University of California, San Diego ISSN: 0888-7381

CMRR Report

Center for Magnetic Recording Research

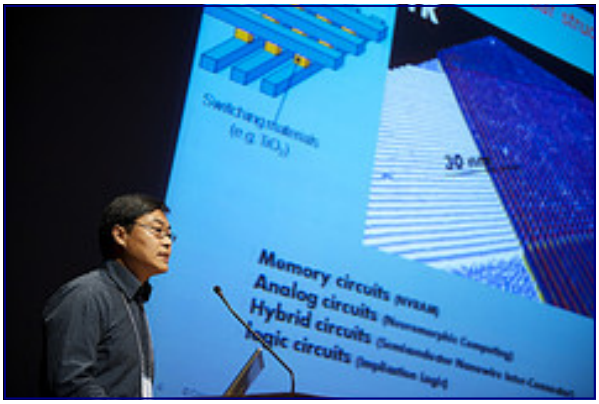
Research Highlight

Chemical Vapor Deposition of Transition-metal Nanostructures

Contents:

Number 35 Winter 2011

2nd Annual Non-Volatile Memories Workshop Attracts over 200 Participants



The 2nd Annual Non-Volatile Memories Workshop (NVMW), which was held March 6-8, 2011 on the UCSD campus, confirmed the growing importance of non-volatile, solid-state memories in emerging data storage and computing applications, as well as the vital role being played by UCSD researchers in accelerating progress in this exciting information technology sector.

Following the successful formula of the 2010 workshop, the interdisciplinary workshop provided a forum for academic and industrial researchers, with expertise in areas ranging from device physics and circuit design to data

(Continued on page 3)

CMRR Professor Frank Talke Receives the 2010 Tribology Gold Medal

Frank E. Talke, an Endowed Chaired Professor at CMRR has been selected to receive the 2010 Tribology Gold Medal. This award is "in recognition of his outstanding achievements in Tribology, in particular, for his meritorious work in the field of magnetic storage systems, ink jet technology, and interferometric instrumentation."

This prestigious award, administered by the United Kingdom Institution of Mechanical Engineers and the Tribology Trust, is internationally recognized as the highest honor in tribology

(Continued on page 2)

(Continued from page 1)

research and its application. Tribology, the study of friction, wear and lubrication, covers many key sciences including physics, chemistry, and engineering. It is vital for improving the reliability of hard disk drives for information storage, as well as the safety of automobiles. The Tribology Gold Medal was established in 1972, and has been awarded to 38 individuals from 12 different countries. The award in the past has been presented by British ambassadors in the case of non-UK recipients and by a Secretary of State in the case of a UK resident medalist.

CMRR and the MAE Department of UCSD congratulate Frank for this latest of his major professional awards, the prestigious Tribology Gold Medal.

CMRR Alumni

Professor of Engineering at Carnegie Mellon University and current Data Storage Systems Center Director Jimmy Zhu has received the IEEE Magnetics Society Achievement Award "for contributions to magnetic storage devices through magnetic modeling." The award, which consists of a diploma with citation and a cash prize, honors one of the society's members each year for his or her lifetime professional achievement. It is the Society's highest award.

"I am truly honored to receive this award from the IEEE Magnetic Society, especially considering the list of people who have received this award in the past," Zhu said.

Jimmy received his Ph.D. from UCSD in 1989 and was advised by CMRR Professor Emeritus H. Neal Bertram.

ECE Best Teacher Award

Professor Joe Ford and CMRR Professor Paul H. Siegel were awarded best teacher awards for the 2009-2010 academic year (for undergraduate and graduate teaching, respectively).

Both faculty members received the highest praise from their students and have demonstrated true excellence in academic instruction. Congratulations to them both!

(Continued from page 1)

encoding and storage system architectures, to share their latest technical advances and exchange forward-looking ideas about the shape of future information storage systems.

The more than 225 attendees included international representatives from over 30 corporations, 34 universities, and 5 government labs, including 62 students and post-graduate researchers.

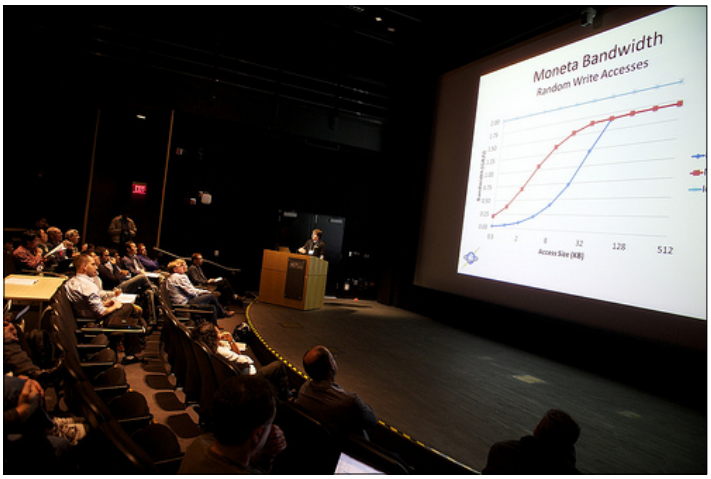
The workshop was organized and hosted by the Non-Volatile Systems Laboratory (NVSL) in the Computer Science and Engineering department, the Center for Magnetic Recording Research (CMRR) and the California Institute of Telecommunications and Information Technology (Calit2) at UCSD.

NVMW General Co-Chairs Paul Siegel and Steven Swanson see the workshop as essential to facilitating the exchange of ideas necessary to make the best use of non-volatile, solid-state memories. “The number and diverse backgrounds of the attendees demonstrate how many disciplines need to work closely together to fully realize the benefits that these technologies can provide. We are very excited that UCSD can play an active role in building a research community around non-volatile memories,” said Swanson.

Corporate sponsorship was provided by IBM Research, Hewlett-Packard (HP), Microsoft Research, Cadence, Google, and LSI. The workshop also received funding from the National Science Foundation. “The generous support of our donors allowed us to make the workshop accessible to a large audience and to provide travel support to more than 40 students and post-docs,” said Siegel.

The workshop program began with a comprehensive tutorial entitled “Phase Change Memory – Fundamentals, Opportunities and Challenges,” presented by Dr. Moinuddin Qureshi and Dr. Bipin Rajendran of IBM Watson Research Center and Prof. Sudhanva Gurumurthi of the University of Virginia. The technical program, assembled by the 20-member Program Committee, featured two sessions each on diverse topics in Devices, Error-Control Coding, Architectures, and Applications, with 32 presentations overall. An additional 21 submissions were represented in the poster session.

The keynote addresses that opened each day of technical sessions were another highlight of the meeting. Prof. Jehoshua (Shuki) Bruck of Caltech spoke on “Rank Modulation for Flash Memories” and Dr. C. Mohan of IBM Almaden Research Center examined “Implications of Storage Class Memories on Software Architectures.”



The workshop atmosphere was informal, with the reception, banquet, luncheons and extended session breaks providing ample opportunity for brainstorming, conversation and discussion. The NVMW 2011 Playlist Contest at the conclusion of the banquet tested the attendees’ knowledge of popular music with “non-volatile, solid-state memory” themes, while exposing the strengths and weaknesses of smartphone music recognition software.

Research Highlight

Chemical Vapor Deposition of Transition-metal Nanostructures

Keith Chan, Chris Doran, Jimmy Kan and Eric Fullerton
University of California, San Diego

As the dimensions of a material approach the nanoscale new physical and chemical properties emerge. Clear understanding of these properties and their new functionality will lead to emerging applications in diverse areas such as catalysis[1], fuel cells[2], thermoelectrics[3], sensors[4], batteries[5], and magnetic devices.[6] Chemical vapor deposition (CVD) techniques have been applied to achieve a broad range of nanostructured materials with a particular focus on the growth of nanowires (NWs). The most common and well-studied CVD methods for NW synthesis have focused on the elemental semiconductors Si and Ge, compound semiconductors including ZnO and InAs, as well as C nanotubes. The synthesis of these high-aspect-ratio materials typically relies on the vapor-liquid-solid (VLS) mechanism using foreign catalyst seeding and lattice-matched single-crystal substrates for morphological control and epitaxy-dependent vertically-oriented growth, respectively.

Research at CMRR has focused on extending CVD to new types of NW materials, particularly transition-metals and their oxides, to broaden their applications and impact. Furthermore the realization of many practical applications will require efficient and economical synthesis techniques that preferably avoid the need for templates or costly single-crystal substrates. Towards this end we have developed an efficient and economical single-step route for the reduction-type synthesis of nano-structured Ni materials using a thermal CVD.[7] By tuning the CVD growth parameters we can synthesize Ni nanostructures including single-crystal cubes (Fig. 1) and horizontally- and vertically-oriented NW arrays (Fig. 2) and polycrystalline Ni/NiO core-shell NWs which all form atop untreated amorphous SiO_2||Si substrates.

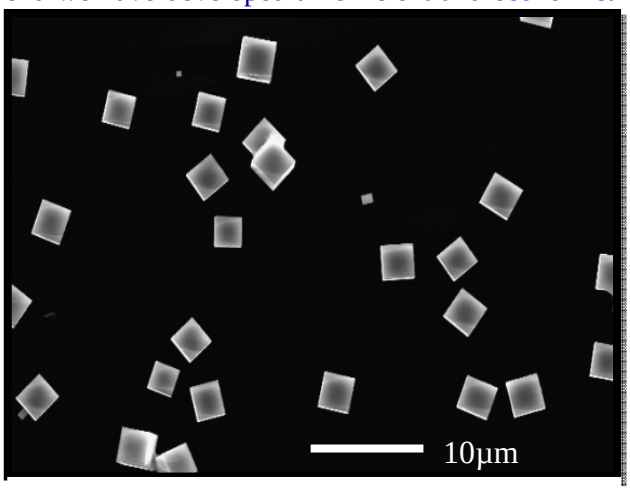


Figure 1: Single-crystal Ni cubes formed on SiOx coated Si substrates.

In addition to the well-known uses of its magnetic behavior in various spin-based devices, nanostructured Ni and Ni-based materials are also critical components in many chemical engineering processes including such examples as the steam reformation of CH_4 in synthesis gas production and other similar applications utilizing the catalytic nature of transition-metal surfaces. Ni-based NWs in particular have high surface area-to-volume ratios and are capable of providing a high density of active sites for surface reactions thereby increasing the efficiency in such applications. Additionally, materials like the core-shell structured Ni-NiO NWs can serve as templates for further material deposition in cases where a non-interacting surface is desired.[6]

Shown in Fig. 2 are two of the synthesized Ni NW phases: vertically oriented NWs (Fig. 2a) and horizontally oriented NWs (Fig. 2b). X-ray and electron diffraction show that the NWs are single-crystal, are oriented along <001> crystallographic direction with a face-centered cubic unit cell of 0.352 nm consistent with bulk Ni and are atomically smooth. The NWs can be grown with diameters ranging from 50 to 300 nm and lengths up to 5 um for vertical NWs (Fig. 1a) and 80 um for horizontal NWs (Fig. 2b). Vertical NW diameter and growth density can be further controlled through temperature adjustment as seen in Figs. 2c and 2d. Figure 2c are 100-nm diameter wires with a relatively low density of 0.1 NW/µm^2 while Fig. 2d are 250-nm diameter NWs with a higher density of 0.3 NW/µm^2.

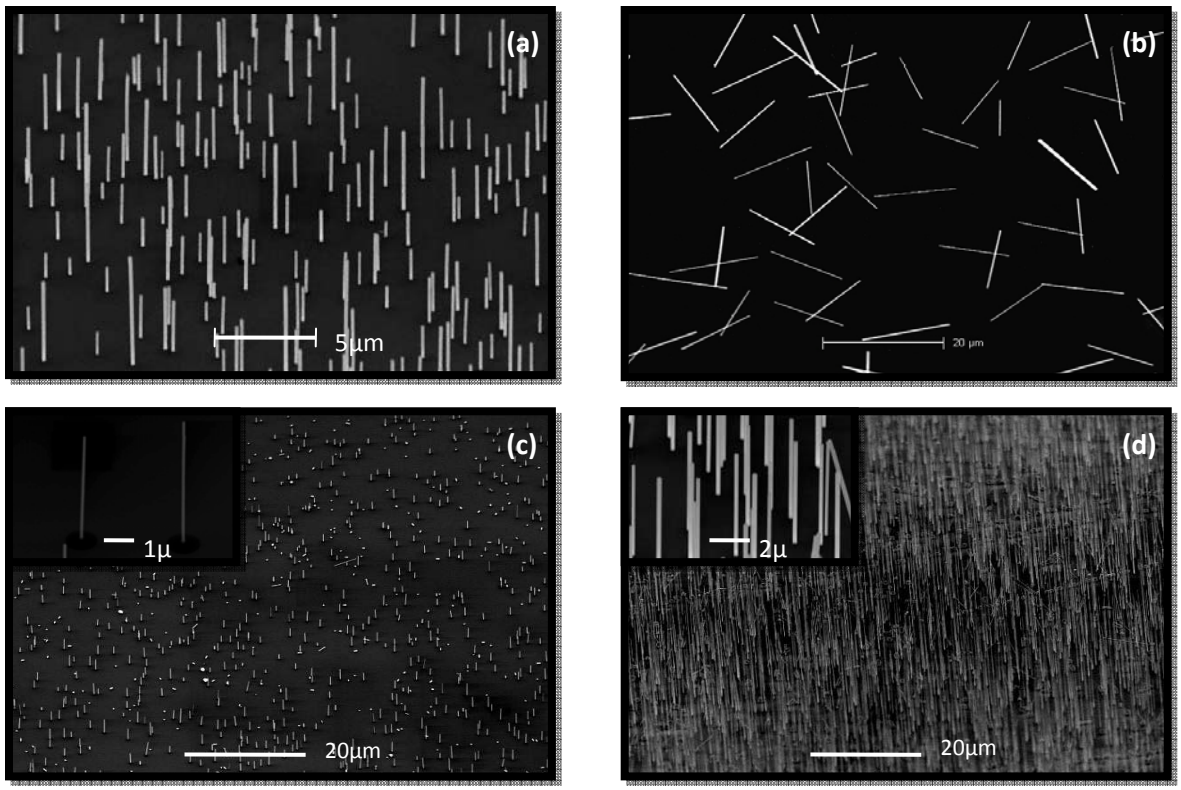


Figure 2: SEM images of as-grown Ni NW arrays with (a) vertical orientation grown at 650˚C, (b) horizontal orientation grown at 700˚C and vertically oriented NWs with (c) low density and diameter near 100nm grown at 630˚C and (d) high density and diameter near 250nm grown at 675˚C.

A detailed formation mechanism for the vertically-oriented, single-crystal NW phase is given in Ref. 7 which relies on a laterally confined layer of Si-based material for growth mediation. Preferential accumulation of Ni adatoms at Si-rich growth sites leads to anisotropic crystallization proceeding along a single direction. The Si responsible for NW formation is likely released from the cleaved sidewalls of the $SiO_2||Si$ substrates. By further controlling the precursor moisture content and temperature a broad range of phases can be formed.

We characterized the magnetic response of individual NWs by magneto-transport measurements (Fig. 3) and x-ray photoemission electron microscopy (Fig. 4). The anisotropic magnetoresistance (AMR) of ferromagnetic materials depends on the relative angle between the magnetization direction and the current flow. Shown in Fig. 3 is the AMR behavior of a 100-nm-diameter vertical NW as measured at 10 K with the applied field both parallel and perpendicular to the NW axis. The AMR curves are nearly reversible (i.e. independent of field history) with only small regions of irreversibility. The NW resistance at $H_{applied}$ = 0 Oe is intermediate between the parallel and perpendicular states indicating a remanent state with an angle of magnetization ~45 degrees to the wire axis. To understand the NW magnetic behavior we have modeled the magnetic response of a <001>-oriented single-crystal NW using micromagnetic simulations and the bulk properties of Ni. Results of the AMR calculations are shown in Fig. 3 which reproduces all of the observed features of the measured AMR data.

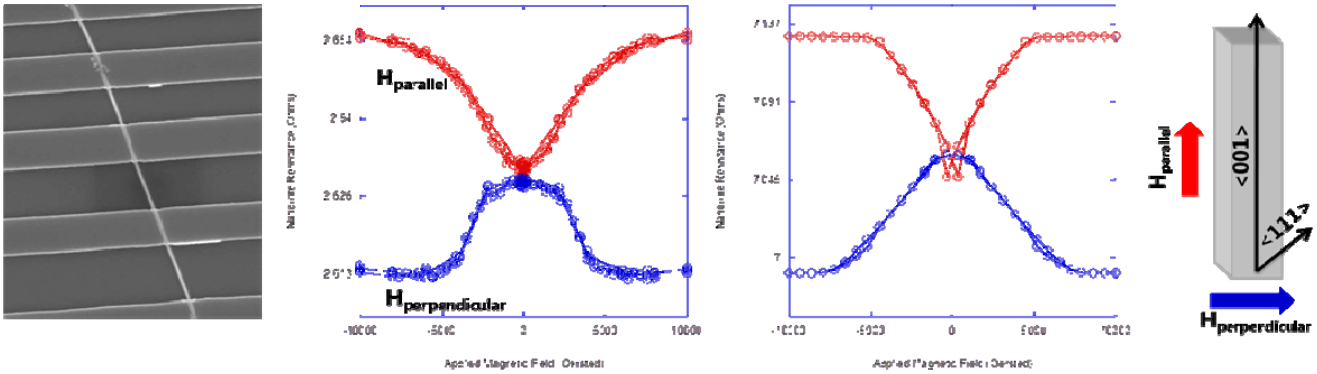


Figure 3: We use magneto-transport measurements of individual Ni NWs to probe their magnetic response to field. The left image is an individual wire with leads where we measure the resistance as a function of applied field parallel and perpendicular to the wire axis. The left graph is the measured data and the right graph is the results of micromagnetic simulations.

The simulations suggest a complex domain behavior that forms during reversal. This behavior results from the competing shape anisotropy of the NW, which favors magnetization along the NW axis, and the magnetocrystalline anisotropy, which favors magnetization along the <111> crystallographic direction. This competition results in the formation of stripe domains down the wire show in the top image of Fig. 4. To confirm the behavior we imaged the domain pattern of individual wires (Fig. 4 bottom image) which agrees quantitatively with the micromagnetic results and shows the wires are behaving as expected for a single-crystal NW.

In conclusion we have developed a simple CVD approach from metal-halide precursors to form and control distinct nanostructured growth phases of Ni. Of particular importance is the establishment of a detailed methodology concerning the growth of NW growth phases which successfully relates specific experimental growth parameters, underlying formation mechanisms, and electrical and magnetic properties. This study of Ni nanostructure growth phases readily lends itself to a generalized approach for nanostructure growth of transition metals that can be applied to a broad range of nanotechnologies.

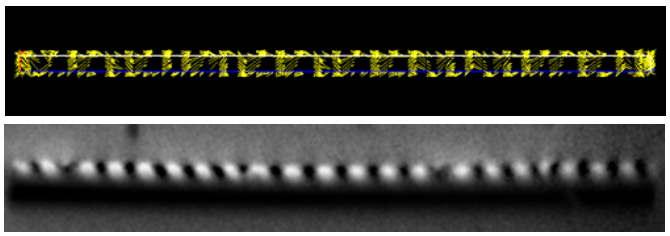


Figure 4: Magnetic domain images (top) for a single-crystal Ni NW compared to magnetic imaging (below).

1. Beebe, T.P.; Goodman, D.W.; Kay, B.D.; Yates, J.T. *J. Chem. Phys.* **1987**, 87(4), 2305-2315.
2. Asazawa, K.; Sakamoto, T.; Yamaguchi, S.; Yamada, K.; Fujikawa, H.; Tanaka, H.; Oguro, K. *J. Electrochem. Soc.* **2009**, 156(4), B509-B512.
3. Boukai, A.I.; Bunimovich, Y.; Tahir-Kheli, J.; Yu, J.K.; Goddard, W.A.; Heath, J.R. *Nature* **2008**, 451(7175), 168-171.
4. Shibli, S.M.A.; Beenakumari, K.S.; Suma, N.D. *Biosens. Bioelectron.* **2006**, 22(5), 633-638.
5. Chan, C.K.; Peng, H.L.; Liu, G.; McIlwrath, K.; Zhang, X.F.; Huggins, R.A.; Cui, Y. *Nat. Nanotechnol*. **2008**, 3(1), 31-35.
6. Chan, K.T.; Doran, C.; Shipton, E.G.; Fullerton, E.E. *IEEE Trans. Magn*. **2010**, 46(6), 2209-2211.
7. Chan, K.T.; Kan, J.J.; Doran, C.; Lu O.; Smith, D.J.; Fullerton, E.E., *Nano Lett.* **2010**, 10, 5070.

Shelly Schultz Symposium

In May 2000, David R. Smith, Willie J. Padilla, D. C. Vier, Sia Nemat-Nasser, and Shelly Schultz, former CMRR Director, published an article in *Physical Review Letters* reporting the first observation of the negative refraction index in a composite medium.

This seminal work has launched a new research field now commonly referred to as "Metamaterials." Ten years of research in hundreds of laboratories around the world show that metamaterials are likely to revolutionize both communications and imaging. A first group of commercial products are already emerging.

On November 4, 2010, a symposium to commemorate this and other discoveries made by Professor Sheldon (Shelly) Schultz, one of the founding members of the Physics Department at UC San Diego, took place. The day-long symposium on "The Discovery of Metamaterials at UCSD" was part of UC San Diego's 50th Anniversary celebrations, and included a public lecture by Sir John Pendry (Imperial College) and Dr. David Smith (Duke) entitled "Metamaterials and the Science of Invisibility."

Other participants of the Schultz symposium included: Don Eigler (IBM), Willie Padilla (Boston College), David Schurig (NCSU), Harold Weinstock (AFOSR), Costas Soukulis (U. of Iowa), Sia Nemat-Nasser (UCSD), A. Starr (Sensometrix), Ami Berkowitz (CMRR), Nader Engheta (U Penn), Lu Sham (UCSD).

The Spring 2011 Research Review and Advisory Council Meeting will be held on May 4-5, 2011. For further information on the CMRR Research Review, please contact Iris Villanueva at 858-534-6196 or ivilla@ucsd.edu .

Selected Papers and Talks

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

Professor Emeritus H. Neal Bertram

S. Karakulak, **P.H. Siegel**, **J.K. Wolf**, and **H.N. Bertram**, "Joint-track equalization and detection for bit patterned media recording," *IEEE Transactions on Magnetics*, Vol. 46, No. 9, (September 2010), pp. 3639-3647.

Professor Eric E. Fullerton

M. Gauvin, **E.E. Fullerton**, and **F.E. Talke**, "Investigation of Fe–Si–N films as magnetic overcoat for high density recording disk drives," *Journal of Applied Physics*, Vol. 108, No. 6, (September 2010), pp. 063925.

A. Berger, S. Mangin, J. McCord, O. Hellwig, and **E.E. Fullerton**, "Cumulative minor loop growth in Co/Pt and Co/Pd multilayers," *Physical Review B*, Vol. 82, No. 10, (September 2010), pp. 104423-1-9.

I. Schmid, M.A. Marioni, P. Kappenberger, S. Romer, M. Parlinska-Wojtan, H.J. Hug, O. Hellwig, M.J. Carey, and **E.E. Fullerton**, "Exchange bias and domain evolution at 10nm scales," *Physical Review Letters*, Vol. 105, No. 19, (November 2010), pp. 197201-1-4.

D. Bedau, H. Liu, J.Z. Sun, J.A. Katine, **E.E. Fullerton**, S. Mangin, and A.D. Kent, "Spin-transfer pulse switching: From the dynamic to the thermally activated regime," *Applied Physics Letters*, Vol. 97, No. 26, (December 2010), pp. 262502-1-3.

K. Chesnel, J.A. Nelson, S.D. Kevan, M.J. Carey, and **E.E. Fullerton**, "Oscillating spatial dependence of domain memory in ferromagnetic films mapped via x-ray speckle correlation," *Physical Review B*, Vol. 83, No. 5, (February 2011), pp. 054436.

J.M.L. Beaujour, A.D. Kent, D. Ravelosona, I. Tudosa, and **E.E. Fullerton**, "Ferromagnetic resonance study of Co/Pd/Co/Ni multilayers with perpendicular anisotropy irradiated with helium ions," *Journal of Applied Physics*, Vol. 109, No. 3, (February 2011), pp. 033917

Professor Sungho Jin

K. Noh, C. Choi, J-Y. Kim, M. Loya, and **S. Jin**, "Long-range ordered aluminum oxide nanotubes by nanoimprint-assisted aluminum film surface engineering," *Journal of Vacuum Science and Technology B*, Vol. 28, No. 6, (November-December 2010), pp. C6M88-C6M92.

Associate Professor Vitaliy Lomakin

M.V. Lubarda, S. Li, B. Livshitz, **E.E. Fullerton**, and **V. Lomakin**, "Reversal in bit patterned media with vertical and lateral exchange," *IEEE Transactions on Magnetics*, Vol. 47, No. 1, (January 2011), pp. 18-25.

Professor Paul H. Siegel

E. Yaakobi, A. Jiang, **P.H. Siegel**, A. Vardy, and **J.K. Wolf**, "On the parallel programming of flash memory cells," *2010 IEEE Information Theory Workshop - ITW 2010 Dublin*, (August 30- Sept. 3, 2010).

G.E. Corazza, A.R. Iyengar, M. Papaleo, **P.H. Siegel**, A. Vanelli-Coralli, and **J.K. Wolf**, "Latency constrained protograph-based LDPC convolutional codes," *2010 6th International Symposium on Turbo Codes & Iterative Information Processing*, Brest France, (September 6-10, 2010).

A. Jiang, R. Mateescu, E. Yaakobi, J. Bruck, **P.H. Siegel**, A. Vardy, and **J.K. Wolf**, "Storage coding for wear leveling in flash memories," *IEEE Transactions on Magnetics*, Vol. 46, No. 10, (October 2010), pp. 5290-5299.

A.R. Iyengar, **P.H. Siegel**, and **J.K. Wolf**, "Write channel model for bit-patterned media recording," *IEEE Transactions on Magnetics*, Vol. 47, No. 1, (January 2011), pp. 35-45.

M.H. Taghavi and **P.H. Siegel**, "Graph-based decoding in the presence of ISI," *IEEE Transactions on Information Theory*, Vol. 57, No. 4, (April 2011), pp. 2188-2202.

(Continued from page 8)

P.H. Siegel, "Coding for Storage Devices," Distinguished Speaker Series, Electrical Engineering Department, Texas A&M, April 5, 2011.

Professor Frank E. Talke

B. Raeymaekers and **F. E. Talke**, "The effect of laser polishing on fretting wear between a hemisphere and a flat plate," *Wear*, Vol. 269, No. 5-6, (July 2010), pp. 416-423.

R. Brunner, G.W. Tyndall, R.J. Waltman, and **F.E. Talke**, "Adhesion between surfaces separated by molecularly thin perfluoropolyether films," *Tribology Letters*, Vol. 40, No. 1, (October 2010), pp. 41-48.

R. Brunner and **F.E. Talke**, "Tribological and mechanical characterization of carbon-coated sliders and disks," *Tribology Letters*, Vol. 40, No. 1, (October 2010), pp. 23-29.

A. Ovcharenko, M. Yang, K. Chun, and **F.E. Talke**, "Effect of impact conditions and slider corner radius on the thermal-mechanical response during slider-disk contacts," *IEEE Transactions on Magnetics*, Vol. 46, No. 10, (October 2010), pp. 3760-3766.

L. Li, I. Etsion, and **F.E. Talke**, "Elastic-plastic spherical contact modeling including roughness effects," *Tribology Letters*, Vol. 40, No. 3, (December 2010), pp. 357-363.

L. Li, A. Ovcharenko, I. Etsion, and **F.E. Talke**, "The effect of asperity flattening during cyclic normal loading of a rough spherical contact," *Tribology Letters*, Vol. 43, No. 3, (December 2010), pp. 347-355.

L. Li., I. Etsion, A. Ovcharenko, and **F.E. Talke**, "The onset of plastic yielding in a spherical shell compressed by a rigid flat," *Journal of Applied Mechanics*, Vol. 78, No. 1, (January 2011), pp. 011016.

L. Li, L. Wang, I. Etsion, and **F.E. Talke**, "The effect of contact conditions and material properties on plastic yield inception in a spherical shell compressed by a rigid flat," *International Journal of Solids and Structures*, Vol. 48, No. 3-4, (February 2011), pp. 463-471.

Professor Jack K. Wolf

A.R. Iyengar, **P.H. Siegel**, and **J.K. Wolf**, "Write channel model for bit-patterned media recording," *21st Magnetic Recording Conference*, La Jolla, CA, USA, (August 16 - 18, 2010).

E. Yaakobi, S. Kayser, **P.H. Siegel**, A. Vardy, and **J.K. Wolf**, "Efficient two-write WOM-codes," *2010 IEEE Information Theory Workshop - ITW 2010 Dublin, Ireland*, (August 30- Sept. 3, 2010).

S. Kayser, E. Yaakobi, **P.H. Siegel**, A. Vardy, and **J.K. Wolf**, "Multiple-write WOM-codes," *Proc. 48th Annual Allerton Conference on Communication, Control and Computing*, Monticello, IL, (September 29 - October 1, 2010).

E. Yaakobi, J. Ma, L. Grupp, **P.H. Siegel**, S. Swanson, and **J.K. Wolf**, "Error characterization and coding schemes for flash memories," *IEEE Globecom 2010*, Miami, FL, (December 2010).

J.K. Wolf, "Will HDDs be Replaced by SSDs?," Plenary Talk, *ACTEMT Workshop, IEEE Globecom*, Miami, Florida, (December 6, 2010).

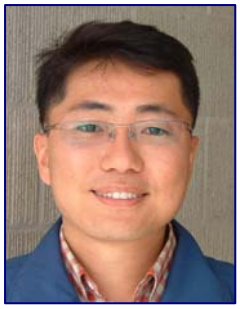
Graduate Students & Researchers Near Completion

Student	Level	Advisor(s)	Dept	Area of Research	Completion
Eitan Yaakobi	Ph.D.	Siegel, Vardy, and Wolf	ECE	Algebraic error-correction codes, coding for flash memory and other applications in data storage and transmission	Spring 2011
Erik Shipton	Ph.D.	Fullerton	Physics	Magnetic materials	Spring 2011

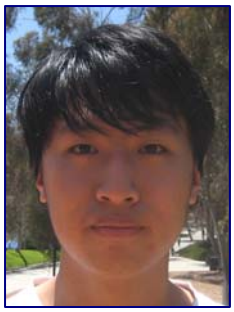
Graduate Degrees Awarded

Uwe Boettcher, a CMRR Ph.D. student advised by Professor Frank E. Talke and co-advised by Professor Raymond A. de Callafon, defended his dissertation successfully in April 2011. His dissertation was entitled "Nano-scale Positioning, Control and Motion Planning in Hard Disk." Uwe is pursuing his career as a Postdoctoral Scholar in Professor Talke's group currently working on active vibration damping in hard drives.

Keith Chan, a student of Professor Eric Fullerton's, received his Ph.D. in April 2011. His dissertation was titled "Nanostructured Magnetic Materials."



David Kim, a student in Professor Sungho Jin's group, received his Ph.D. in December 2010. His thesis was entitled "New Nano Structure Approaches for Bulk Thermoelectric Materials." He is now a Samsung Electronics engineer in Korea, doing R&D on nanomaterials and electronics materials.



Han Wang a student in Professor Siegel's group received his Master's degree in March 2011. He is currently employed as an engineer at Broadcom in San Diego.

New Graduate Student

Sohini Manna is a new graduate student in Professor Fullerton's group. She received her B.E. in Chemical Engineering from Birla Institute of Technology & Science (BITS), Pilani, India, in 2010. Following her undergraduate education, she worked at the Laboratory for Quantum Magnetism at Ecole Polytechnique Fédérale de Lausanne (EPFL) where she performed SQUID magnetometry measurements. She joined the Nanoengineering Department at UCSD in the Fall of 2010. Sohini currently works on development of synthesis techniques and applications for nanowires.

Visiting Scholar

Professor Young Keun Kim is a Visiting Research Scientist hosted by Professor Eric Fullerton, taking his sabbatical leave from March through August, 2011. He is a faculty member of the Department of Materials Science and Engineering at Korea University, Seoul, Korea. He received his Ph.D. degree in Materials Engineering from MIT, Cambridge, Massachusetts, in 1993. Until right before he came to CMRR, he had served in university administration for three years as the President of the Korea University's Research and Business Foundation, in charge of managing university research funds, intellectual property rights, and technology transfer. His research interests include materials development for magnetic information storage and nanostructures for biomedical applications. At UCSD, he enjoys interacting with Fullerton Lab members in the area of spintronics and magnetic nanostructures.

Visiting Student

Charles-Henri Lambert is currently a graduate student at the Ecole des Mines de Nancy in France, majoring in Materials Science and Nanoengineering. In the Fall of 2010 he joined the Nanomagnetism and Spintronic team of Stéphane Mangin in Nancy. Currently he is a visitor in the Fullerton Nanomagnetism laboratory. He is working on the spin transfer phenomenon in nanopillars with perpendicular anisotropy.

New Postdoctoral Scholars

Pablo A. Salas received his Ph.D. in Engineering Sciences/Applied Mechanics in December 2010. He is currently a postdoctoral researcher for Professor Frank Talke, investigating the time-dependent effects of active thermal flying height control sliders. His research interests include structural mechanics, finite elements, composite materials, design optimization and uncertainty quantification.

Vojtech Uhlir is a postdoctoral researcher in Professor Eric Fullerton's group. In 2010, he received a Ph.D. in Physics from the University of Grenoble, France and in Physical and Materials Engineering from Brno University of Technology, the Czech Republic for his work on current-induced magnetization dynamics in nanostructures. Currently, he is involved in several projects – all-optical magnetic recording, current-induced domain-wall motion in magnetic nanowires and modification of magnetic properties by electric field.

CMRR
Center for Magnetic Recording Research

NSF Grant

Professor Paul H. Siegel received funding from the National Science Foundation to support travel grants for students and postdoctoral researchers attending the 2nd Annual Non-Volatile Memories Workshop, held at UCSD on March 6-8, 2011.

CMRR Director:
Paul H. Siegel

Newsletter Editor:
Jan Neumann James

Photography:
Ray Descoteaux
John Hanacek
Betty Manoulian

Contributors:
Eric Fullerton
Jan Neumann James
Betty Manoulian
Paul Siegel
Iris Villanueva

http://cmrr.ucsd.edu

From the Directors

As this issue of CMRR Report goes to press, the baton of Center leadership is about to be handed off in a smooth exchange. This transition in the Directorship is in step with our ongoing efforts to revitalize the Center's technical mission. You can expect to see extensive engagement with the recently formed Advanced Storage Technology Consortium, as well as a significant expansion of our thrust in solid-state storage devices and systems. We're also undertaking major new scientific initiatives in partnership with colleagues in the Division of Physical Sciences.

There will be changes in our team roster, too. We'll celebrate the storied career of Professor Jack Wolf, the first holder of a CMRR Endowed Chair and the very model of an engineering professor, as he advances to Professor Emeritus status after 27 years at the Center. New talent will be recruited and appointments to our open endowed chair positions will be made, revitalizing our research line-up. We'll say farewell and extend our warmest thanks to two of the Center's incomparable support staff – Betty Manoulian and Jan Neumann James – who will retire this Spring after 25 years apiece of service to CMRR.

We congratulate Jack, Betty, and Jan, as well as all members of the "CMRR family," past and present, for compiling such a remarkably successful track record in the quest for ever more useful information storage technologies. We are in good position for the next leg of the race, which should be the most exciting yet!


Paul H. Siegel


Eric Fullerton

CMRR Research Review Highlights

The Fall Research Review was held October 13 – 14, 2010. Over 42 people from CMRR Industrial Sponsor companies and other invited guests participated in the meeting. Over 30 technical presentations by students and faculty were presented.

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 .

CMRR
University of California, San Diego
Center for Magnetic Recording Research, 0401
9500 Gilman Drive
La Jolla, CA 92093-0401