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CMRR Report

Center for Magnetic Recording Research

Number 33 Winter 2010

Two Research Highlights from Professor Talke's Group

Contents:

Inaugural UC San Diego Non-Volatile Memories Workshop Draws Over 130 Researchers From Around the World

More than 130 academic and industrial researchers from around the world assembled for the inaugural UCSD Non-Volatile Memories Workshop (NVMW) on April 11-13 2010, hosted by the Center for Magnetic Recording Research, the Non-Volatile Systems Laboratory (NVSL), and the San Diego branch of the California Institute for Telecommunications and Information Technology (Calit2).

The two-day workshop included thirty invited speakers who gave presentations on a range of topics including device technologies, channel modeling and coding, system architectures, and non-volatile memory applications. The workshop also included a technical overview of solid-state storage presented by Khaled Amer of the Storage Networking Industry Association (SNIA). The speakers included researchers from leading academic, industrial, and government research labs at Google, IBM, Microsoft, Hewlett Packard, Carnegie Mellon University, Caltech, Los Alamos National Laboratory, and UCSD, as well as representatives from leading companies working on non-volatile memories such as Qualcomm, Numonyx, Fusion-io, Grandis, and SanDisk.

In bringing together scientists and engineers working on different aspects of advanced non-volatile storage devices and systems, the workshop facilitated the exchange of ideas, insights, and knowledge within a broad community of practitioners and researchers, fostering the establishment of new collaborations that can propel future progress in the design and application of non-volatile memories.

"We wanted to encourage the cross-disciplinary, outside-the-box kind of thinking that will be required to realize the

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CMRR Prof. Jack Wolf Elected to National Academy of Sciences

On April 27, the National Academy of Sciences (NAS) announced the election of CMRR **Professor Jack K. Wolf** to membership in that prestigious institution, one of the highest honors that can be bestowed on U.S. scientists and engineers.

A professor in Electrical and Computer Engineering in the Jacobs School of Engineering, Jack was among the 72 new members and 18 foreign associates elected to the academy this year "in recognition of their distinguished and continuing achievements in original research."

Jack joins 86 other UC San Diego faculty members who have previously been named to membership in the academy, which was signed into being by President Abraham Lincoln in 1863 to serve as an official adviser to the federal government on matters of science and technology.

"Jack Wolf works in the area of information theory, and UCSD has one of the strongest – if not the strongest – academic information theory groups in the country," said Larry Larson, professor and chair of the ECE Department in the Jacobs School. "Jack played a big role in building this up; he is at the heart of our historical strength in this field, which now includes the UCSD Information Theory and Applications Center."

In the field of information theory, Jack is probably best known for the Slepian-Wolf theorem, which is a fundamental result that addresses efficient compression of correlated streams of data. The Slepian-Wolf theorem was published in 1973, but it has experienced an explosion of renewed interest because of its applicability to new technologies such as distributed sensor networks. With the advent of new and powerful channel coding schemes such as turbo codes and LDPC codes, practical systems implementing "Slepian-Wolf coding" now can approach the efficiency promised by the famous theorem.

Jack is also widely recognized as an expert in signal processing and coding techniques for digital recording. He was an early proponent of applying information theory and communications theory in the design of high-capacity storage devices using magnetic and optical recording. Ideas that originated in the research of Jack's "Signal Processing" group at CMRR – known as the "WolfPack" – have found their way into several commercial magnetic tape and disk drives.

Election to the NAS is just the latest of numerous honors that Jack has received. He is also a member of the National Academy of Engineering and the American Academy of Arts and Sciences, and he is the recipient of the 2004 IEEE Richard W. Hamming Medal, the 2001 Claude E. Shannon Award of the IEEE Information Theory Society, the 1998 IEEE Koji Kobayashi Computers and Communications Award, and the 1990 E. H. Armstrong Achievement Award of the IEEE Communications Society. Also known for being an outstanding teacher, Jack received a UCSD Distinguished Teaching Award in 2000. Congratulations, Jack!

Intel Fellowship Award

Eitan Yaakobi, a CMRR graduate student co-advised by Profs. Paul Siegel and Jack Wolf has been awarded a **2010-2011 Intel Corporation Ph.D. Fellowship.** "The Intel Corporation Ph.D. Fellowship Program awards fellowships to Ph.D. candidates pursuing leading-edge work in fields related to Intel's business and research interests. Select U.S. universities are invited to submit a limited number of students for consideration. Those students selected by

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From the Director

At the time of my last "From the Director" article, we were in the beginning stages of organizing the UCSD Non-volatile Memories Workshop (NVMW). Our intention was to take a "vertical approach" and invite speakers representing the different layers of the storage system stack, including device technologies, data encoding, system architecture, and applications. As the cover story in this issue describes in more detail, the workshop was a resounding success, with a "sold-out" crowd of over 130 registered attendees representing virtually all segments of the solid-state storage industry and academic research community. In view of the overwhelmingly positive response, we have already started planning for NVMW 2011, so keep your eyes peeled for the announcement on the CMRR website and be sure to register early!

With a growing number of funded projects and collaborations, it is clear that the CMRR-SSD effort is on a strong upward trajectory. We have just had our first Ph.D. student (see page 14) graduate directly to an R&D position in the SSD industry, while another (see page 2) has just been awarded a prestigious Intel Ph.D. Fellowship on the basis of his research on coding methods for flash memory.

At the same time, Center faculty and researchers continue to address a slew of key problems relevant to future generations of disk and tape drive technology. The Research Highlight articles from the labs of Prof. Frank Talke (sse page 4) and Prof. Raymond de Callafon (see page 8) describe their state-of-the-art work in head-disk interactions and servo control.

Those attending the Special Session on "Research Directions in HAMR" at the Spring Research Review will see that, in addition to our work on BPMR, we are expanding our work on HAMR by engaging with other distinguished UCSD faculty members with expertise in lasers, optics, and nanophotonics. The inclusion of industry experts in this session emphasizes our commitment to doing fundamental *and* relevant work in this area.

Speaking of distinguished faculty members, I hope you will join me in congratulating Prof. Jack Wolf on the occasion of his election to the National Academy of Sciences (see page 2). Jack is also a member of the National Academy of Engineering, so this latest of his many professional awards puts him in rarified company.

In order to sustain its record of technological and human contributions to the storage industry, CMRR needs the support, both financial and technical, of those companies that benefit from the Center's activities. If you wish to learn more about how CMRR can help you target your university support funds toward projects and students that help you achieve your technology and recruitment goals, please contact me.

I hope you enjoy the rest of this exciting issue.

Jonathan Sapan, a graduate student in Professor Eric Fullerton's group has been awarded an Honorable Mention in the 2010 National Science Foundation Graduate Research Fellowship Program competition. This program "recognizes and supports outstanding graduate students in NSF-supported science, technology, engineering, and mathematics disciplines who are pursuing research-based master's and doctoral degrees in the U.S. and abroad."

Jonathan has also been selected to attend the National School on Neutron and X-ray Scattering from June 12-26, 2010. The school is a two-week program funded by the Department of Energy (one week at Argonne National Lab in Argonne, IL and one week at Oak Ridge National Lab in Oak Ridge, TN) consisting of lectures and experiments in the use of X-rays and neutrons to characterize materials.

Lastly, Jonathan is currently one of 10 semifinalists for the position of Student Regent at the University of California. He will be interviewed at UC Berkeley on May 7th, after which 3 finalists will be chosen. The UC Regents will interview the three finalists and select the next Student Regent.

Research Highlight TRANSIENT SLIDER-DISK CONTACTS IN THE PRESENCE OF SPHERICAL CONTAMINATION PARTICLES

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Introduction

A number of investigations have been published that deal with tribological failure and erasure of information in magnetic recording disk drives due to particles being trapped in the head-disk interface [1-3]. In the above studies, the following situations were treated: mechanical contact [1], soft-particle contact [2], and sliding of a large particle in the head-disk interface [3]. In all studies steady state conditions were assumed.

No studies have been published, however, on transient slider-disk contacts in the presence of contamination particles. The goal of the present work is to investigate this latter situation and study the tribological failure of the head disk interface and the erasure of information during transient contacts in the presence of contamination particles.

Numerical Model

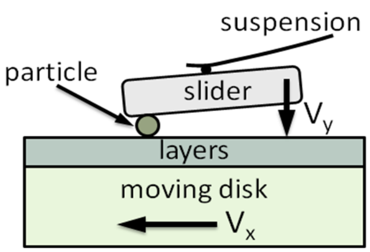

Fig.1 Schematic model of particle trapped in HDI.

Figure 1 shows the head-disk interface during a transient contact in the presence of a contamination particle. The impact velocity of the slider is denoted by V_y while the disk velocity is denoted by V_x. The particle is assumed to be spherical in shape with radius *R*, adhering solidly to the surface of the rotating disk during a transient contact.

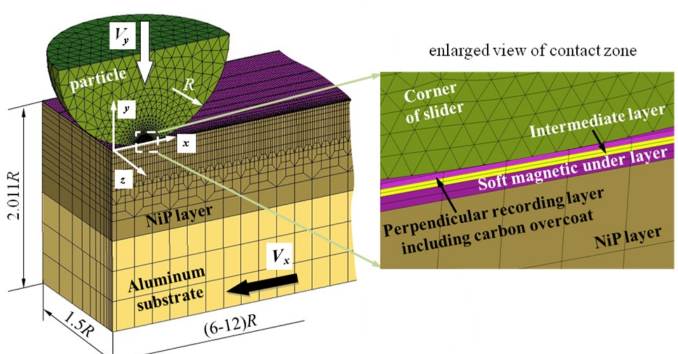

Fig.2 Finite element model of particle-disk contact for layered disk with aluminum substrate.

Figure 2 shows the finite element model of the particle-disk contact for a magnetic recording disk with aluminum substrate. This model "lumps" the carbon overcoat, the magnetic layer, and all sublayers into one layer on the substrate [4]. The top surface of the spherical particle is assumed to be rigid and has a constant initial temperature identical to that of the disk to which the particle adheres. Three typical materials were used to represent contamination particle, namely, stainless steel (SS), polyoxymethylene (POM), and alumina (Al_2O_3). The mechanical and thermal material properties of these particles are summarized in Table 1. The material properties for the layered disk structure with aluminum and glass substrates are given in Ref. [4].

Table 1. Material properties of contamination particles.

Property	Symbol [units]	SS Particle	POM Particle	Al_2O_3 Particle
Young's modulus	E [GPa]	195	3	400
Yield strength	Y [GPa]	0.48	0.03	6.40
Poisson's ratio	ν [-]	0.276	0.40	0.30
Density	ρ [kg/m^3]	7840	1450	4300
Specific heat	c [$J\ kg^{-1}K^{-1}$]	498	1470	860
Thermal conductivity	k [$W\ m^{-1}\ K^{-1}$]	15.20	0.21	24.00
Thermal expansion	α [$10^{-6}K^{-1}$]	17.6	60.0	7.5

Results and Discussion

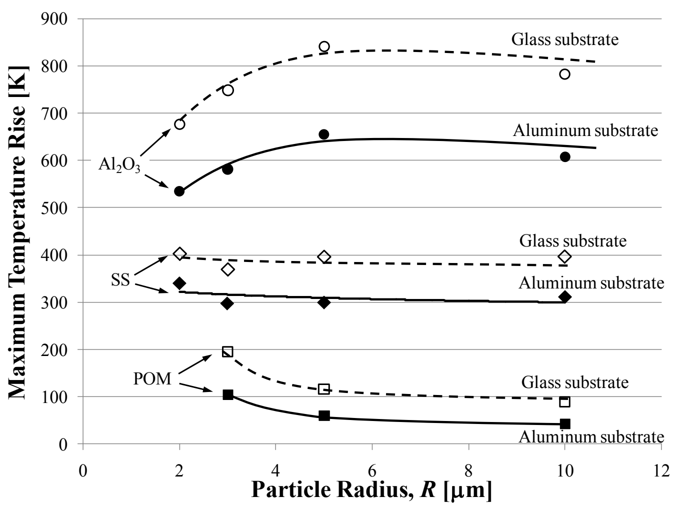

Fig.3 Maximum temperature rise on the surface of the recording layer caused by contamination particles for glass and aluminum substrate.

Figures 3 - 5 show the maximum temperature rise, the plastically deformed area, and the maximum residual penetration on the disk surface, respectively, for stainless steel, polymer and alumina contamination particles as a function of the particle radius for both glass and aluminum substrate disks. The numerical results were obtained for typical impact conditions of a slider on a disk, namely, a slider vertical initial velocity of V_y= 0.2 m/s, a disk circumferential velocity of V_x= 10 m/s and a coefficient of friction of μ = 0.2. We assume that the slider has a mass of 0.5 mg.

We observe from Fig. 3 that glass substrate disks results in a higher maximum temperature rise in comparison with Ni-P/aluminum substrate, which is consistent with findings in Ref. [4]. We observe that alumina particles lead to a higher maximum temperature rise than semi-hard stainless steel or soft polyoxymethylene particles due to the larger contact pressure resulting in higher frictional heating. We also observe that the maximum temperature rise becomes independent of particle size for particle radius larger than 5 mm. However, the maximum temperature rise is a function of the particle size as the radius becomes small.

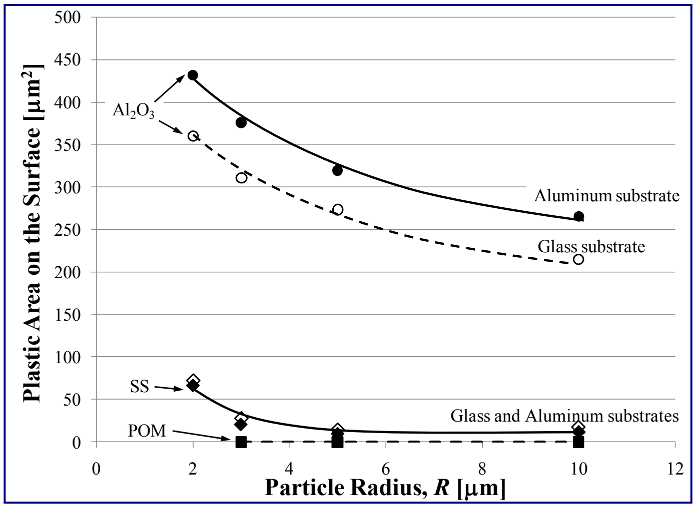

Fig.4 Plastic area on the surface of the recording layer caused by contamination particles for glass and aluminum substrate

Figure 4 shows that for hard alumina particles, glass substrate results in a smaller plastically deformed area in comparison with aluminum substrate due to the higher yield strength of glass [4]. However, for the softer stainless steel contamination particles we observe nearly the same values of the plastically deformed area. We also note that soft polyoxymethylene particles do not cause any plastic deformation on the surface of the recording layer. The plastic area on the surface of the recording layer tends to decrease with larger particle radius since contact pressure decreases.

Figure 5 shows that the maximum residual penetration is significant for hard particles such as alumina, and is larger for aluminum substrate than for glass substrate. The latter is in agreement with numerical results shown in Fig. 4. Stainless steel and soft polyoxymethylene particles do not result in any residual penetration on the disk surface for either substrate.

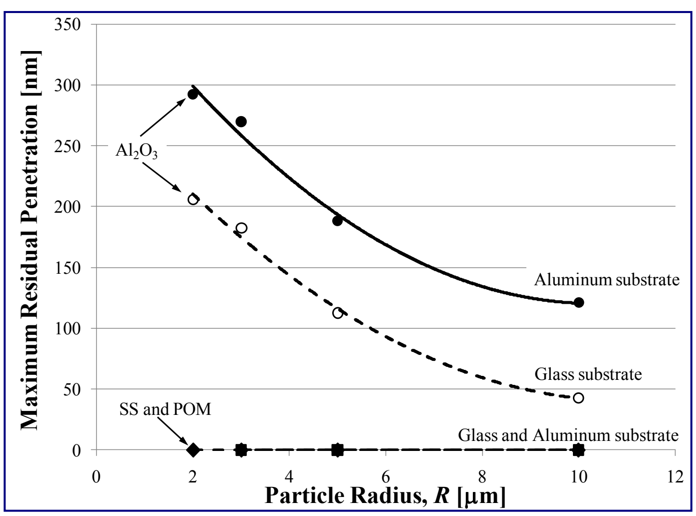

Fig.5 Maximum residual penetration on disk surface caused by contamination particles for glass and aluminum substrate.

Numerical simulations of particles with radii less that 2 μm were also performed. Depending on the material properties of the contamination particles, we observed that small particles are either pushed deep into the substrate (alumina) or are flattened out on the surface of the disk (SS and POM). Further investigations will be presented to elucidate the combined effect of inverse magnetostriction and frictional heating on the thermal erasure of magnetic information.

Conclusion

Soft particles such as polyoxymethylene do not show plastic deformation of the magnetic recording layer during transient slider disk contacts. Temperature increases on the order of one hundred degrees of Centigrade are predicted, indicating that thermal erasure may be a possible tribological failure mechanism. Semi-hard particles such as stainless steel particles seem to cause little physical damage (residual plastic deformation) of the recording layer, but result in a temperature rise of several hundred degrees of Centigrade, which could lead to thermal erasure. Hard particles such as alumina are predicted to result in significant plastic deformation combined with high temperature rise which can lead to loss of data in a similar way as "conventional" slider-disk contacts [4]. It is apparent that hard contamination particles represent the most severe problem for the tribological integrity of magnetic recording disk drives.

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(Continued from page 2)

their university are then carefully reviewed by the Intel fellows and their designees who choose the winning students. The program encourages applicants from underrepresented minority groups, including women, to apply through their university. The fellowship includes a cash award (tuition and stipend), an Intel Technical Liaison and travel funds to meet the liaison either at a conference or at Intel. These students are also prioritized for internships and hiring within the company. This is a highly competitive program with a limited number of fellowships awarded annually," according to the Intel website.

Professor Wolf stated that "Eitan is one of the top two or three of the 60+ Ph.D. students that I have advised in my 45 years of university teaching. He is extremely bright and very highly motivated. He grasps new concepts almost instantly and has demonstrated excellence in working in a number of different research areas."

Eitan was chosen as one of the 2009 winners of the **Marconi Society Young Scholar Award**. These awards were presented in Bologna, Italy to five outstanding young researchers from France, Germany, Israel, Italy, and the United States.

Congratulations, Eitan!

Research Highlight

SERVO SIGNAL DATA PROCESSING FOR FLYING HEIGHT CONTROL IN HARD DISK DRIVES

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Introduction

In recent years, thermal actuated flying height control has been implemented in Hard Disk Drives (HDD) to reduce the effect of flying height variations due to manufacturing tolerances or write current introduced pole tip protrusion (Fig. 1). A stable low flying height is necessary to achieve low bit error rates (BER) [1]. Thermal flying height control is used in a "static manner" in current disk drives. The principle of thermal flying height control is based on the application of a current to a resistance heater positioned in close proximity to the read write element, thereby causing a thermal deformation of the head which causes a reduction in the static flying height at the read write element. Dynamic flying height variations of a slider over a disk are composed of repeatable and non-repeatable contributions. As the name suggests, repeatable variations of flying height occur at the same angular and radial position of the slider above the disk [2]. Thus, the question arises as to whether a thermal flying height control slider can be used to dynamically control the flying height variations between slider and disk. The objective of this paper is to study whether a thermal actuator could be used to reduce the effect that disk waviness and vibrations have on the flying height modulation of the head disk interface. Our main goal is to investigate active flying height control of a thermal slider up to the kilohertz regime.

In-situ flying height estimation

Most of the reported algorithms on in-situ flying height estimation are based on a specific data pattern that is written on the disk thereby resulting in certain harmonics in the frequency spectrum of the read signal. Commonly used is the triple harmonics method [2,3,4] that uses the '111100' data pattern to create three major harmonics. The logarithm of the ratio of the third over the first harmonic is proportional to the flying height modulation. Ratios of different harmonics other than the third and the first have also used and servo pattern might be taken into account [5]. Approaches have also been implemented based on maximum or average amplitudes [6] rather than harmonics amplitudes. Also, approaches that employ random data instead of a fixed data pattern were proposed [7].

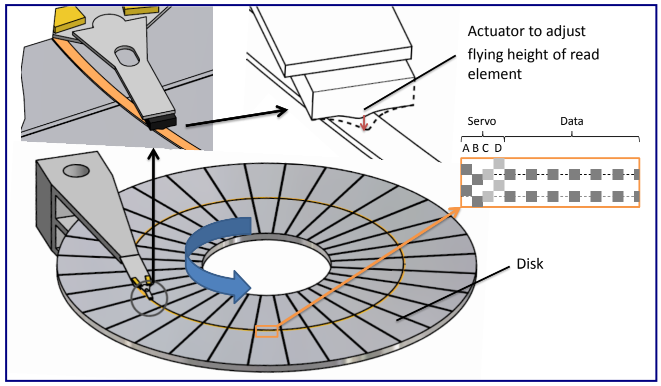

Fig.1 Flying height control in a HDD

A technique that extracts both the PES and the flying height information is reported in [8] where radially adjacent and circumferentially aligned servo bursts are generated with different frequency contributions to generate position error and flying height signals. Other techniques are the pulse width method [9], the spectral fitting method [10] and methods that estimate the flying height based on the slope of isolated pulses of the read back signal [11]. Some of these estimation algorithms embody at least one of the following disadvantages:

1. Cross-track-motion can wrongfully be detected as a change in flying height

2. The measurement can strongly depend on the radial position of the read element with respect to the disk (skew angle)

3. A particular data pattern and/or the data sector is necessary, and, thus, storage space is lost

4. The method may not be capable for perpendicular magnetic recording

Servo signal based flying height estimation

The estimation scheme proposed in this study for the measurement of the variation of flying height is based on the servo pattern written on the disk. Using the servo pattern for the estimation of flying height has a number of advantages. At every servo sector the off-track spacing is known since the position error signal (PES) is generated. Hence, the effect of cross-track motion of the head on the flying height signal can be eliminated. The servo can be an amplitude based servo or a timing based servo. Timing based servo applications have been shown to be more accurate than amplitude based counterparts [12]. The estimation of flying height variation using an amplitude based servo pattern will be shown in this study. The following assumptions are made: 1.) The change in magnetic spacing corresponds to a change in flying height which requires a constant carbon overcoat and lubricant thickness (Fig. 2), 2.) The flying height variation of adjacent servo bursts within the same servo sector is small compared to the flying height variation between adjacent servo sectors. 3.) The writing process is less sensitive to flying height variations than the reading process [4].

Based on those assumptions we can compute the change in flying height from the Wallace equation. The Fourier transform of the read back signal Φ decays exponentially with increasing distance d from the magnetic medium [13]. We can measure the signal voltage at a specific frequency in the frequency domain of two subsequent servo bursts e.g. A and B

$$\Phi_A(k,d)+\Phi_B(k,d) = (\Phi_A(k,0)+\Phi_B(k,0))e^{-kd}$$

where $k=2\pi/\lambda$ is the wave number. The flying height change $\Delta d=d-d_{ref}$ can be calculated from

$$\Delta d = -\frac{\lambda}{2\pi}\ln\left(\frac{\Phi_A(\lambda,d)+\Phi_B(\lambda,d)}{\Phi_A(\lambda,d_{ref})+\Phi_B(\lambda,d_{ref})}\right) \quad (1)$$

The fluctuation of the product of the recording layer thickness and the remanent magnetization (Mrt) of the recording media [4] causes read back signal modulation, and, therefore modulations in the measured flying height. The harmonics ratio method referred to earlier decreases this effect. The proposed servo sum method estimates the flying height based on the first harmonic of the whole servo burst and is therefore insensitive to small variations in Mrt and the recording layer thickness within the burst.

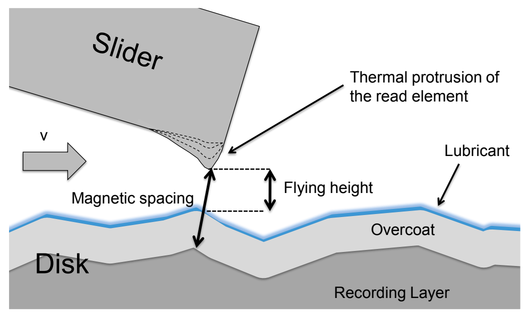

Fig.2 Flying height definition

The cross-track characteristics of the flying height change estimate (1) are shown in Fig.3. It can be observed that the estimate is fairly insensitive to cross-track motion for about 80% of the track width. It should be noted that the shape of the curve in Fig. 3 depends strongly on the servo spacing which is assumed to be known and constant over the whole disk.

Spin stand measurements

We have performed a number of measurements using a disk head tester (MicroPhysics) and longitudinal media and heads. A simple dual servo signal with

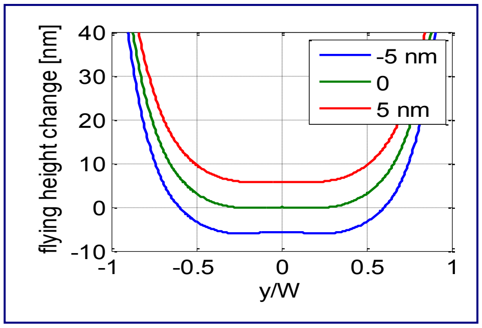

Fig.3 Simulated cross-track characteristics

A and B bursts was written onto the disk at a track density of 130 k tracks per inch. The first harmonic of the servo was fixed at 56.25 MHz regardless of the position of the read element. The read back signal was captured using a 2GS/s digitizer. The results for one revolution are shown in Fig. 4. Here, the PES was computed by

$$PES = \frac{A-B}{A+B} \qquad (2)$$

where A and B refers to the first harmonics of the A and B bursts, respectively, and Δd is computed using (1). The power applied to the thermal actuator was varied from 0 (blue curve) to approx. 100mW (red curve). From Fig. 4 it can be observed that the estimated flying height decreases as the heater power increases. More importantly, we observe that the dynamic variation of Δd stays relatively constant.

It is noted that 'written-in' variations in servo burst spacing are anticipated to influence the estimation of Δd.

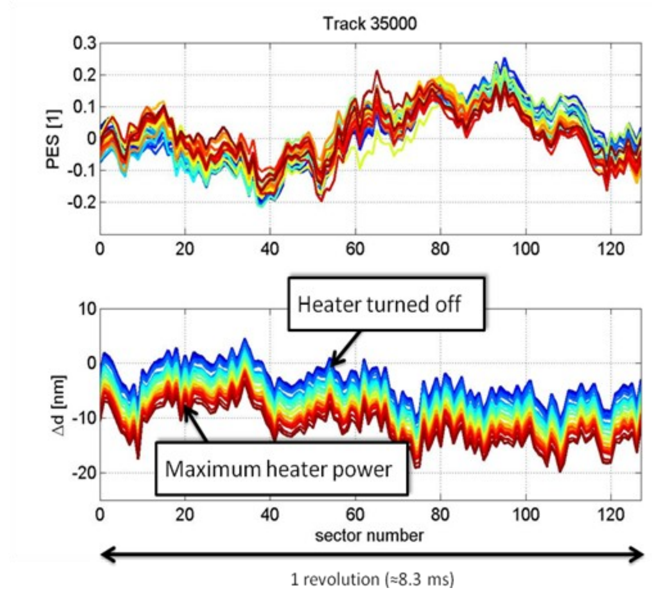

Fig.4 PES and flying height modulation for one revolution at different heater power levels at r=30mm

Conclusions

A flying height estimation technique based on the first harmonics of the servo signal has been proposed. Both simulations and measurements show high sensitivity of the estimate to a change in flying height and a small sensitivity to cross-track motion of the read element. The estimation is strongly influenced by the accuracy of the servo writing process, i.e., by the cross-track spacing between the A and B burst in each servo sector.

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full potential of these new storage technologies," said Professor Paul Siegel, Director of CMRR and Co-Chair of the NVMW organizing committee.

The final session emphasized the richness of applications that NVM technology will impact, from mobile communications to enterprise storage to large-scale biological studies, and it included perspectives of representatives from Qualcomm, STEC, and Google. "It was very exciting to hear about such a wide range of applications. It shows how game-changing these technologies will be," said Steven Swanson, an Assistant Professor in UCSD's Computer Science and Engineering Department, the head of the NVSL, and Co-Chair of the NVMW organizing committee.

The technical talks were complemented by a dinner panel addressing grand challenges in NVM research. Panel participants included researchers from Microsoft Research, IBM, SanDisk, San Diego Supercomputer Center (SDSC), and the Global Information Industry Center at UCSD.

"The success of the workshop reaffirms the importance and timeliness of CMRR's new research thrust in solid-state storage," said Siegel. "The combined vision, expertise, and collaborative spirit of researchers at CMRR, NVSL, SDSC, and Calit2 have positioned UCSD to become the academic leader in this rapidly growing field."

The technical program and the slides for many of the presentations are available on the NVMW website (http://cmrr.ucsd.edu/education/workshops/Program.htm).

News about future NVMW events will be available on the CMRR and NVSL websites.

Selected Papers and Talks

A complete listing of CMRR papers & talks can be found at: http://cmrr.ucsd.edu

Professor Emeritus H. Neal Bertram

H.N. Bertram, M.E. Schabes, and M. Alex, "Measurements and analysis of noise power versus density in perpendicular recording," *IEEE Transactions on Magnetics*, Vol. 45, No. 10, (October 2009), pp. 3562-3564.

B. Livshitz, A. Inomata, **H.N. Bertram**, and **V. Lomakin**, "Semi-analytical approach for analysis of BER in conventional and staggered bit patterned media," *IEEE Transactions on Magnetics*, Vol. 45, No. 10, (October 2009), pp. 3519-3522.

Professor Eric E. Fullerton

E. Shipton, K. Chan, T. Hauet, O. Hellwig, and **E.E. Fullerton**, "Suppression of the perpendicular anisotropy at the CoO Néel temperature in exchange-biased CoO/[Co/Pt] multilayers," *Applied Physics Letters*, Vol. 95, No. 13, (September 2009), pp. 132509-1-3.

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D. Bedau, H. Liu, J.-J. Bouzaglou, A.D. Kent, J.Z. Sun, J.A. Katine, **E.E. Fullerton**, and S. Mangin, "Ultrafast spin-transfer switching in spin valve nanopillars with perpendicular anisotropy," *Applied Physics Letters*, Vol. 96, No. 2, (January 2010), pp. 022514-1 - 022514-3.

Professor Paul H. Siegel

Z. Wu, **P.H. Siegel**, **J.K. Wolf**, and **H.N. Bertram**, "Analysis of nonlinear transition shift and write pre-compensation in perpendicular recording systems," *IEEE Journal on Selected Areas in Communications*, Vol. 28, No. 2, (February 2010), pp. 158-166.

A.R. Iyengar, **P.H. Siegel**, and **J.K. Wolf**, "LDPC codes for the cascaded BSC-BAWGN channel," *Proceedings of the Forty-Seventh Annual Allerton Conference on Communication, Control and Computing*, (September 30 - October 2, 2009), pp. 620-627.

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Professor Frank E. Talke

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The Spring 2010 Research Review and Advisory Council Meeting will be held on May 5-6, 2010. For further information on the CMRR Research Review, please contact Iris Villanueva at 858-534-6196 or ivilla@ucsd.edu .

CMRR Research Review Highlights

The Fall Research Review was held October 28-29, 2009. Over 30 people from CMRR Industrial Sponsor companies and other invited guests participated in the meeting.

In addition to the sessions devoted to technical presentations of CMRR research results, the Review featured a special session presentation by University of CA, Riverside Professor, Sakhrat Khizroev. His talk was entitled “Multilevel Three-Dimensional Magnetic Recording.”

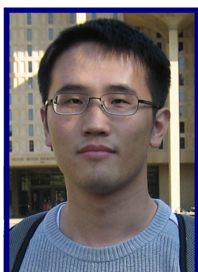
CMRR Sponsor company employees may access the abstracts and viewgraphs of all Research Review presentations on the CMRR website in the Sponsor Resources section at http://cmrr.ucsd.edu/sponsors/ Contact Jan Neumann with any questions regarding Sponsor Resources at jneumann@ucsd.edu .

Graduate Degrees Awarded

Amir (Hadi) Djahanshahi was a member of Professor Siegel's Signal Transmission and Recording (STAR) group. He received his Ph.D. in March 2010. His thesis is entitled "Optimizing and Decoding LDPC with Graph-based Techniques." Hadi is now employed as a Senior Algorithm Engineer at Quantenna Communications, Inc., a provider of wireless home-networking solutions, headquartered in Fremont, California.

Seyhan Karakulak was a member of Professor Paul H. Siegel's and Professor Jack K. Wolf's research groups since July 2005. She received her Ph.D. in April 2010. Her dissertation was on channel modeling and signal processing for bit-patterned media recording. She collaborated with Professor Emeritus H. Neal Bertram in her thesis work. She will soon join STEC, Incorporated in San Diego. STEC is a global leader in solid-state storage solutions for enterprise and OEM businesses.

New Graduate Student



Xiaojie Zhang is currently a Ph.D. student in the department of Electrical and Computer Engineering at UCSD. His advisor is Professor Paul Siegel. Zhang received his B.S. degree in Electrical Engineering from Shanghai Jiao Tong University, Shanghai, China, in 2004, and his M.S. degree in Electrical Engineering from Seoul National University, Seoul, Korea, in 2006. From 2006 to 2008, he was a research engineer in Samsung Electronics, Suwon, Korea. His research interests include wireless communication, multiuser scheduling, cross-layer communication system design, and coding theory. He is presently working on performance analysis of LDPC codes.

Gifts, Grants and Awards

Professor Eric Fullerton has received funds from NSF to support his research project entitled "Electrical Control of Nanoscale Magnetic Device."

Qualcomm Corporation has awarded **Professor Fullerton** a research grant to support his work on "Materials Research for STT-MRAM."

Professor **Frank Talke** and Hitachi Asia have a collaborative research agreement entitled "Advance Technologies for Head-Disk Interface with Areal Density of 10Tb/in^2 Magnetic Recording."

Visitors

Wai Ho Mow is a visiting scholar in Paul Siegel's group from Hong Kong University of Science and Technology. He received his Ph.D. degree in Information Engineering from the Chinese University of Hong Kong. He was the recipient of the Croucher Research Fellowship (HK), the Humboldt Research Fellowship (Germany), the Telecommunications Advancement Research Fellowship (Japan), the Tan Chin Tuan Academic Exchange Fellowship (Singapore), the Wong Kuan Cheng Education Foundation Academic Exchange Award (China), the Foreign Expert Bureau Fellowship (China) and the Royal Academy of Engineering Award for Short Research Exchanges with China and India (UK). His research interests are in the areas of wireless communications, coding and information theory. He pioneered the lattice approach to signal detection problems and unified all known constructions of perfect roots-of-unity sequences (widely used as CAZAC preambles and radar signals). Since June 2002, he has been the principal investigator of over 10 funded research projects. He has published one book, and co-authored over 20 filed patent applications and over 100 technical publications, among which he is the sole author of over 40.

Saeed Sharifi Tehrani is a visiting graduate student in Professor Siegel's group. He received the B.Sc. degree in computer engineering from Sharif University of Technology, Tehran, Iran, in 2002 and the M.Sc. degree in electrical and computer engineering from the University of Alberta, Edmonton, AB, Canada in 2005. He is currently working towards his Ph.D. degree at the Department of Electrical and Computer Engineering, McGill University, Montreal, QC, Canada. Mr. Sharifi Tehrani received the Post Graduate Scholarship Award from the Alberta Informatics Circle of Research Excellence (iCORE) during his M.Sc. study at the University of Alberta. He is also an awardee of the doctoral research scholarship from the Fonds Québécois de la Recherche sur la Nature et les Technologies (FQRNT) as well as a recipient of the Alexander Graham Bell Canada Graduate Scholarship (CGS Doctoral) from the Natural Science and Engineering Council of Canada (NSERC). Mr. Sharifi Tehrani's research interests include stochastic decoding, digital signal processing systems, low-complexity error-control coding techniques, and design and hardware implementation of iterative decoders.

Graduate Students & Researchers Near Completion

Student	Level	Advisor	Dept	Area of Research	Completion
Edward Choi	Ph.D.	Jin	MAE	Magnetic recording media	June 2010
Eric Kim	Ph.D.	Jin	MAE	Nanopatterning of engineering materials	June 2010
Caleb Kong	Ph.D.	Jin	MAE	Magnetic nanoparticles & nanocapsules	September 2010
Mariana Loya	Ph.D.	Jin	MAE	Surface nanapatterning using radio frequency	September 2010
Paul (Yeoungchin)Yoon	Ph.D.	Talke	MAE	Slider dynamics and tribology of the head/disk interface	June 2010

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The 21st Magnetic Recording Conference 2010

August 16-18, 2010

The 21st Magnetic Recording Conference (TMRC 2010) will be held August 16-18, 2010 at the University of San Diego, California, USA.

TMRC 2010 will focus on MAGNETIC RECORDING MEDIA and TRIBOLOGY. Approximately 30 invited papers of the highest quality will be presented orally at the conference and will later be published in the *IEEE Transaction on Magnetics*. The topics to be presented include:

- Advanced Perpendicular Magnetic Recording Media
- Head Disk Interface, Overcoats, Lubes & Tribology
- Bit Patterned and Discrete Track Media
- Energy Assisted Magnetic Recording Media
- L10 and L11 Ordered Media
- Magnetic Modeling and Micromagnetics
- Recording Systems and Physics
- Advanced Recording Channels and Detection Algorithms
- Media Aspects of STT-RAM, M-RAM & Racetrack

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