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CMRR Report
Center for Magnetic Recording Research

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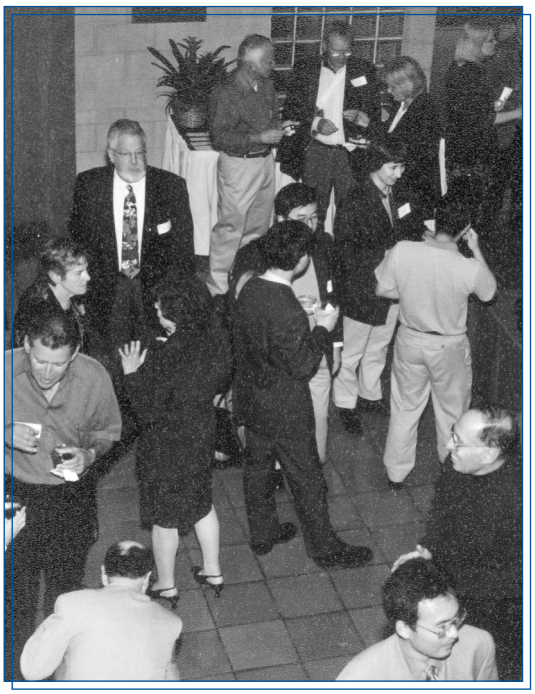
CONTENTS

CMRR Celebrates Twenty Years

This year, the Center for Magnetic Recording Research (CMRR) is celebrating the 20th anniversary of its founding as an Organized Research Unit at UC San Diego. In conjunction with the Spring Research Review (May 7-8), several special events recognized this milestone in the Center's history.

On Monday, May 5, the first Shannon Memorial Lecture was presented in the CMRR Auditorium by Prof. Toby Berger,

On Tuesday, May 6, there was a special birthday celebration honoring the many individuals who have contributed to the Center's 20 years of success. All CMRR students - past and present - were invited, along with visiting researchers, representatives of our industry and government sponsors, and, of course, Center administrative staff, technical staff, and faculty.



GUESTS CELEBRATE CMRR'S 20TH ANNIVERSARY AT THE MAY 6 RECEPTION HELD AT CMRR.

The festivities began at 5:00 p.m. with a reception in the CMRR lobby. Beneath a banner displaying the CMRR logo and proclaiming the anniversary, the 140 guests – including 30 CMRR alumni – enjoyed hors-d'oeuvres and conversation while being entertained with the delightful music of the Samba Jazz trio, led by former CMRR Research Scientist Dr. Lineu Barbosa.

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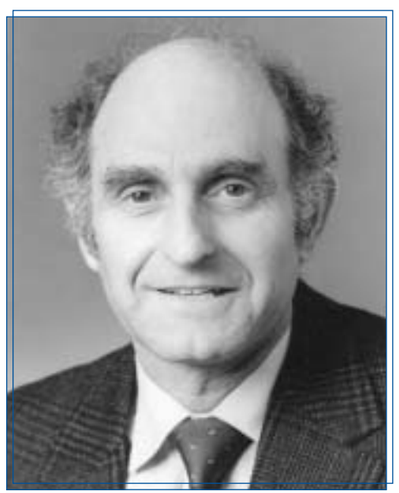
CMRR establishes "Schultz Prize"

The year 2003 marks the 20th anniversary of the founding of the Center for Magnetic Recording Research, a truly landmark event in the history of industry-university partnerships at UC San Diego. In recognition and celebration of this event, CMRR has established the **Sheldon Schultz Prize for Excellence in Graduate Student Research**. The Prize is named in honor of former CMRR Director, Sheldon Schultz, who skillfully guided the Center from November 1990 through August 2000.

The Schultz Prize is intended to annually recognize CMRR graduate students who have distinguished themselves through the creativity of their research and the impact of their publications. The selection of the recipient will be based upon the recommendation of a committee consisting of CMRR faculty members, with input from selected experts in information storage technology.

The first Schultz Prize was awarded jointly to **Geoffrey Beach**, a member of Prof. Ami Berkowitz's Magnetic Materials and Devices group, and Kai-Zhong Gao, who recently received his Ph.D. degree from Prof. Neal Bertram's Magnetic Recording Physics and Micromagnetics group. The awards were presented at the 20th Anniversary Celebration dinner, May 6, 2003.

KAI-ZHONG GAO (SECOND FROM LEFT) AND GEOFF BEACH (FAR RIGHT) SHARE THE FIRST SHELDON SCHULTZ PRIZE FOR EXCELLENCE IN GRADUATE STUDENT RESEARCH. THE HONOREES ARE JOINED BY (LEFT TO RIGHT) PROFS. SHELLY SCHULTZ, NEAL BERTRAM, GAO'S ADVISOR AND AMI BERKOWITZ, BEACH'S ADVISOR



Geoffrey Beach is completing his Ph.D. dissertation on "Magnetic Properties of Co_XFe_{100-X} Metal/Native Oxide Multilayers." In his research, Geoff has pioneered a new, and very successful, approach to developing multilayer thin films suitable for use in the design of recording heads and disks capable of operating at extremely high data transfer rates and storage densities.

In addition to their potential technological value, these materials represent an entirely new type of magnetic material, making their analysis a subject of basic scientific importance. To characterize these multilayer films, Geoff has very creatively utilized a wide range of measurement techniques. In collaboration with Ami and Prof. Sunil Sinha, he recently conducted the first experiments on Asterix, a unique new apparatus for neutron diffraction and reflection at LANSCE - the Los Alamos Neutron Science Center. These experiments were highlighted by the Los Alamos National Laboratory on their website (and also in the Fall 2002 issue of CMRR Report).

The nomination and endorsement of Geoff for this award noted that Geoff has established an impressive number of fruitful collaborations with scientists in academia, government research labs, and industry, and cited his creativity, initiative, dedication, and enthusiasm for research.

Kai-Zhong Gao recently completed the defense of his doctoral dissertation, entitled "Optimization of Write Heads and Media for Ultra High Density and Data Rate Magnetic Recording", and recently joined Seagate Technology in Bloomington, Minnesota.

In his research, Kai-Zhong used micromagnetic analysis to investigate novel configurations of recording heads and magnetic media that address the grand challenge of achieving storage densities of one trillion bits of information in one square-inch of disk area. His creative approach to the problem resulted in

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FROM THE DIRECTOR

In this issue of the CMRR Report, you will find several articles (and photos) relating to the Center's 20th anniversary celebration, which was combined with our recent Spring Research Review. The well-attended events highlighted the strength of the ties that bind together the diverse members of CMRR's "extended family," as well as the breadth and depth of the contributions that the members of this family have made to modern data storage technology over the past two decades.

CMRR's success has its roots in the commitment of the university and its sponsors in government and industry to supporting an interdisciplinary research center addressing the vital area of information storage. Considering the benefits that have arisen from this commitment in the past, and the exciting prospects for information storage research in the future, I trust that in another twenty years, there will be cause for a celebration even bigger and better that the one we've just enjoyed.

Paul H. Siegel

— Paul H. Siegel, Director

CMRR Research Reviews

Since the publication of the Fall 2002 CMRR Report, the Center has held two semi-annual Research Reviews.

Fall 2002 Research Review Summary

CMRR hosted 45 persons from the CMRR Industrial Sponsor companies and other invited guests at the semi-annual Research Review and Advisory Council meeting on November 20-21, 2002. The program followed the usual format of two days of talks highlighting the work of the CMRR faculty, researchers and graduate students as well as CMRR affiliated faculty members. Dr. Giora Tarnopolsky, President, TarnoTek, gave the Special Session presentation entitled "Areal Density Growth: Is It the Manifest Destiny of the Hard Disk Drive?" Tours of the CMRR labs and private discussions with students and researchers began at 4:30 p.m. The evening's activities culminated with dinner at CMRR and the Advisory Council meeting at 7:30 p.m.

The meetings officially adjourned at 4:30 p.m., November 21, however several guests stayed for additional lab tours and private discussions.

Spring 2003 Research Review Summary

Nine member organizations of the CMRR Industrial Sponsor companies, and other invited guests, were represented at the CMRR Spring Research Review, 20th Anniversary Celebration, and Advisory Council Meeting May 7 and 8. The Special Session entitled "CMRR –The First 20 Years and Beyond" featured talks by UCSD faculty and members of the data storage industry who were instrumental in the founding and development of the Center (see related article, CMRR Celebrates Twenty Years on page 1).

CMRR Sponsor company employees may access the abstracts and graphs of the Research Review presentations on the CMRR website in the Sponsor Resources section.

The Fall 2003 Research Review is scheduled for November 12-13, 2003. If you have not received invitations to previous Research Reviews, please contact Cheryl Hacker (chacker@ucsd.edu or 858-534-6563) to have your name added to the invitation list.

Distinguished Alumni Awards

In connection with the Center's 20th Anniversary Celebration, the CMRR Distinguished Alumnni Award was established to recognize outstanding graduates who have had notable impact upon the science, engineering, and business of information storage technology. On May 6, 2003, at the Anniversary Banquet, the first Distinguished Alumni Awards were presented to ***Christopher Lacey*** *and* ***Kelly Knudson Fitzpatrick****.*

CHRIS LACEY (RIGHT), CMRR DISTINGUISHED ALUMNUS, RECEIVES CONGRATULATIONS FROM HIS FORMER ADVISOR, PROFESSOR FRANK TALKE.

A graduate of Frank Talke's group, **Christopher Lacey** received his Ph.D. in 1992, with a dissertation entitled "The Head/Tape Interface." During his Ph.D. studies, Chris developed novel experimental methods and numerical simulations to study the interface between the recording head and the magnetic medium in tape storage devices. As a summer intern, he collaborated with Phase Metrics on the extension of these techniques to the setting of magnetic disk recording.

After graduation, Christopher founded Micro Physics, a company that specializes in instrumentation for the data storage industry. The company's widely used products include recording head testers, head-medium space analyzers, and numerical simulation tools for flying-height analysis.

The endorsing statements for this award cited Chris's "striking" research in mechanics, including his innovative experimental techniques. In fact, a search of the US Patent and Trademark Office database uncovered 12 patents with Chris Lacey as inventor or co-inventor.

KELLY KNUDSON FITZPATRICK IS CONGRATULATED ON RECEIVING THE CMRR DISTINGUISHED ALUMNI AWARD BY DIRECTOR PAUL SIEGEL (LEFT) AND FORMER ADVISOR, PROFESSOR JACK WOLF.

Kelly Knudson Fitzpatrick received her Ph.D. in 1994 from Jack Wolf's group, known at the time as "Codes R Us."

As part of her Ph.D. thesis, which was entitled "Detection and Error-Correction for Partial Response Channels," Kelly came up with the idea of using a simplified algorithm for reliable detection of data from magnetic recording channels using various error-control codes and equalization techniques. The essence of the idea is to ignore the code in the detector and then check whether or not the detector produces a code word from the code. If it does, the detection process is complete. If it does not, the detector is told that it has made a mistake and a correction process takes place to find the correct code word.

When Kelly joined Quantum (now Maxtor) she extended this "post-processing" idea to so-called higher-order partial response equalization. She was granted what proved to be a very important patent on this invention, entitled "Reduced Complexity EPR4 Post-Processor for Sampled Data Detection." This invention became the basis of the read-write channel technology incorporated into Quantum's product line, and it ultimately earned Kelly the very prestigious "Quantum Inventor of the Year Award".

First Annual Shannon Memorial Lecture

On Monday, May 5, UC San Diego inaugurated a new series of annual lectures named for Claude E. Shannon, the father of information theory. The series was established through the endowment of a lectureship to commemorate Shannon's achievements and to recognize their vast impact upon modern society. A bust of Shannon, situated in the CMRR lobby, bears a plaque with the following inscription:

Claude Elwood Shannon
(1916-2001)
Father of Information Theory
His formulation of the mathematical theory of communication provided the foundation for the development of data storage and transmission systems that launched the information age

Each year an outstanding information theorist will be selected to present the Shannon Memorial Lecture, on or about Shannon's birthday (April 30). The series will be hosted at CMRR by Prof. Jack K. Wolf, Jacobs School electrical and computer engineering professor and CMRR endowed chair. (Prof. Wolf received the 2001 Claude E. Shannon Award from the IEEE Information Theory Society.)

The inaugural lecture, entitled "Information Theory in Real Neural Nets," was presented by Toby Berger, Irwin and Joan Jacobs Professor of Engineering, Electrical and Computer Engineering, at Cornell University. Prof. Berger was the 2002 Claude E. Shannon Award recipient, and is recognized as a pioneer in the application of information-theoretic concepts to living systems. The Shannon Memorial Lecture was webcast live via the Cal-$(IT)^2$ website at www.calit2.net, where an archived video of the lecture can be viewed on-demand.

Support for the webcast, reception, and a dinner in honor of Prof. Berger was kindly provided by the San Diego Division of Cal-$(IT)^2$.

ABSTRACT

Neural signaling in the human brain can be modeled as a time-discrete binary random field. The nodes of this field's graph are the brain's neurons, believed to number circa 10^{11}. The field's time step duration is 2.5 ms, which is the Gabor time width of a typical neural spike. Field random variable $B_{i,k}$ equals 1 if neuron i sends a spike down its axon during time slot k and equals 0 otherwise.

A typical neuron in the brain has some 10,000 immediate neighbors from which it receives spike trains and another roughly 10,000 neighbors to whom it delivers its own spike train. Despite these high in-degrees and out-degrees, the connectivity matrix is extremely sparse, since the connection density is only circa $10^4/10^{11}=10^{-7}$. Each neural spike visits each of its 10^4 destinations within the same time slot, so the brain delivers some 10^{15} binary digits (to their destinations) several hundred times per second. Although the Internet perhaps also moves several hundred petabits during one second, it has many relay nodes and therefore may deliver less information per second to its destination than does a single brain. Certainly, the Internet does not compute and transmit to all intended destinations a new petabit 2.5 ms later that depends intimately on the values assumed by the previous one. Since the computing power and especially the communicating power of an individual neuron are relatively weak compared to those of modern electronic computer logic elements, we reach the inescapable conclusion that the brain's celebrated computing prowess must stem in considerable measure from its topological connectivity.

We discuss how to model neural regions responsible for sensory perception as time-discrete, finite-memory channels with feedback. The input and output spaces of these regions are binary vectors that possess millions of components. The channel's latest output vector, which serves also as the channel state, gets fed back to the channel input. We show that energy efficient information transmission across such neural regions necessarily results in an output process that is first-order Markovian, though not necessarily homoge-

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Research Highlights

CMRR's project on intelligent disk drive storage systems ("iStor") is sponsored by the Sloan Foundation Information Storage Industry Center at UCSD. Our initial project study was CMRR SMART, which developed disk drive failure warning methods allowing four times higher warning accuracy than current disk drive technology, at low false alarm rates (see "Improved disk drive failure warnings" IEEE Trans. Reliability, vol. 51, p 350-7, September 2002)

A paper on SMART by ECE graduate student researcher Joe Murray has been accepted for presentation at the 2003 International Conference on Artificial Neural Networks. It compares past CMRR SMART warning methods to pattern recognition support vector methods, to unsupervised clustering, and to reverse arrangements statistical rank tests. The latter test looks for upward trends in drive internal error counts, by tracking the number of times a new error count is higher than previous counts.

Intelligent storage features offer benefits in storage system performance and to user application programs. A recent IEEE Spectrum article by Dr. Gordon Hughes' ("Wise Drives," August 2002) points out that work on intelligent storage dates from the 1980's (such as the Teradata data processing computer and Active Disks), pushing data-centric computing downward in computer architecture, but rarely penetrating through the computer-disk drive interface. CMRR currently has three active projects based on the potential iStor features listed in this IEEE Spectrum article.

Intelligent storage system ("iStor") features are enabled by changes in internal drive technology and in computer data access methodology. We see extensions of object-based storage devices (OSD in the SCSI architecture) as a basis for storage systems and user application programs to interface to iStor features. Current abstractions such as storage virtualization miss iStor opportunities because they use drives simply as block data storage devices. OSD allows abstraction of storage away from physical device management, for virtualization and for real-time quality-of-service management. This can allow tight control of physical storage performance by data intensive user applications such as database programs.

A computer system has been configured to experimentally test the disk drive secure erase "SE" intelligent feature that CMRR put into the standard drive computer interface specs, SCSI and ATA. We are developing a CMRR SE test protocol to verify that SE deletes all user data from test drives, beyond the possibility of recovery.

A third iStor project has begun to study storage system performance improvements by using the "time-to-data" feature from the Spectrum article. A computer simulation will determine data access speedups made possible by letting storage systems query drives to find the quickest order to access records in a multi-task user request queue. An experimental project is in progress to study time-to-data by using existing SCSI commands which return the head and disk physical positions at any time.

CMRR is also participating in a Storage Networking Industry Association (snia.org) initiative to form a storage network users interest group at ISIC.

"Secure Erasure" Project

CMRR's storage systems project on "secure erasure" of disk drive data has just been renewed by the National Security Agency, with Gordon Hughes as Principal Investigator. This three-year $150,000 project answers a significant data storage user need to reliably eradicate data from computer hard drives for security and privacy reasons. The need for "secure erasure" arises when:

- A user releases disks or they are removed from systems for maintenance.
- Storage devices are re-configured for other uses or users, for instance in expiring leased data storage facilities at a storage service provider or data center.
- A project is completed and the data must be purged to protect "need to know" or to prepare drives for new users or applications.
- A virus has been detected and all possible traces of the offending code must be eliminated.

The "secure erase" (SE) command is now part of the standard disk drive specifications (IDE/ATA and SCSI) at CMRR's request. It is a positive, easy-to-use data destroy command, amounting to "electronic data shredding." It completely erases all possible user data areas by overwriting. SE is a simple addition to the existing "format drive" command currently present in computer operating systems and storage systems, and consequently adds little or no cost to drives.

Secure erase is required by the ATA specification, although it is optional in SCSI. The new "serial ATA" drives will be able to advertise SE as a user feature in their competition with SCSI and fiber channel drives for market share in low-end storage systems.

The new secure erase project is testing a CMRR protocol for evaluating the SE feature in individual drive models to insure that erased data is not recoverable.

Secure erasure capability will be required by the U.S. government for their disk drive purchases. Considering the security feature this capability offers to many users we expect there will be considerable commercial interest in this capability as well.

For additional information on the secure erasure initiative, contact Gordon Hughes <gfhughes@ucsd.edu>.

Lake Arrowhead Conference

The 22nd annual CMRR Interactive Workshop on Information Storage was held December 8 to 11, 2002 at the UCLA Conference Center at Lake Arrowhead. The Workshop motto for 22 years has been "Let no foil go unchallenged." This year, 23 technologists debated "Heads, media and mechanics to reach terabit density in hard disk drives."

In the opening tutorial session on Nano Storage, Stephen Chou, Princeton University, discussed nanoimprinting lithography for 10 nm bits, and Stuart Solin, Washington University, proposed exotic semiconductor-based spintronic read sensors. Over three days, terabit per square inch areal density technology challenges in magnetic recording heads, read/write channels, disc magnetics, and drive mechanics were discussed. The mechanics session was moderated by CMRR Professor Frank Talke. A session on non-magnetic alternative technologies covered the possibility that recording physics limits might soon be reached.

- Gordon Hughes,
Workshop Chair

WORKSHOP AGENDA:

Sunday - December 8

Tutorial: Nano Storage

Speakers: Stephen Chou, Princeton University and Stuart Solin, Washington University

Monday - December 9

Session I: Read sensors and channels

Moderator: Dave Thompson, IBM retiree

Session II: Recording media

Moderator: Dave Wachenschwanz, Komag

Tuesday - December 10

Session III: Mechanics

Moderator: Frank Talke, CMRR

Session IV: Patterned media and non-magnetic recording alternatives

Moderator: Bruce Terris, Hitachi Global Storage Technologies

Wednesday - December 11

Session V: Overflow and TMRC Review

Moderator: John Best, Hitachi Global Storage Technologies

CMRR Information Center offers resources on storage technology

Many of you may not be aware that CMRR has an Information Center/ Library. Formed in October 1984, it provides a centralized location for information resources on storage technology. The collection includes books, journals, theses, technical reports, standards and specifications, and databases. While the collection is open to any researcher for in-house consultation, more specialized services are only available to members of the sponsoring companies of CMRR.
These services include:

- Photocopies of journal articles
- Loan of books
- Loan or purchase of videotapes of the CMRR weekly seminar series and the monthly lecture series sponsored by the IEEE Magnetics Society.
- Copies of theses, from CMRR as well as from other institutions
- Copies of patents
- Copies of industry standards
- Searches of commercial databases such as INSPEC, Chemical Abstracts, Compendex, World Patents Index, etc. These searches can be done as a one-time retrospective search covering any period of time from approximately 1970 to date. A search profile can also be established to track an area of interest and results will be emailed on a monthly basis.

Requests can be made via telephone, fax, email, or via our Web site at **http://cmrr.ucsd.edu/icenter/**. Please note that while the searchable database of all CMRR seminars, Research Review presentations, and student theses is publicly accessible from our Web site, a more full-featured search including full abstracts and links to PowerPoint presentations and where available a link to a streaming video file is only available to members of CMRR sponsoring companies. An on-line ordering function is also available to members of CMRR sponsoring companies via the password-protected Web page. You can register to receive the password at the site.

The holdings of the CMRR collection are listed in the UCSD Libraries on-line catalog ROGER, publicly accessible at **http://roger.ucsd.edu/** After searching by any of the available indexes – author, title, keyword, subject, or call number, you can restrict your results with the "Limit this Search" function found at the bottom of the screen and then indicating "cmrr" in the "Where Item is located" search box, again located near the bottom of the screen.

The Information Center is open Monday to Friday: 8:30 a.m. - 4:30 p.m. and closed Saturday and Sunday. Given our small staff we suggest a call to confirm that staff are available to assist you, should you be planning to visit in person.

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CMRR WELCOMES NEW AFFILIATED FACULTY

Dr. Sungho Jin received his Ph.D. degree in materials science and engineering from the University of California, Berkeley in 1974. After two years of research at Lawrence Berkeley Laboratory, he joined Bell Laboratories at Murray Hill, New Jersey in 1976. He carried out research at Bell Labs for 26 years, first as a Member of Technical Staff, and later on as Technical Manager of the Applied Materials and Metallurgy Research Group. He joined University of California, San Diego in July, 2002 as a Professor of Materials Science and Endowed Chair, and is currently serving as Director of UCSD's Materials Science & Engineering Program where he is actively engaged in improving and expanding both materials education and materials research. As a part of such initiatives, five new courses dealing with electronic/magnetic/photonic materials, nanomaterials, biomaterials, MEMS, and inventions/patents have been added to the curriculum.

Dr. Jin's research activities for the past two decades include many aspects of magnetism and magnetic materials such as permanent magnets, semi-hard magnets, soft magnets, magnetic sensors, magnetic switching, CMR phenomenon and materials, magnetically tunable devices, and flux pinning of superconductors. His research interests/programs at UCSD related to magnetics include the design and study of new magnetic materials and devices, in particular, ultra-high-density magnetic recording media, transport and spin-related behavior of thin film magnetic materials, magnetic tuning of telecom-related devices, and study of biomagnetism. The activities of his research group with six graduate students, two postdoctoral fellows and a research scientist also include R&D of nanomaterials, biomaterials and MEMS.

Sunil Sinha is the LANSCE Professor in the Physics Department at UCSD, a joint appointment with UCSD and Los Alamos National Laboratory. He has worked as a Senior Scientist at Brookhaven National Laboratory, where he was Head of the X-Ray Scattering Group and, prior to coming to UCSD, at Argonne National Laboratory where he was Associate Director of the Experimental Facilities Division of the Advanced Photon Synchrotron Source. He was also a Senior Research Associate at Exxon's Corporate Research Laboratories in Annandale, N.J. His interests lie in the use of X-Ray and Neutron Scattering to study the structure and dynamics of materials.

Prof. Sinha is collaborating with Prof. Ami Berkowitz's group to study the magnetostriction and magnetic structure in magnetic nanoparticles. They plan to investigate by X-Ray diffraction at the Advanced Photon Source the "giant magnetostriction" effect in nanoparticles of Terfenol. In addition, numerical simulations have indicated the existence of multisublattice antiferromagnetic structures in NiO nanoparticles, as opposed to the conventional bulk 2-sublattice antiferromagnetic structure. Prof. Sinha and Prof. Berkowitz's groups will use neutron diffraction at the Los Alamos neutron scattering facility to look for these novel structures.

Prof. Sinha's awards and honors include the Ernest O. Lawrence Medal of USDOE (1996) and the Arthur H. Compton Award (2000).

Recent Gifts, Grants, Awards, and Internships

Prof. **Ami Berkowitz** has received an award from the **Raytheon Company** entitled "Magnetic Meta-Materials for RF and Power Electronics." The project covers the development of FeCo/insulator meta-materials using the spark erosion process. A design of experiments will then be performed to identify the most promising FeCo/insulator material. Additional work may then be performed to optimize the material characteristics. These powders will be used in the preparation of magnetic pastes. The targeted operating frequency range for these materials is 30 MHz to 100 MHz.

Lawrence Livermore National Laboratory has awarded a supplement to Prof. Ami Berkowitz's Multi University Research Initiative "Terfenol and Ni Particles Produced by Spark Erosion." The current project is a collaboration with UCLA and LLNL in an investigation of the magnetostrictive properties of composites in which Terfenol particles prepared by the spark erosion method are disposed in a polymer matrix. The supplement, which extends the project through September 2003, allows the investigation of the optimization of magnetostrictive properties of the composites by determining the influence of size, shape, crystallinity, texture, alignment, and volume fraction on these properties. It is important for this study to know if the magnetostrictive properties of the particles are the same as those of the bulk material, and, if they are not the same, how they differ.

Dr. **Fred Spada**, CMRR Associate Research Scientist, will be participating in the recently announced Multi-Terabyte Tape System, a **NIST/ATP** Program managed by **Imation** and **Peregrine Recording Technology.** Dr. Spada's research will focus on electrochemical issues that can influence magnetic spacing via interactions among the sputtered metal tape layer, protective overcoat, lubricants, and the critical reading and writing elements in the recording head. The goal of these studies will be to identify the important interactions and exploit this knowledge to reduce pole tip recession, assist in the selection of potential lubricants, and identify any incompatibilities that may affect long-term system reliability.

The **Information Storage Industry Consortium (INSIC)** has recently funded four new CMRR projects under the Extremely High Density Recording (EHDR) Program.

Prof. **Neal Bertram** will direct a project on "Intercoupled Experimental and Theoretical Studies of Perpendicular Recording." The research involves the development of an efficient technique to determine the recorded transition parameter and cross track transition correlation length. Both these parameters are critical in the typically jitter dominated SNR. Knowledge of each one can give direction to media development, in particular the roles of distributions and intergranular interactions. A previous method utilized the transition noise spectrum, but for perpendicular media a time analysis of the noise is utilized. One thousand transitions in a medium density square wave pattern are sampled with about 400 sample points per transition. The correlation function, after DC noise removal, is analyzed in terms of eigenmodes. The first two dominant modes give the transition characteristics independent of the geometry, such as medium spacing.

Profs. **Paul Siegel, Jack Wolf**, and **Neal Bertram** will collaborate on the development of an "Improved Data Stream Simulator for Perpendicular Recording." The simulator, based upon a microtrack model of the recording process, should accurately represent the signal and noise characteristics expected in a perpendicular recording system operating at high areal density (> 300 Gb/in^2). Results of micromagnetic modeling will provide guidance for incorporation of various recording effects, such as nonlinear transition shift, cross-track pulse shape variations, track curvature, DC noise, and partial erasure. Spinstand measurements will be used to validate the model. The simulator output is intended to serve as the input to a "software channel" and will be made available to participants in the EHDR Signal Processing team, permitting performance comparisons of various coding, equalization, and detection techniques.

Prof. **Paul Siegel** has also received funding for a project on "Error Control Coding for Terabit per Square Inch Recording." The research effort will examine algorithms and architectures for iterative soft-decision decoding of Reed-Solomon codes on partial response channels. In particular, new methods for generating soft outputs from soft-decision Reed-Solomon decoders will be evaluated. Applications to high-rate parity-sharing code architectures will also be addressed.

Finally, Prof. **Frank Talke** will investigate "The Optimization of Textured Sliders."

CMRR's storage systems project on "Secure Erasure" of disk drive data has just been renewed by the **National Security Agency**, with Dr. **Gordon Hughes** as Principal Investigator. This three-year project addresses a significant need of many data storage users, namely, the need to reliably eradicate data from computer hard drives for security and privacy reasons. (For more details, see the related article in the Research Highlights section on page 6.)

Talke Receives Seagate Information Technology Award

Professor Frank E. Talke of CMRR and Professor David B. Bogy, UC Berkeley, were recently awarded the Annual Seagate Information Technology Award. This award, jointly sponsored by the Tribology Division of the American Society of Mechanical Engineers (ASME) and Seagate Technology, LLC was being awarded for the first time. In annoucing the award in October 2002, Harvey P. Nixon ASME Chair, Tribology Division and Mark Kryder, Senior Vice President and Director of Research for Seagate cited the substantial, life long contributions Talke and Bogy have made to the advancement of tribology of magnetic storage devices.

Ph.D.'s Awarded

Kai-Zhong Gao, a member of Prof. Neal Bertram's Magnetic Recording Physics and Micromagnetics group since 1997, received his Ph. D. in Physics in November 2002. His thesis, "Optimization of Write Heads and Media for Ultra High Density and Data Rate Magnetic Recording," focused on perpendicular recording systems.

Kai-Zhong's research interests are primarily in magnetic recording physics, especially focused on perpendicular recording systems, including: 1) large scale three dimensional micromagnetic simulations in both magnetic recording head and media, 2) perpendicular recording head design and optimization, 3) tilted and conventional perpendicular recording analysis, and 4) dynamic gyro-magnetic switching time and switching field limits study.

A recent paper, co-authored by Prof. Bertram and Dr. Gao published in Institute of Electrical and Electronics Engineers Transaction on Magnetics, proposed and analyzed a tilted perpendicular system and compared it to conventional perpendicular recording. This new recording scheme is believed to be an alternative approach for ultra high density magnetic recording with areal density beyond 1 Tbit/in^2. Currently Kai-Zhong is a Senior Development Engineer at Seagate, Bloomington, working on a variety of issues, including perpendicular recording analysis.

Henry Pfister joined Professor Paul Siegel's research group in 1998 and was awarded his Ph.D. in Electrical Engineering in March 2003. His research focused on information theory and error-correcting codes, and resulted in the dissertation entitled, "On the Capacity of Finite State Channels and the Analysis of Convolutional Accumulate-m Codes". The applications of this research include new techniques in the signal processing area of magnetic storage. After completing his Ph.D., he spent the month of April wandering around Australia and New Zealand. In May, he started work in Corporate Research and Development at Qualcomm, Inc. in San Diego.

CMRR WELCOMES NEW RESEARCHERS

Jan Jose joined Prof. Frank Talke's group in September 2002 for a one-year exchange program under the Max Planck Research Awards for International Cooperation. During the previous four years, Jan studied Electrical Engineering at the University of Rostock with special emphasis on applied microelectronics. Following his visiting appointment at CMRR, Jan will return to the University of Rostock to write his diploma thesis. Jan has three primary objectives during his stay in the United States: 1) to write another thesis, which is needed to finish his studies in Germany, 2) to get to know the American way of life, and 3) to improve his English.

Maik Duwensee is not really new to CMRR. He was a visiting graduate student in Prof. Frank Talke's group during the academic year 1999/2000. After his year at UCSD he returned to Germany to finish his Diploma Degree at the University of Rostock. He graduated in June 2001. His final thesis dealt with "Active Sway Motion Damping for an Underconstrained Cable Manipulator". Following graduation, Maik became a Research Assistant at the Institute for Drive Mechanics and Mechatronics at Rostock University for one year. He worked on a simulation program dealing with the dynamics of cars with air-spring-dampers. Maik re-joined the Talke group as a Ph.D. student last November.

Besides work Maik enjoys doing any kind of outdoor activities; his favorites include whitewater kayaking, surfing and snowboarding. He also likes to travel and often combines kayaking and traveling. He has been kayaking in Wales, Ireland, France, Austria, Czech Republic, Morocco, Germany and California (and there are still plenty of places to visit). Although far away from home, he remains a member of the local kayak club Kanuklub Buetzow 1952 e.V., and tries to stay in contact as much as possible.

Dagmar Goll will spend 2003 as a visiting post-doc working with both Profs. Neal Bertram and Ami Berkowitz. Dr. Goll is sponsored on a fellowship from the DAAD (German Academic Exchange Service), a central agency of the institutions of higher education in the Federal Republic of Germany which organizes international academic exchange programs. Scholarship recipients are chosen in a national competition by a selection committee made up of prominent German professors in their respective disciplines. Dr. Goll received her Ph.D. from the Max Planck Institute for Metals Research (Stuttgart, Germany) in December 2001, and continued there as a postdoctoral research assistant for one year working with Prof. G. Schuetz. Her research interests include permanent magnets, ferromagnetic small particles, nanostructures and thin films, micromagnetism (analytical, numerical, finite elements) and electron microscopy. Besides her research, Dagmar enjoys playing the piano, walking, biking, swimming, reading and gardening.

Ralf Brunner became a research assistant in Prof. Talke's Group in March 2003, and wants to do research using his background in technical physics. He is a German graduate student from the Technical University of Ilmenau. Following his studies, he had internships at several companies and institutions to get experience for his career. He worked at EOS – Electro Optical – Systems in Munich/Germany with laser – sintering machines and CO2-Lasers. Last year he was working for the Federal Institute for Materials Research and Testing in Berlin/Germany in the Tribology Group of Prof. Santner, where he was involved with finishing the project of developing an UHV-Tribometer by testing, re-building and putting it into operation. It was there that he met Prof. Talke who invited Ralf to work with him in his labs at CMRR. During his one-year stay at CMRR, he will write his diploma thesis to finish his degree in Germany. During his free time, Ralf likes to play badminton and the guitar.

Marcia Levitt Recognized for 15 Years of Service at UCSD

Marcia Levitt celebrated 15 years of service at the University of California, San Diego in November 2002. Marcia began working at UCSD's County Medical Health Services at the UCSD Medical Center in November 1987 before transferring to the Center for Molecular Research on the La Jolla campus.

In September 1994, Marcia joined CMRR as assistant to Profs. Ami Berkowitz and Frank Talke, and very quickly became a key member of the CMRR family.

PROFESSORS AMI BERKOWITZ (LEFT) AND FRANK TALKE CONGRATULATE MARCIA LEVITT FOR 15 YEARS OF SERVICE AT UCSD.

Graduate Students & Researchers Near Completion

STUDENT	LEVEL	ADVISOR	DEPT	RESEARCH INTEREST	COMPLETION DATE
Geoff Beach	Ph.D.	Berkowitz	Physics	Properties and behaviors of nano-structured materials with applications in magnetic recording	June 2003
Xiaobin Wang	Ph.D.	Bertram	Physics	Thermal reversal of recording media	June 2003
Eric Jayson	Ph.D.	Talke	MAE	Head/disk interface tribology	June 2003
Lin Zhou	Vstg Asst Proj Sci	Talke	CMRR	Head/disk interface tribology	Summer 2003
Ramakrishna Akella	Ph.D.	Wolf	ECE	Detection	Fall 2003
Vladimir Dorfman	Ph.D.	Wolf	ECE	Signal processing	Summer 2003
Brian Kurkoski	Ph.D.	Wolf/Siegel	ECE	Coding	December 2003
John Miller	Ph.D.	Wolf	ECE	Coding	June 2003

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The lobby featured several newly installed exhibits highlighting the founding of the Center, the technical contributions of our faculty and students, and the remarkable technological achievements of the data storage industry. Two very interesting display cases were designed and put together by CMRR librarians Dawn Talbot and Jan Neumann. One contained correspondence, memoranda, architectural blueprints, and photos pertaining to the establishment and construction of the Center. The second paid tribute to the exceptional group of student researchers who have earned their graduate degrees at CMRR over the past 20 years. It included the bound Ph.D. dissertations of the first CMRR Ph.D. recipient (Cathy French, Wolf group) and of the most recent (Henry Pfister, Siegel group), as well as a selection of theses from the other faculty research groups. The titles and dates of all of the other CMRR dissertations (on chips color-coded according to CMRR faculty research groups) were spread throughout the display case. Dawn and Jan also produced a binder of thesis titles and abstracts that traced the fascinating chronology of all graduate degrees completed at CMRR. (Copies of the binder were provided to attendees of the event and are still available from the CMRR Information Center upon request.)

Also on display was a colorful and informative exhibit, generously donated by CMRR sponsor **Hitachi Global Storage Technologies**, highlighting key developments in the history of magnetic recording technology from the fifties to the present. This exhibit, which comprises three posters, each 6-feet tall and 3-feet wide, is now permanently mounted in the CMRR lobby.

Following the reception, guests strolled through campus to the UCSD Faculty Club for the 20th Anniversary Awards Program and Banquet. Welcoming remarks were given by CMRR Director Paul Siegel and UCSD Vice Chancellor for Research and Dean of Graduate Studies Richard E. Attiyeh. Prof. Siegel then described the establishment of the Sheldon Schultz Prize for Excellence in Graduate Student Research, named in honor of former CMRR Director Shelly Schultz (Research Professor of Physics). He went on to introduce Prof. Schultz, who gave a brief speech accepting the Prize in his name. Prof. Siegel then announced the first Schultz Prize was being jointly awarded to Geoffrey Beach, a member of Prof. Ami Berkowitz's Magnetic Materials and Devices group, and Kai-Zhong Gao, a member of Prof. Neal Bertram's Magnetic Recording Physics and Micromagnetics group. Each winner was presented with a framed certificate and a $1,000 cash prize. (See Schultz Prize article on page 2 for more details.)

The celebratory events confirmed the important role that members of the CMRR "family" have played, and continue to play, in the advancement of information storage technology and its applications.

Following the presentation of the Schultz Prize, the newly established Distinguished Alumni Award was announced. The award is to be presented on an occasional basis to a CMRR alumnus/a whose contributions to the scientific, engineering, or business of information storage technology have been particularly noteworthy. Again, there were two inaugural recipients of the award - Christopher Lacey (Ph.D. 1992, Prof. Frank Talke - faculty advisor) and Kelly Knudson Fitzpatrick (Ph.D. 1994, Prof. Jack K. Wolf - faculty advisor). The recipients were presented with framed certificates. (See the related article on page 4 about these Distinguished Alumni.)

CMRR DIRECTOR EMERITUS SHELLY SCHULTZ (CENTER), WIFE CAROL AND SON DAVID CELEBRATE CMRR'S 20TH ANNIVERSARY.

The evening's festivities concluded with dinner and entertainment provided by RONDO, a four-piece chamber group led by cellist, Galina Oshay.

Finally, on Wednesday, May 7, during the first day of the Spring Research Review, there was a Special Session celebrating the past and anticipating the future of the Center and, more generally, of information storage technology. The Special Session, entitled "CMRR –The First 20 Years and Beyond," was organized and hosted by CMRR Director Paul Siegel. It featured a program of talks by several distinguished speakers from UCSD and the data storage industry who provided personal historical reflections as well as future speculations:

Professor M. Lea Rudee (founding Dean of Engineering at UCSD)
"UCSD and CMRR - At the Beginning"

Dr. James U. Lemke (UCSD Revelle Medal recipient, credited with conceiving and guiding the establishment of CMRR)
"CMRR - A Retrospective"

Dr. Denis Mee (IBM Fellow Emeritus)
"1983-A Pivotal Year in Magnetic Recording"

Prof. Shelly Schultz (CMRR Director, Emeritus)
"Data Storage and Societal Future - Can We Plan Effectively?"

Dr. A. Currie Munce (VP for Research at Hitachi Global Storage Technologies)
"The Next 20 Years of Digital Storage"

All in all, the celebratory events confirmed the important role that members of the CMRR "family" have played, and continue to play, in the advancement of information storage technology and its applications.

CMRR gratefully acknowledges QUALCOMM Incorporated, LSI Logic, and Cal-(IT)^2 for their generous support of the CMRR 20th Anniversary Celebration.

"Schultz Prize"

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two exceptionally innovative ideas: a novel tapered-pole write-head and a recording technique based upon "tilted perpendicular" recording media.

Kai-Zhong's analysis and simulation studies indicate that these techniques have the potential to overcome several problems that presently impede the attainment of densities in excess of 200 billion bits per square inch, and his work has stimulated great interest in the data storage industry.

The statements endorsing Kai-Zhong's nomination for this prize cited his deep understanding of magnetic recording, his talent for research, and his influential publications that together set a standard for evaluation of novel recording systems.

Biography of Sheldon Schultz

Sheldon (Shelly) Schultz earned his Ph.D. in physics from Columbia University in 1960, and an M.E. degree from Stevens Institute of Technology in 1954. He came to UC San Diego in 1960, (when it was still called UCLJ!) as part of the first group that founded the physics department, and helped initiate the planning for what was to become the current UCSD campus. He became active with CMRR at its earliest stages in 1982 serving on the initial planning, search, and building advisory committees. He initiated a research program at CMRR devoted to providing a quantitative experimental set of data to fully characterize the micromagnetics and hysteresis in thin films and sub-micron particles with an emphasis on new experimental techniques and advanced instrumentation. His most recent research activities are devoted to Negative Index of Refraction (also called left-handed) Metamaterials, Photonic Band Gap structures, and plasmon resonant nanoparticles for bio/medical diagnostic labels.

How to Contribute

CMRR's goal is to endow the Prize so that it can be awarded annually and in perpetuity. If you are interested in making a donation of any amount to the Schultz Prize, you will help move us closer to the endowment target of $50,000. Checks should be made payable to "UC San Diego Foundation" with a notation on the check or a brief cover letter designating the contribution for the "Schultz Prize." Your donation is 100% tax-deductible, and an official acknowledgement of your contribution will be provided to you. All correspondence pertaining to the Prize can be directed to:

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CMRR Report
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Shannon Memorial Lecture Abstract

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neous. Likewise, the joint (input, output) is first-order Markov, though the input process is not necessarily Markov.

How the brain goes about assuring that the sensory information that gets conveyed within and among its application-specific neural regions is the information that is most pertinent to the tasks that need to be addressed is only vaguely understood at present. We suggest an approach to energy-efficient joint source-channel neural coding of sensory information based on extensions of concepts from multiterminal information theory coupled with ideas from recursive estimation theory.

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