



CMRR Report

Center for Magnetic Recording Research

Research Highlight

Modeling, Servo Control and Motion Planning for High Track Density Recording

by

Raymond de Callafon

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Summer 2008

Talke Receives ASME Medal

Frank E. Talke, an Endowed Chaired Professor at CMRR has been awarded the **2008 ASME Society Medal** “for lifetime contributions to the understanding of the tribology and mechanics of magnetic recording disk and tape drives, for pioneering efforts in the development of color drop-on-demand inkjet printing technology, and for bridging academic and industrial research.”



The American Society of Mechanical Engineers has over 130,000 members from academia, industry, and national laboratories.

This society honors its outstanding members through symposia, awards, medals, honorary memberships, and the society's medal.

Among these the honorary membership and the society medal are bestowed to very few members with exceptional educational and innovative scientific and industrial contributions to the art and science of mechanical engineering.

Professor Paul H. Siegel has received the Jacob School of Engineering “Outstanding Teacher of the Year” award for 2008. This award, initiated by the UCSD Triton Engineering Student Council, is given to one teacher from the Jacobs School for excellence in teaching and for inspiring greater achievement in our students, based on nominations submitted by the undergraduate student body.

Professor Talke will receive this award at a special dinner at the 2008 ASME International Congress & Exposition held in Boston on November 3, 2008.

Spada Receives INSIC Award

INSIC's Technical Achievement Award, which recognizes the contributor of a specific technical achievement in an INSIC Research Program, for a contribution judged to provide a significant advancement toward the Program's goals, was presented to

Dr. Frederick E. Spada, University of California San Diego, Center for Magnetic Recording Research (UCSD CMRR). Dr. Spada

has been engaged in a meticulous investigation over an extended period of the possible erosion, corrosion and deposition of materials in magnetic tape recording heads which



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2008 Sheldon Schultz Prize for Excellence

On April 23, 2008 the Schultz Prize was awarded to co-recipients **Ralf Brunner** and **Junsheng Han**. The prize is presented in recognition of CMRR graduate students who have distinguished themselves through the creativity of their research and the impact of their publications.

Ralf first came to CMRR as a visiting student in Professor Talke's group from the Technical University of Ilmenau, Germany, in March 2003. He rejoined the Talke group in the summer of 2004 as a Ph.D. student. In 2007, Ralf received a Graduate Student Fellowship Award from the ASME Information Storage and Processing Systems Division. In June 2008, Ralf received the UCSD MAE Award for Outstanding Graduate Student. He is currently completing his dissertation and will defend it this December.



Left to Right: Professor Paul H. Siegel, Junsheng Han, Professor Emeritus Sheldon Schultz, Ralf Brunner, and Professor Frank E. Talke

Junsheng Han, a member of Professor Paul Siegel's group, received his Ph.D. in April 2008. His dissertation was entitled "Code Representation and Performance of Graph-Based Decoding." Junsheng is currently employed at Qualcomm Corporation in San Diego.

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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."

You can also submit an [online donation](http://www.jacobsschool.ucsd.edu/external/external_giving/) at http://www.jacobsschool.ucsd.edu/external/external_giving/. Click on "Give Now" and under "fund" select "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 Schultz Prize can be directed to:

Professor Paul H. Siegel, Director
University of California-San Diego
Center for Magnetic Recording Research, #0401
9500 Gilman Drive
La Jolla, CA 92093-0401

New Associate Director

Nate Heintzman was appointed as the new Associate Director at the Center for Magnetic Recording Research under the UC Discovery Fellow Program. Nate will manage diverse programs within the Center that focus on facilitating collaborative information technology ventures between CMRR scientists and industry affiliates in the San Diego area and beyond. He will perform similar duties at UCSD's Center for Wireless Communications (CWC). Nate received his Ph.D. in Biomedical Sciences at UCSD, has consulted for various companies in the science community, and serves as the Vice President of Operations and Chief Academic Advisor for Insulindependence, a non-profit diabetes advocacy organization. More information is available at <http://www.mysdsce.com/profile/Nate>



From the Director

CMRR is celebrating its 25th anniversary this year – a truly astounding achievement. The Center stands as a testament to the immense value of university-industry cooperative research. Yet, the data storage industry appears to be in a transitional period. Attrition, consolidation, and re-organization have taken a toll on the roster of companies conducting R&D in disk and tape storage, with fewer still able to devote resources to finding “the next big thing, and beyond.”

This is a time when storage industry players can leverage their R&D dollars by investing them in CMRR projects. The many forms of the return on such an investment are reflected in this issue of CMRR Report. The research conducted by our innovative, award-winning faculty members, research scientists, post-doctoral researchers, and graduate students provides valuable insight into forward-looking storage technologies. State and federal programs (including the UC Discovery Program that is supporting our new Associate Director, Dr. Nate Heintzman) enhance our research efforts and augment your return.

At the same time, the Center produces new generations of highly skilled and highly sought-after scientists and engineers who, after graduation, continue to push the frontiers of data storage in industrial and academic roles. I’m sure you’ll recognize in the cumulative list of CMRR graduates (on pages 4 and 5) the names of many key contributors to the amazing technology of data storage that has transformed the modern world. So, with an eye to the future, this may be the right time to increase your level of support for CMRR and your level of participation in our technical activities. I encourage you to explore the possibilities with us.

All of us at CMRR are grateful to the many organizations that have sponsored our technical programs during the past quarter century. I look forward with enthusiasm to the next quarter century of cooperative progress in storage technology and systems. And I hope you enjoy this issue of CMRR Report.



Shannon Graduate Fellowship Awarded

Paolo Minero, a Ph.D. student of ECE Professor Massimo Franceschetti, is the first recipient of the **Shannon Memorial Fellowship**. The purpose of this endowed fellowship is to honor an outstanding graduate student at UCSD whose research is in the field of information theory.

Paolo joined UCSD in September of 2006 from UC Berkeley. While at UCSD, he has solved two important problems in the field of control with rate-limited feedback, and wireless networks capacity; and he is currently making very good progress in solving a third problem related to multi-user communications.



Left to Right: Professor Jack K. Wolf and Paolo Minero

Outstanding Student Awards

Ralf Brunner, a graduate student in Professor Talke’s lab has received the UCSD MAE award for “2008 Outstanding Graduate Student.” He has been recognized as a dedicated researcher in his field.

Hao Zheng, a graduate student in Professor Talke’s lab received the “2008 ASME/ISPS Best Conference Paper.” The paper entitled “Effect of Suspension Design on the Non-Operational Shock Response in a Load/Unload Hard Disk Drive” was coauthored with A.N. Murthy, E.B. Fanslau Jr., and Professor F.E. Talke.

Two CMRR graduates, **Henry Pfister** and **Joseph Soriaga**, have received a “2007 Best Paper Award” from the Data Storage Technical Committee of the IEEE Communications Society. The paper entitled “Determining and Approaching Achievable Rates of Binary Intersymbol Interference Channels Using Multistage Decoding,” was published in the April 2007 issue of the *IEEE Transactions on Information Theory* and was coauthored with Professor Paul H. Siegel.

CMRR Celebrates its 25th Anniversary 1983-2008

March 31, 1983 – UCSD Announces establishment of a \$12 million Center for Magnetic Recording Research

March 31, 1983 – **Dr. Albert Hoagland** appointed acting director

March 31, 1983 – Founding sponsors: Applied Magnetics Corporation, Control Data Corporation, Data Electronics, Inc., Eastman Kodak Company, IBM Corporation, National Micronetics, Inc., Pfizer Pigments, Inc., Seagate Technology, 3M, Verbatim Corporation

August 3, 1984 – Groundbreaking ceremonies

August 27, 1984 – **John C. Mallinson** named first director of the Center

January 1, 1985 - **Dr. Jack K. Wolf** accepts first CMRR Endowed Chair

January 22, 1985 - **Dr. H. Neal Bertram** appointed to CMRR Endowed Chair

March 27, 1986 – CMRR building dedicated

March 1986 – **Dr. Frank E. Talke** appointed to CMRR Endowed Chair

October 1, 1986 – **Dr. Ami E. Berkowitz** appointed to CMRR Endowed Chair

October 1987 – CMRR confers first Ph.D. to Catherine French, a student in Professor Jack Wolf's group

December 1989 – IBM & CMRR researchers announce that they have set a world record by successfully packing a billion bits of information onto a single square inch of magnetic disk surface, an information density 15 to 30 times greater than the storage capacity of then available computer hard disk drives.

July 1, 1990 – **Professor Sheldon Schultz** appointed CMRR Director

CMRR M.S. (in italics) & Ph.D. Students Shirish Altekar, Alan Armstrong, *Pat Ash*, Joseph Aubuchon, Sharon Aviran, Constant Baggen, *Marvin Balaoro*, Alexander Barany, Mladen Barbic, Richard Barndt, Eric Baugh, Geoff Beach, Paul Bender, Eric Boerner, *Chris Briggs*, Matthew Carey, Joseph Caroselli, Eric Champion, Jiangxin Chen, Michael Cheng, *Craig Cocchi*, Chiara Daraio, Ismail Demirkan, Saurabh Deoras, *Glenn Dixon*, Vladimir Dorfman, Maik Duwensee, Gregory Fischer, James Fitzpatrick, *Lucas Fornace*, Lyle Fredrickson, Catherine French, Arnon Friedmann, *Edward Fu*, Kai-Zhong Gao, Andrew Gapin, *Brook Garrettson*, Jason Goldberg, *Prajakta Gudadhe*, Junsheng Han, *David Harper*, Joshua Harrison, Eric Jayson, Zhen Jin, *Raymond Karam*, Bernhard Knigge, Kelly Knudson, Richard Kodama, Brian Kurkoski, Christopher Lacey, Patrick Lee, *Pablo Levi*, Gang Lin, Yinyi Lin, Alfred Liu, *Kok Keun Lue*, Peng Luo, Eric Macdonald, Ashok Machcha, David Margulies, Marcus Marrow, Peter McEwen, Thomas McMillan, John Miller, Bruce Moision, Aravind Murthy, Robert O'Barr, Mats Oberg, Qingzhi Peng, enry Pfister, *Hung Dong Pham*, Tom Pisanic, Christopher Platt, Vijay Prabhakaran, Edward Price, Matt Pufall, Bart Raeymaekers, Sreenivasa Raghavan, *Winfried Richter*, *Timothy Riener*, *Jeff Rutland*, Craig



May 4, 1993 – CMRR celebrates 10th anniversary

February 19, 1997 – **Dr. Gordon F. Hughes** appointed CMRR Associate Director

July 1, 2000 - **Professor Paul H. Siegel** appointed CMRR Director

October 16, 2001 – Claude E. Shannon Symposium and Statue Dedication held at CMRR

May 20, 2003 – Shannon Memorial Lecture Fund established

May 6, 2003 – CMRR celebrates 20th anniversary

May 6, 2003 – CMRR establishes endowment fund for Sheldon Schultz Prize for Excellence in Graduate Student Research

July 1, 2004 – CMRR welcomes **Professor Sungho Jin**

September 20, 2004 – **Professor H. Neal Bertram** retires

September 30, 2005 – **Gordon F. Hughes**, Associate Director of CMRR, retires

November 1, 2006 - **Professor Eric Fullerton** appointed to CMRR Endowed Chair

July 10, 2007– The Shannon Graduate Fellowship Fund established

July 24, 2007 - **Professor Paul H. Siegel** appointed to CMRR Endowed Chair

October 30, 2008—CMRR celebrates 25th anniversary



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 Storage Tek
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 Toshiba
 3-M
 Verbatim Corporation
 Western Digital

Salling, Gene Sandler, Sandrawattie Sankar, Manfred Schabes, Christian Seberino, *Peter Shchupak*, Thomas Silva, Steven Slade, Joseph Smyth, Joseph Soriaga, Thomas Souvignier, *Aaron Swann*, M. Hossein Taghavi, Kentaro Takano, Sanwu Tan, Ryan Taylor, *Vince Tobin*, *Doug Trauner*, Bogdan Valcu, *David Wachenschwanz*, Michael Wahl, Joan Tang Waltman, *David E-Min Wang*, Jason Wang, Xiaobin Wang, Anthony Weathers, Stefan Weissner, Yiqian Wu, Xinzhi Xing, Jianfeng Xu, Min Yang, *Ping Yeh*, Jae-Young Yi, Samuel Yuan, Jiadong Zhang, Yun Zhang, Qing Zhao, Hong Zhou, Jian-Gang Zhu, *Pablo Ziperovich*.

Research Highlight **Modeling, Servo Control and Motion Planning for High Track Density Recording** by Raymond de Callafon

An essential component for high density and fast performance mechanical data storage systems is the ability to follow the physical tracks on which data exchange takes place. Data exchange in the form of reading and writing (magnetic) bits typically requires off-track positioning errors of a read/write element less than 10 percent of the actual track pitch. To give an indication of the position accuracy required, one of the latest developments in perpendicular recording technology used in modern hard disk drives, that remain to be an indispensable storage resource for digital appliances and recording equipment, have shown recording capabilities on an ultra-narrow track pitch of 65nm. Such ultra-narrow track pitches obviously places high demands on the performance and accuracy of the servo system needed to follow the physical tracks within less than 10nm accuracy.

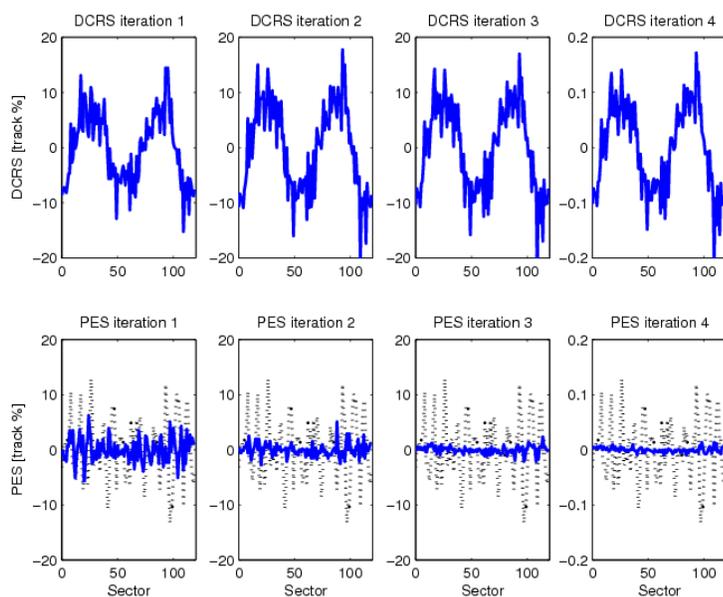
The design problem of a high performance and robust servo system is an intricate trade-off determined by actual system dynamics (actuator bandwidth), incomplete knowledge of system dynamics (uncertainty and product variations) and disturbances (rotating media, windage, friction) acting on the system. The Advanced Motion and Servo Laboratory (AMSL) at the CMRR directed by Prof. de Callafon, focuses on the development of high performance and robust servo control algorithms by developing the tools and algorithms to improve the information on system and disturbances dynamics. Better information on system and disturbances dynamics can alleviate the intricate design problem and help tune servo control and motion planning algorithms to squeeze out the maximally achievable performance. The ultimate goal is to develop these methods in such a way that they can be integrated in the firmware of system, providing automatic identification and tuning for servo control.

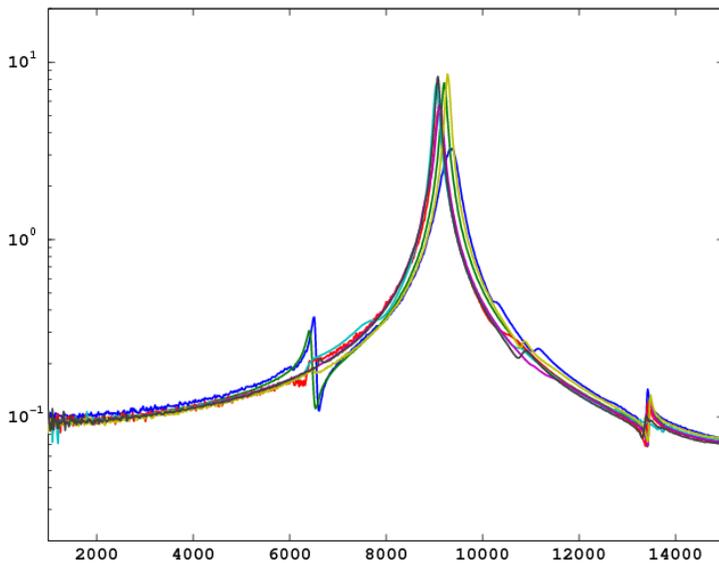
Supported by partial funding from the Information Storage Industry Consortium (INSIC) TAPE and EHDR program, the AMSL houses several magnetic data storage experiments that include hard disk drives (HDD) and linear tape open (LTO) storage systems. The unique property of the experiments in the AMSL is the ability to measure an *in situ* magnetically coded off-track Position Error Signal (PES), while having the opportunity to inject independent excitation signals during servo operation. This allows Prof. de Callafon and his students to perform experiments that can unravel the dynamics of the servo actuator and characterize the spectrum of any stochastic disturbances (non-repeatable runout errors) that cause PES and limit servo performance. A recent publication in Automatica [1] summarizes the two-step identification



procedure that allows estimation of models for actuator and disturbance dynamics, whereas collaborative work with Prof. Oboe [2] has shown the successful implementation of this procedure on actual data obtained from a HDD system.

Independently, work funded by several gifts from Headway to the AMSL has unleashed the ability to target specific periodic disturbance (repeatable runout errors) typically seen in the rotating storage media of a HDD. By the development of an Iterative Learning Control algorithm, that only requires limited knowledge of the closed-loop response of a servo actuator, Prof. de Callafon and his student Matthew Graham were able to show in [3] how fast decay of all periodic disturbance components can be obtained. Progress of the actual measurement of the PES obtained from one of the HDD applications in the AMSL in the CMRR has been depicted in the figure on the left.





The experimental data obtained from several dual-stage actuators was also the basis of a study associated to model uncertainty due to product variabilities. Dual-stage actuators are much smaller and thus provide a larger dynamic range for high bandwidth servo, but bandwidth is limited due to uncertainties in the dynamic behavior of the actuator. Such variations can be seen in many practical situations where one servo control algorithm is required to work with a large set of possible variations in actuator dynamics [4]. Independent work with Prof. Oboe [5] and Prof. Horowitz [6] have shown how such variations can be modeled in a single model with both an unstructured and structured uncertainty description. A snapshot of the measured frequency responses used in this study of seven (same model) dual-stage actuators has been depicted in the figure on the right.

Recent work of the AMSL also includes the development of new frequency domain identification techniques that are distributed to sponsors via a Matlab® coded Graphical User Interface that are based on realization methods [7]. Realization methods are data-based modeling techniques that do not require optimization techniques to compute parameter estimates of models. Instead, straightforward matrix analysis techniques such as a Singular Value Decomposition or a QR factorization are needed to compute a state space realizations of a discrete-time actuator model.

Our most recent realization technique allows the estimation of full actuator dynamics on the basis of simple step response experiments. The ability to perform repeated simple experiments and the absence of optimization code needed to compute parameter estimates brings the opportunity to code these estimation techniques directly in firmware much closer to reality. We are confident that automatic servo tuning based on actual *in situ* measurements from actuator and disturbance dynamics provides new opportunities towards designing optimal servo control algorithms that can minimize position error signals. With such enhanced modeling and servo control algorithms in place and encoded in firmware, ultra-narrow track pitches will provide less of a challenge for future high density data recording systems.

- [1] J. Zeng and R.A. de Callafon, "Control Relevant Estimation of Plant and Disturbance Dynamics - Model Approximation on the Basis of Closed-Loop Data," *Automatica*, Vol. 42, No. 11, pp. 1951-1957, 2006.
- [2] R. Antonello, R. Oboe, and R.A. de Callafon, "An Identification Experiment For Simultaneous Estimation of Low-Order Actuator and Windage Models in a Hard Disk Drive," *IEEE International Symposium On Industrial Electronics*, Vigo, Spain, pp. 3102-3107, 2007.
- [3] M.R. Graham and R.A. de Callafon, "An Iterative Learning Design for Repeatable Runout Cancellation in Disk Drives," *IEEE Transactions on Control Systems Technology*, Vol. 14, No. 3, pp. 474-482, 2006.
- [4] M.R. Graham, R.A. de Callafon, and L. Shrinkle, "Modeling and Low-Order Control of Hard Disk Drives with Consideration for Product Variability," *IEEE Transactions On Magnetics*, Vol. 42, No. 10, pp. 2588-2590, 2006.
- [5] M. Rotunno, R. Oboe, and R.A. de Callafon, "Modeling Product Variations in Hard Disk Drive Micro-Actuator Suspensions," *Microsystem Technologies*, Vol. 12, No. 9, pp. 803-813, 2006.
- [6] R.A. de Callafon, R. Nagamune, and R. Horowitz, "Robust Dynamic Modeling and Control of Dual-Stage Actuators," *IEEE Transactions on Magnetics*, Vol. 42, No. 2, pp. 247-254, 2006.
- [7] M. Claes, M.R. Graham, and R.A. de Callafon, "Frequency Domain Subspace Identification of a Tape Servo System," *Microsystem Technologies*, Vol. 13, pp. 1439-1447, 2007.

Selected Papers and Talks

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

Professor Emeritus Ami E. Berkowitz

J.I. Hong, F.T. Parker, V.C. Solomon, P. Madras, D.J. Smith, and **A.E. Berkowitz**, "Fabrication of spherical particles with mixed amorphous/crystalline nanostructured cores and insulating oxide shells," *Journal of Materials Research*, Vol. 23, (2008), pp. 1758-1763.

A.E. Berkowitz, G.F. Rodriguez, J.I. Hong, K. An, T. Hyeon, N. Agarwal, D.J. Smith, and **E.E. Fullerton**, "Monodispersed MnO nanoparticles with epitaxial Mn₃O₄ shells," *Journal of Physics D: Applied Physics*, Vol. 41, No. 13, (July 2008), pp. 134007-1-5.

Professor Emeritus H. Neal Bertram

H.N. Bertram, M.E. Schabes, **V. Lomakin**, and B. Livshitz, "Nucleation fields in composite medium grains," *Journal of Applied Physics*, Vol. 103, No. 7, (April 2008), pp. 07F508-1-3.

B. Livshitz, R. Choi, **V. Lomakin**, A. Inomata, and **H.N. Bertram**, "Fast precessional reversal in perpendicular composite patterned media," *Journal of Applied Physics*, Vol. 103, No. 7, (April 2008), pp. 07C516-1-3.

S. Karakulak, **P.H. Siegel**, **J.K. Wolf**, and **H.N. Bertram**, "Equalization and detection for patterned media recording," *IEEE International Magnetism Conference 2008, Madrid, Spain*, (May 4-8, 2008).

H.N. Bertram, B. Wilson, and R. Wood, "Error rate expression for perpendicular magnetic recording," *IEEE Transactions on Magnetism*, Vol. 44, No. 10, (October 2008), pp. 2414-2422.

Professor Eric E. Fullerton

D. Stanescu, D. Ravelosona, V. Mathet, C. Chappert, Y. Samson, C. Beigne, J. Ferre, J. Gierak, E. Bouhris, and **E.E. Fullerton**, "Tailoring magnetism in CoNi films with perpendicular anisotropy by ion irradiation," *Journal of Applied Physics*, Vol. 103, No. 7, (April 2008), pp. 07B529-1-3.

E.E. Fullerton and S. Mangin, "Origin of the magneto-thermoelectric voltage in cluster-assembled metallic nanostructures," *Nature Materials*, Vol. 7, No. 4, (April 2008), pp. 257-258.

J.A. Katine and **E. E. Fullerton**, "Device implications of spin-transfer torques," *Journal of Magnetism and Magnetic Materials*, Vol. 320, No. 7, (April 2008), pp. 1217-1226.

S.M. Watson, T. Hauet, J.A. Borchers, S. Mangin, and **E.E. Fullerton**, "Interfacial magnetic domain wall formation in perpendicular-anisotropy, exchange-spring films," *Applied Physics Letters*, Vol. 92, No. 20, (May 2008), pp. 202507-1-3.

Professor Sungho Jin

I-C. Chen, Li-H. Chen, A. Gapin, **S. Jin**, L. Yuan, and S-H. Liou, "Iron-platinum-coated carbon nanocone probes on tipless cantilevers for high resolution magnetic force imaging," *Nanotechnology*, Vol. 19, No. 7, (February 2008), pp. 075501.

Professor Paul H. Siegel

N. Kashyap and **P.H. Siegel**, "Ghostbusting: coding for optical communications," DIMACS Series in Discrete Mathematics and Theoretical Computer Science, Advances in Information Recording, Vol. 73, (February 2008), pp. 147-164.

A.H. Djahanshahi, **P.H. Siegel**, and L.B. Milstein, "Decoding on graphs: LDPC-coded MISO systems and belief propagation," *IEEE Wireless Communications and Networking Conference, Las Vegas, NV*, (March/April 2008), pp. 94-99.

J. Han, **P.H. Siegel**, and A. Vardy, "Improved probabilistic bounds on stopping redundancy," *IEEE Transactions on Information Theory*, Vol. 54, No. 4, (April 2008), pp. 1749 - 1753.

Professor Frank E. Talke

D.E. Lee, B. Raeymaekers, and **F.E. Talke**, "In-situ monitoring of the brush/rotor interface in a homopolar motor with acoustic emission," *Australian Journal of Mechanical Engineering*, Vol. 6, No. 1, (2008), pp. 53-59.

J. Kim, J. Wang, H-J. Kang, and **F.E. Talke**, "A study of nano-mechanical and macro-mechanical properties of ethylene vinyl acetate," *Polymer Engineering & Science*, Vol. 48, No. 2, (February 2008), pp. 277-282.

B. Raeymaekers, D.E. Lee and **F.E. Talke**, "A Study of the brush/rotor interface of a homopolar motor using acoustic emission," *Tribology International*, Vol. 41, No. 5, (May 2008), pp. 443-448.

H. Zheng, A.N. Murthy, E.B. Fanslau Jr., and **F.E. Talke**, "Effect of suspension design on the non-operational shock response in a load/unload hard disk drive," *ISPS'08 - 18th Annual ASME Conference on Information Storage and Processing Systems, Santa Clara, CA*, (June 16-17, 2008).

(Continued from page 8)

Y. Yoon and **F.E. Talke**, "The effect of grooves of discrete track recording media on the touch-down and take-off hysteresis of magnetic recording sliders," *ISPS'08 – 18th Annual ASME Conference on Information Storage and Processing Systems*, Santa Clara, CA, (June 16-17, 2008), Paper ID No. THN-F4.

Professor Jack K. Wolf

S. Aviran, **P.H. Siegel**, and **J.K. Wolf**, "Optimal parsing trees for run-length coding of biased data," *IEEE Transactions on Information Theory*, Vol. 54, No. 2, (February 2008), pp. 841-849.

Z. Wu, **P.H. Siegel**, **J.K. Wolf**, and **H.N. Bertram**, "Mean-adjusted pattern-dependent noise prediction for perpendicular recording channels with nonlinear transition shift," *IEEE International Magnetism Conference 2008*, Madrid, Spain, (May 4-8, 2008).

Z. Wu, **H.N. Bertram**, **P.H. Siegel**, and **J.K. Wolf**, "Nonlinear transition shift and write precompensation in perpendicular magnetic recording," *Proceedings IEEE International Conference on Communications*, Beijing, China, (May 19-23, 2008), pp. 1972-1976.

Graduate Students & Researchers Near Completion

Student	Level	Advisor	Dept	Research	Completion
Ralf Brunner	Ph.D.	Talke	MAE	Carbon coating and lubrication studies for wear protection of the head/disk interface	December 2008
Zheng Wu	Ph.D.	Siegel/ Wolf	ECE	Recording channel modeling; equalization and detection techniques; error-control coding algorithms and architectures	Fall 2008

The Fall 2008 Research Review and Advisory Council Meeting will be held on October 29-30, 2008. For further information on the Fall Review, please contact Betty Manoulian at 858-534-6707 or bmanoulian@ucsd.edu.

CMRR Research Review Highlights

The Spring Research Review held in April 2008 was a well attended success. Over fifty people from CMRR Industrial Sponsor companies and other invited guests participated in the meeting, including several who participated via teleconference.

In addition to the sessions devoted to technical presentations of CMRR research results, the Review featured a special presentation by Richard Bradshaw entitled "Digital Magnetic Storage on Flexible Media: The Future of Tapes as Long Term Archival Media."

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/subpgset.htm>. Contact Jan Neumann at jneumann@ucsd.edu with any questions regarding Sponsor Resources.

Graduate Degree Awarded



M. Hossein Taghavi, an electrical engineering graduate student in Professor Siegel's group, received his Ph.D. in October 2008. His dissertation was entitled "Decoding Linear Codes via Optimization and Graph-Based Techniques," and his research was mainly on error-correcting codes and detection algorithms for magnetic recording systems. In October 2008, Mohammad joined the corporate R&D division of QUALCOMM in San Diego.

New Postdoctoral Scholar

Dr. Andrey Ovcharenko is a new postdoctoral scholar in Professor Frank Talke's group. He received his Ph.D. from the Israel Institute of Technology (Technion). His dissertation was entitled "Experimental Investigation of Junction Growth in Elastic-Plastic Spherical Contact." At CMRR, Andrey will be involved in simulation of patterned media using the Reynolds equation and contact mechanics of suspension and gimbal assembly. Outside the lab, Andrey enjoys mountain skiing, tennis, and hiking.

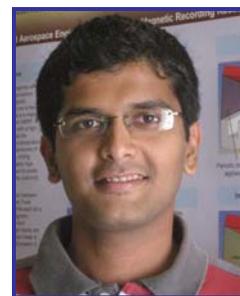


New Graduate Students



Jonathan Sapan is a new graduate student in Professor Eric Fullerton's group. Jonathan was born in San Francisco and raised in San Rafael, CA. He received his B.S.E. in electrical engineering from Princeton University in 2004. Before coming to UCSD, he spent two years as an engineer at the GE Global Research Center in Niskayuna, NY, and two years at technology companies in the Boston area.

Aravind Iyengar is a new graduate student in Professor Paul Siegel and Professor Jack Wolf's lab. He received his Bachelor's Degree in electrical engineering from the Indian Institute of Technology, Madras. His research interests include coding and information theory. He is presently working on Non-binary LDPC Codes.



Visitors



Joerg Fritzsche is a visiting student in Professor Frank Talke's lab for the academic year 2008/2009. Joerg is here on a scholarship from the German Academic Exchange Service (DAAD). During his stay he will perform research at CMRR and attend courses at UCSD. In 2005, he joined the mechanical engineering program at the University of Rostock. In 2007, he passed his intermediate examination successfully and is now specializing in thermodynamics and fluid mechanics. Outside of the lab, Joerg enjoys surfing, swimming, and living in San Diego.

Sebastian Helm is a visiting student in Professor Frank Talke's lab for the academic year 2008/2009. Sebastian is here on a scholarship from the German Academic Exchange Service (DAAD). In 2005, he joined the mechanical engineering program at the University of Rostock. In 2007 he passed his pre-diploma successfully, and since then he is specializing in solid and fluid mechanics. Outside of the lab, Sebastian enjoys soccer, American football, and surfing.



Longqiu Li has joined Professor Frank Talke's lab as a visiting graduate student for the academic year 2008/2009. He is here on a scholarship from the China Scholarship Council (CSC). He received his Bachelors (BS) degree in Mechanical Design Manufacturing and Automation Engineering in 2005 from Harbin Institute of Technology (HIT), China. He became a Ph.D. student in 2005. His current research is related to experimental and theoretical studies of fretting wear of the head-disk dimple/gimbal and the tribology of the head-disk interface. Outside of work and study, Longqiu is very fond of traveling, singing, and playing ping pong.

Christian Minx is a visiting student in Professor Frank E. Talke's lab for the academic year 2008/2009. Christian is here on a scholarship from the German Academic Exchange Service (DAAD). In 2005, he joined the mechanical engineering program at the University of Rostock. In 2007, he passed his pre-diploma successfully, specializing in applied mechanics. Outside of the lab, Christian enjoys being a soccer referee and listening to music.



Gifts, Grants and Awards

INSIC EHDR Program supported the following CMRR research projects:

- Professor **Frank E. Talke** and **Dr. Fred Spada's** research on "Lubrication and Wear Studies of Carbon-Free Disks."
- Professors **Vitaliy Lomakin** and **Eric E. Fullerton** proposal "Controlled Lateral and Vertical Exchange in Patterned Composite Media."
- Travel support for **H. Neal Bertram** to attend INSIC EHDR meetings.

Other support:

- Professor **Paul H. Siegel** received an NSF award to support his research on "Code Representation and Performance of Graph-Based Decoding."
- **Dr. Fred Spada** received funding from NSA to continue his NSA Project on "Magnetic Storage Device Secure Erasure."



Zheng Wu, a doctoral student co-advised by Prof. Siegel and Prof. Wolf, had a productive summer internship at the Samsung R&D Center, Samsung Information Systems America (SISA), in San Jose, California. The topic of her project was write precompensation for nonlinear transition shift (NLTS) in perpendicular magnetic recording systems. NLTS is a phenomenon that occurs during the process of writing magnetic transitions. It affects the readback signal and can degrade the system performance. An effective way to combat NLTS is to offset the location of the written transition, a technique called “write precompensation.” The precompensation required for any given transition depends upon the location of previously written transitions. There is no simple or direct method to optimize the precompensation values for different patterns of transitions in order to minimize the system bit error rate. The conventional approach is to empirically “tune” the precompensation using a brute-force search over all possible values. Zheng’s project, supervised by Dr. Yawshing Tang, investigated a new method to determine effective precompensation values. The method is much simpler than the brute-force approach, and it was found to give performance very close to optimal in experimental tests on actual disk drives.

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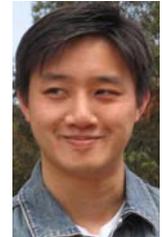
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Keith Chan, a member of Professor Fullerton’s group, spent the summer at Seagate Technology in Fremont, California, working on perpendicular recording media with the advanced development team.

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may result from electrochemical processes at the head-tape interface during tape motion. His research has identified conditions under which material deposition will occur on the critical areas of the head near the poles and gap. Dr. Spada’s methodology has been actively peeling away the layers of this very complex problem. His work has clearly demonstrated the following important findings:

- The role of the tape’s fatty acid ester lubricants in material transport and deposition.
- The role of head material composition in the wear and deposition processes.
- The very dramatic change in the operational chemistry of material removal from the metal elements in recording head structures and the re-deposition on the substrates, as a function of humidity and galvanic current path.
- The importance of electrochemical effects on material migration (both corrosion and deposition) in head structures.



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