demand for higher-spindle speed drives and higher throughput necessary for Internet server class disks.

The Plasma-Nitrided Titanium-Alloy Substrate

The plasma-nitrided titanium-alloy disk provides several advantages for furthering advances in areal density and rotational velocity. The formation of the titanium nitride (TiN) layer results in a six-fold increase in the Young’s modulus at the surface, thereby producing a substantially stiffer and stronger skin around the body. Combined with the significantly increased hardness of the altered surface region, the material displays improved impact

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	Glass	Ti/TiN
Young's modulus (GPa)	83.5	106.9/640
Poisson's ratio	0.23	0.341
Fracture toughness (MPa.m ^{0.5})	0.9	50
Knoop microhardness (kg/mm ²)	670	310/1500
Highest process temperature (°C)	350	600
Turn magnetic at high temperature	No	No
Surface smoothness and flatness altered with temperature	No	No
Biasable	No	Yes
Circumferentially texturable	No	Yes
Flatness	Excellent	Excellent
Smoothness	Excellent	Excellent
Flaws	Excellent	Excellent
Impact resistance (G)	350	1000
Hygroscopic	Yes	No

The fracture toughness of a material relates to the

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and wear resistance. This surface region is not a deposited coating, but rather a gradient layer created by nitrogen diffusion into—and reaction with—the metal. The resulting disk has a mechanical vibrational frequency spectrum exhibiting strong high frequency dampening at and above 10,000 Hz.

The titanium-alloy substrate allows temperatures as high as 600°C in the sputter-deposition of magnetic media. Thus, a practical disk substrate is available for the preparation of barium ferrite (BaFe₁₂O₁₉) media for perpendicular magnetic recording that requires a temperature of at least 500°C during sputtering with the substrate biasing. Perpendicular recording has the potential for major increases in areal density over that of the longitudinal magnetic recording films presently used.

By switching to titanium-alloy substrates, magnetic media technologists can obtain higher coercivity and higher density with current cobalt alloys without waiting for the development of new “high coercivity” media. Heating a disk substrate (with well-defined circumferential texturing) to 250°C - >300°C, together with substrate bias sputtering, can dramatically improve magnetic properties (high coercivity which increases signal amplitude, high remanence squareness/high coercive squareness which increases signal speed, and low media noise which increases the signal-to-noise ratio), and hence, recording performance.

The titanium disk substrate (a biasable metal that is nonmagnetic at all temperatures) has an advantage over other substrates because it permits the fabrication of optimized magnetic recording media. The plasma-nitrided disk surface is provided with a circumferential texture and may be provided with a separately textured landing zone with the use of a pulsed laser beam. The disk is then ready for the direct sputter deposition of the magnetic media.

The titanium disk is not susceptible to any long-term hazardous effects given the very high fracture toughness and fatigue strength of the titanium alloy. Circumferential texturing of the disk substrate provides an in-plane circumferential (versus radial) anisotropy, improving the read-signal parametrics of the magnetic media. Because glass substrates are textured differently, they do not have this advantage.

Flat and supersmooth surface finishes with very low flaw counts have been achieved on titanium-alloy substrates. Surface roughness values with both arithmetic roughness average, R_a , and total peak-to-valley roughness, R_{pv} , that were previously unattainable with any polycrystalline material have now been reached. Due to the stability and homogeneity of titanium and its alloys, the surface finish remains unchanged with temperature.

The plasma-nitrided titanium-alloy disk, with its hard durable surface and low flutter at high RPM, would provide the high-end server market with a high performance disk.

Yield Analysis

The capability to process glass and titanium substrate materials at higher temperatures than the Al/NiP substrate without any surface finish, flatness, or material changes will enable higher densities and the improvement of magnetic media production yields. The improved surface integrity and hardness of the glass substrate will also assist in reducing flaw generation during drive build and production testing. The Ti/TiN substrate will provide additional protection in this area because the TiN surface is more than twice as hard as current substrates and has very high fracture toughness. The low initial flaw count for both alternative substrates will assist in lowering drive production failures. These two features alone could result in major improvements in drive production yields.

The glass disk data indicates that the comparatively low Young's modulus and very low fracture toughness could limit this product to the lower RPM disk drives. In contrast, the Ti/TiN substrate has a high Young's modulus with a fracture toughness that is typical of all high-strength metals, and thereby provides a significant yield advantage for the high-performance server disk drive market.

Substrate-biasing and circumferential-texturing are two techniques used in the production of magnetic media for the enhancement of the coercivity and film switching speed. Since glass cannot be biased or textured, Ti/TiN is biasable and TiN is one of the best metal compounds for the development of fine texturing patterns, the improved read signals from Ti/TiN substrates should produce magnetic films that provide higher magnetic-media and drive production yields.

Current projections for the price of a 95 mm glass substrate are \$3.00 in year 2000. Production costs for a 95 mm Ti/TiN substrate will be similar to costs for ultra superpolish conventional disks, and the cost for Ti/TiN disks in 84 mm and 65 mm form factors will be less than the cost of ultra superpolish disks. This is due to its durable, rugged metallic material and surface, allowing the process for finishing a Ti/TiN blank into a media-ready substrate to differ substantially from the processes for conventional and glass substrates. Bulk removal and flattening can be accomplished with high-speed ductile-mode grinding at higher throughput and yields than is believed attainable with softer conventional material and the brittle glass material. The hard TiN outer surface of the Ti/TiN substrate is amenable and friendly to higher-speed methods of achieving a media-ready textured surface finish. This technology also presents the opportunity for higher throughput and higher yields than are attained with conventional planetary systems.

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Increasingly tighter specifications are taking a high toll on yields in the processing of conventional substrates. Industry observers report that first-pass yields for nickel-plating conventional aluminum disks often fall to between 45 percent and 60 percent in some large manufacturing plants. Loss of blanks during earlier grinding, loss of substrates during media deposition and losses during drive assembly add to cost. The increased surface hardness of glass substrates should reduce loss during some processing steps; however, its brittle /fracture nature may also present a yield issue.

Irrespective of the nominal price of newer alternative substrates, the real cost can only be understood when the disk drive industry assesses the full benefit from yield improvements. A good figure of merit in analyzing the cost improvement due to increased media or drive yields is: each one percent improvement in yield is equivalent to a savings of \$0.10 per disk. ♦

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2. J. E. Ritter, *Crack Propagation in Ceramics*, in *Ceramics and Glasses, Engineered Materials Handbook, Vol. 4, ASM International, Materials Park, Ohio, 1991, p. 6947*.

Richard Weir is the co-founder, president and COO of Titanium X Corporation. He has over 30 years of operations and senior management experience in the disk drive and computer industries, including service with IBM, Burroughs, IBIS, XEROX-PARC and Micropolis.

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IDEMA Fellowship winners present research findings at DISKCON USA University Luncheon

IDEMA Fellowship Award winners Shingo Tamaru, Carnegie Mellon University; Yun Li, Stanford University; and Hany Gross, UC Berkeley will present details about their research at the University Forum Luncheon from 12:00 p.m. to 2:00 p.m. on Wednesday, Sept. 22 at the San Jose Convention Center during DISKCON USA. The luncheon is \$25 for members and \$35 for nonmembers.

Shingo Tamaru

First-place winner, Shingo Tamaru, was awarded \$25,000 to conduct research in the area of advanced test equipment for magnetic recording heads. As data rates climb toward 500 MHz and beyond and the magnetic switching of the heads becomes the limiting factor in data rate performance, it is important for the disk drive industry to understand the switching behavior of write heads. After building a high-speed Kerr magneto-optic imaging system for studying the dynamic response of magnetic materials recording heads, Tamaru is beginning to image the switching behavior of write heads at the air-bearing surface with picoseconds of resolution.

Yun Li

Stanford University's Yun Li received the second place award which totals \$10,000 for his research on epitaxial growth of spin dependent tunneling junctions. This junction consists of two ferromagnetic layers separated by an insulating layer thin enough to allow quantum tunneling. Spin dependent tunneling has an advantage compared with giant magnetoresistance in that it has higher magnetoresistance since it utilizes bulk scatter-

ing in an electric current perpendicular plane configuration. This advantage means that spin dependent tunneling has great potential in increasing the sensitivity of magnetic reading sensors and non-volatile magnetic memory. However, the resistance of spin dependent tunneling junction is currently too high for real applications due to the difficulties of reducing insulator thickness. Li's approach is to use an epitaxial method to provide an atomically flat underlayer for growing an ultrathin insulating layer above, thus reducing the tunneling resistance substantially. The results of patterned samples by epitaxial growth will be discussed.

Hany Gross

The research of third-place award winner, Hany Gross, focuses on the area of head-disk interface dynamics, with emphasis on pico-system dynamics, especially suspension frequency contributions in the air-bearing frequency range. The focus of his research is to ensure an accurate and reliable simulation of the air-bearing dynamics of pico-systems, with TSA and other type suspensions. His work involves experimental modal testing using laser Doppler vibrometry, finite element modeling, and numerical simulation of pico-slider/suspension assemblies.

Register for the luncheon at www.idema.org/events/diskcon.

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ISO 9000 Registration: Good business practice or requirement? IDEMA workshop provides insight into this critical business trend.

The International Standard on Quality, ISO 9000, was launched in 1987 as a set of good business practices which includes training, process control, commitment to quality and a review of customer orders before acceptance. Today, however, ISO 9000 registration is becoming a requirement for data storage companies worldwide. To help storage companies learn more about this critical business trend, IDEMA is offering The Journey to ISO 9000, an introductory workshop on ISO 9000 registration, on Oct. 13 from 11:30 a.m. to 1:30 p.m. at the IDEMA office in Santa Clara, Calif.

In 1993, 27,000 companies were ISO 9000 registered. By the end of 2000, the number of registered companies is expected to reach 500,000. The pressure to complete ISO 9000 registration is driven by companies who require their vendors to supply high quality products—100 percent of the time. In fact, many international organizations, government bodies and businesses are requiring suppliers to present proof of ISO 9000 registration before allowing them to quote on a project.

A survey conducted by Dun & Bradstreet indicated that companies who had completed registration had better documentation, increased quality awareness by employees, enhanced communications, and greater productivity and efficiency. Other benefits from using ISO 9000 in operations resulted in a 10 percent reduction of operating costs, a decrease in rejects and improvements in delivery systems.

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- *An Introduction to GMR Head Technology*
- *Understanding Thin Film Head Manufacturing Basics*

Online registration for Dec. classes available after Oct. 1.

IDEMA offers worldwide on-site classes

These classes are offered exclusively to your employees, customers, or vendors at your convenience. Offering the classes to your customers or vendors is a great way to reward customer loyalty and increase awareness of how your product fits into the bigger computer storage picture. Call Sally Bryant at 408-330-8106 for more information or to schedule a class.

IDEMA Asia Pacific

S.H. Goh, Executive Director

It is estimated that the Asia-Pacific region outside Japan produces more than 80 percent of the world's production of hard disk drives (HDDs). In Singapore alone, HDDs account for 35 percent of the total electronics output and about 15 percent of the Gross Domestic Product.

Therefore, IDEMA Asia-Pacific plays a significant role in satisfying the needs of our members in the region for enhanced communication and furtherance of the storage industry. Key objectives for 1999 include:

- *Provide basic technical education classes through a certification recognized by the industry*
- *Continue to disseminate latest developments in technology through seminars and industry participation*
- *Extend IDEMA services beyond Singapore to Malaysia, Thailand and the Philippines*
- *Provide a platform for issues in the industry to be discussed*

IDEMA's new education program, leading to a Certificate of Competence in Storage Technology, is fully operational and rapidly being adopted as the defacto certification for industry participants who need fundamental training in data storage technologies. More than 150 classes will be held by year's end. The biggest challenge is to keep the materials updated to reflect current technology. To help us in this effort, the materials are frequently reviewed by our education committee. Other improvements being made to this program include instructor training by IDEMA Asia-Pacific members and the addition of industry veterans to the instruction team.

In June, IDEMA Asia-Pacific organized the Storage Technology Symposium, sponsored exclusively by Seagate Technology. One hundred fifty five people attended this inaugural event. The significance of this symposium is that for the first time, a major HDD company took a leadership role in providing and securing speakers and helping to organize the event. Another first is the expansion of the event's scope to include companies like SGI (formerly Silicon Graphics) and EMC. The half-day symposium covered a broad mix of subjects addressing challenges on GMR, platform manufacturing, laser microprocessing, data warehousing, and system storage infrastructure design. It ended with a keynote luncheon featuring John Monroe, chief HDD analyst at Dataquest. His talk was a colorful and vivid presentation of industry trends. Mr. Monroe clearly voiced the industry's key issue of senseless pricing and stressed that market profitability does not equate to bottom-line profitability.

Recently in the Philippines, I presented a paper on an overview of the HDD Market and Technology at the SEIPI conference (a Philippines semiconductor industry association). Nearly 600 people were in attendance. IDEMA Asia-Pacific is in the process

of establishing a steering committee to guide IDEMA's activities in the Philippines. The committee will be chaired by Peter Maguire, Lighthouse Worldwide Solutions, with members from Read-Rite, Hitachi, Fujitsu, NEC and TDK. It is our objective to provide IDEMA activities, including symposia, breakfast and tea talks, and education classes within the second half of 1999.

In Thailand, I presented a paper on addressing the training needs for the Southeast Asia HDD industry at a workshop organized by the National Science & Technology Development Agency, Federation of Thai Industry, Thailand Board of Investment, The University of San Diego and The Brooker Group. Government and industry participants identified HDD industry workforce training as one of their leading issues. With our heightened visibility, IDEMA Asia-Pacific is now seen as being able to address this critical educational need. It is likely that the Asia Institute of Technology, one of the top universities in the region, will cooperate with IDEMA in an education program similar to IDEMA's program with Singapore Polytechnic. A management steering committee is being formed in Thailand to help guide IDEMA activities and education programs there.

To provide the platform for members to communicate on technical issues, we have started our first standards subcommittee on microcontamination, which is chaired by Raymond Thomas, Lighthouse Worldwide Solutions. The aim is to provide a platform for storage engineers to give input on current standards development in the United States. In time, IDEMA Asia-Pacific members and other storage professionals will be able to fully participate in standards development as many of the key issues are faced in our region where the majority of manufacturing is located.

IDEMA Asia-Pacific is very active in supplying services to its members in the region and is looking forward to expanding services to industry participants in Thailand and the Philippines.

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International Disk Drive Equipment and Materials Association

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