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4-1-2006

Interfaces, Volume 8, Issue 1 - Spring 2006

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Volume 8, Issue 1 Spring 2006

INTERFACES

The Newsletter of the Nebraska Center for Materials and Nanoscience
at the University of Nebraska-Lincoln

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Online @ http://www.unl.edu/ncmn/news/Newsletter_2006.shtml

From the Director

The publication of this issue of *Interfaces* finds us in the midst of frantic activity involving research, reviews, strategic planning and other activities. In the following I will outline some of these developments. Our NSF Materials Research Science and Engineering Center (MRSEC) hosted its annual two-day Review and Symposium on September 20 and 21. The External Advisory Board evaluated each of our projects and gave our Executive Committee valuable advice on the quality and continuing support of our Interdisciplinary Research Groups and Seed Projects. The Symposium "Emerging Challenges in Nanomagnetics," featured invited talks by Sara Majetich (Carnegie-Mellon), Andreas Berger (Hitachi-San Jose), Sam Bader (Argonne), Eugene Chudnovsky (CUNY), Chris Leighton (Minnesota), Andrei Slavin (Oakland U.), and David Pappas (NIST). Both events, including a Poster Session and Dinner, were educational and enjoyable.

A new event was hosted by our MRSEC recently. The First Nebraska MRSEC/Industry Workshop "Nanomagnetics and Applications" was held on January 31. Vice Chancellor Prem Paul welcomed the audience of about 50 people, and Associate Vice Chancellor John Brasch discussed Tech Transfer at Nebraska. Three MRSEC overview talks were presented by David Sellmyer, Sy-Hwang Liou, and Evgeny Tsymbal. Dr. Ping He of the J. A. Wollam Company presented an overview of applications of ellipsometry to thin-film characterization. In the afternoon the group held parallel sessions on magnetic films/data storage, magnetic materials/hard magnets, and magnetic sensors/TMR/GMR. Invited speakers in these sessions included J.-U. Thiele (Hitachi-San Jose), Bin Lu (Seagate), Andreas Berger (Hitachi-San Jose), Oleg Mryasov (Seagate), Jinfang Liu (EEC), Mike McFarland (Acree Tech), Olle Heinonen Seagate), and Nebraska researchers Jeff Shield, Andrei Sokolov, and J. D. Burton. This Workshop was most effective in promoting new and extended collaborations of MRSEC faculty and students with major companies in the USA.

The adoption of a new name for CMRA is in progress. The CMRA Advisory Committee, Deans of Arts and Sciences and Engineering, Academic Planning Committee, Vice Chancellor for Research, and Senior Vice Chancellor for Academic Affairs have approved the new name: **Nebraska Center for Materials and Nanoscience**. This new name effectively reflects our

strong emphasis on materials science and engineering, and the study of phenomena and applications of nanoscale structures. The name also better couples us with the National Nanotechnology Initiative.

We are extremely excited and hopeful about the possibility for new buildings for a Physical Sciences Center and a Nanoscale Science and Engineering Building. Planning activities on these centers has begun and we are most hopeful that funding will materialize to consolidate CMRA Central Facilities and space for other materials and nanoscience research.

A large group of faculty, students and postdocs attended the annual Magnetism and Magnetic Materials Conference in October in San Jose. Our researchers presented some 24 papers, one of the largest set from any university at this conference.

Finally, CMRA administer the Nanoscale Science and Technology Program of Excellence supported by special funding from the University. We are delighted that 10 new faculty hires have been accomplished already, with searches underway for two more for next fall. We welcome the most recent hires for 05/06 including Li Tan (Engineering Mechanics), Kirill Belashchenko (Physics), and Mathias Schubert (Electrical Engineering). The University also is providing funding for a new Nanofabrication Facility, and we are most grateful for all of the above support.

David J. Sellmyer

UNL Team Wins $3M DoD Grant

Reprinted with permission from Scarlet (4/21/05), written by Kim Hachiya

A team of engineers — led by NCMN's Yongfeng Lu, associate professor of electrical engineering — have received a three-year grant exceeding $3 million to refine a process that coats surfaces with thin diamond films.

The team is composed of engineers from UNL and the University of Missouri-Rolla. The grant came from the Department of Defense's Office of Naval Research and brings the possibility of an additional $2 million in years four and five of the study.

The grant was awarded in March and announced April 14 2005 by UNL.

Joining Lu on the team are Hai-Lung Tsai of the Department of Mechanical and Aerospace Engineering at the University of Missouri-Rolla and head project leader for UMR; Lan Jiang, mechanical engineer, UMR; Matthew O'Keefe, metallurgical engineer, UMR Robert Schwartz, materials engineer, UMR; and Xinwei Wang, mechanical engineer, UNL.

The process under exploration by the team was developed in the mid-1990s by Michigan–based QQC, Inc. That firm used over-lapping pulsed lasers to deposit thin coatings of diamond and diamond–like carbon on surfaces. The underlying reasons for the process are unknown –the technology has preceded the science. That makes it hard to improve the process or extend it to other material systems. Lu's team will attempt to tease out the "how" of the technology.

"If we can understand the science of the phenomenon, "Lu said, "and understand the principles behind it, we can use it for other materials besides diamonds."

The ability to coat surfaces – making them stronger, lighter and more resistant to corrosion or abrasion – has many applications. Military hardware is an obvious example, but the ability to coat surgical tools, auto bodies, airplanes or even golf clubs have been posited as potential uses. The diamond coating increases the hardness of the surface and protects it from humidity, abrasion, corrosion or other deformations.

The QQC firm used overlapping light pulses from three types of high-powered lasers – eximer, yttrium-aluminum–garnet or YAG, and carbon dioxide – to vaporize a thin layer when scanned across a material such as steel. This creates an electrically charged, superheated plasma of iron atoms that bonds to the surface as a new substance. But the fundamental science of how this works is still unknown.

The UNL-UMR coating technique will be "customized" to specific coating/substrate systems using three laser systems — a resonance absorption laser, a UV laser, and a controlled plasma cooling and coating formation laser.

The team will work to establish the knowledge of the physics behind the process and develop a way to do this in "open atmosphere" rather than a vacuum, allowing coatings to be deposited on items like ships or airplanes. The team will test this system both theoretically, using computer models, and experimentally using the lasers.

The grant was one of 33 awarded through the DoD's Multidisciplinary University Research Initiative Program. More than 120 proposals were submitted in the competitive grant process. The DoD awarded $146 million over the five years to 27 universities.

Prem Paul, UNL's vice chancellor for research, said the proposal is an example of building competitive strength through multidisciplinary collaboration. He noted that only about a quarter of the submitted proposals won funding, and the institutions that received funding are among the nation's most prestigious.

Recent Achievements of Center Researchers

Fellowships

Peter A. Dowben (Physics) and Xiao C. Zeng (Chemistry) were selected Fellow of the American Physical Society. Dowben was cited "for his significant experimental contributions to surface magnetism, spin polarization in complex magnetic systems, and metal-to-nonmetal transitions in reduced dimensionality" and Zeng "for his original contributions to the study of vapor-liquid nucleation and discoveries of novel nanostructures of two-dimensional ice, one-dimensional ice nanotubes, ground-state silicon clusters and single-walled silicon nanotubes." Peter Dowben was also elected to Fellowship in the Institute of Physics (U.K.).

Promotions and Tenure

Promotion to Full Professor: **David Berkowitz** (Chemistry), **Jennifer Brand** (Chem. Eng.), **Gustavo Larsen** (Chem. Eng.), **Evgeny Tsymbal** (Physics and Astronomy).

Promotion to Associate Professor: **John Belot** (Chemistry), **Anu Subramanian** (Chem. Eng.).

Granted Tenure: **John Belot** (Chemistry), **Yongfeng Lu** (Electr. Eng.), **Anu Subramanian** (Chem. Eng.), **Evgeny Tsymbal** (Physics and Astronomy).

Awards

Christian Binek received a NSF Career Award for his project "Education and Research on Nanoscale Spintronic Systems and Heterostructures". **Rodney J. Soukup** received the Meritorious Service Award from the IEEE Education Society.

McBroom Professorship

The College of Engineering and Technology awarded the first Robert C. McBroom Professorship to Engineering Mechanics Professor **Yuris A. Dzenis**.

Best Paper Awards

- The paper "The Heteroisomeric Diode" by Anthony N.Caruso, Ravi B. Billa, Snjezana Balaz, **Jennifer I. Brand**, and **P. A. Dowben**, published in J. Phys.: Condens. Matter 16, L139-L146 (2004), was selected as one of the best papers of 2004 in JPCM.

- The paper "Research Experiences for Teachers in Materials Science: A Case Study" by M.A. Strand (Southeast Community College Milford), S. Wignall (Seward High School), and **D.L.**

Leslie-Pelecky won the Trophy Award for Best Symposium Proceedings Paper at the 2004 MRS Fall Meeting.

- The paper "Broadening Middle-School Students' Images of Science and Scientists" by **D.L. Leslie-Pelecky** and G.A. Buck of UNL and A. Zabawa of Lincoln Public Schools won the Ribbon Award for Best Symposium Proceedings Paper Nomination at the 2004 MRS Fall Meeting.

- The paper "Nanotube Magnetism," by Y.C. Sui, **R. Skomski,** K.D. Sorge, and **D.J. Sellmyer**, Appl. Phys. Lett. 84, 1525 (2004), was the most downloaded paper published by the American Institute of Physics for a two-month period after publication.

Student Awards and Honors

Andrew Nelson (Mentor: Stephen DiMagno) and **Anthony Caruso** (Mentor: Peter Dowben) were presented with the Lowe R. and Mavis M. Folsom Distinguished Doctoral Dissertation Award. **Luis Rosa** (Physics, Peter Dowben) received the UNL College of Arts and Sciences Graduate Research Assistant Award.

The following CMRA-affiliated students have earned their PhDs during the last year:
Shampa Aich (Chem. and Mat. Eng., Jeff Shield), **Anthony Caruso** (Physics, P. Dowben), **Lan Gao** (Physics, Sy-Hwang Liou), **Christina Othon** (Physics, Stephen Ducharme), **Luis Rosa** (Physics, P. Dowben), **Ildar Sabirianov** (Physics, Bernard Doudin).

The following CMRA-affiliated students have earned their M.S. degrees during the last year:
Kishore Amaravadi (Mech. Eng., Jeff Shield), **Snjezana Balaz** (Physics, P. Dowben), **V.K. Ravindran** (Mech. Eng., Jeff Shield), **Ildar Sabirianov** (Physics, Bernard Doudin), **Jason L. Schrader** (Elect. Eng., R. J. Soukup), **David Wisbey** (Physics, P. Dowben).

New Jobs:

Anthony Caruso: Research Scientist, Center for Nanoscale Science and Engineering, Fargo, ND
Maria Daniil: Postdoc, Naval Research Laboratory
Lan Gao: Postdoc, Oak Ridge National Laboratory
Luis Rosa: Postdoc, Princeton University
Korey Sorge: Asst. Prof., Florida Atlantic Univ.
Hao Zeng: Asst. Prof., SUNY-Buffalo
Jian Zhou: Postdoc, University of California, Berkeley

Nanocomposite Permanent Magnets

by Jeff Shield

Permanent magnet materials continue to be one of the most technologically diverse classes of materials, with applications ranging from motors and generators to traveling wave tubes in industries just as diverse—automotive, consumer electronics, and the petrochemical industry, to name just a few. The figure of merit that describes permanent magnets is the maximum energy product. The energy product defines the amount of energy that a given permanent magnet can produce, and is the largest product between the induction and magnetic field in the second quadrant of the hysteresis loop. During the twentieth century, the development of new materials and processes led to dramatic improvements in the maximum energy product, doubling every 15 years (Figure 1).

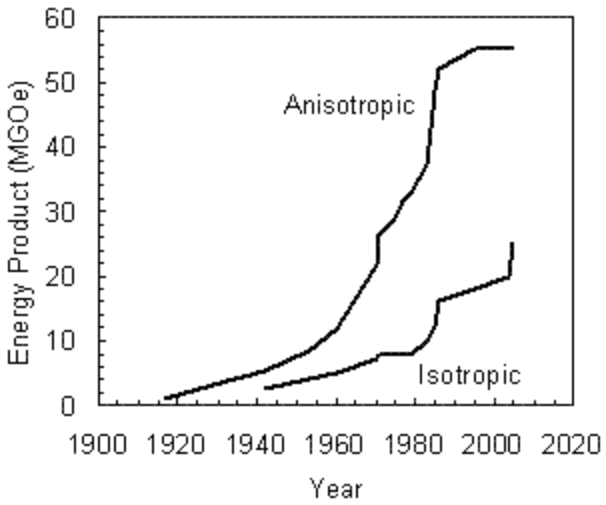

Figure 1. The maximum energy product has increased exponentially over the past 100 years. This figure shows the increase for both isotropic and anisotropic materials.

The development of higher energy products is complicated by the necessity of both a high coercivity and a high magnetization. Obtaining a high coercivity usually requires dilution of the primary magnetic species (Fe or Co), which lowers the magnetization and thus the achievable maximum energy product. The theoretical maximum energy product, then, for the current best material—$Nd_2Fe_{14}B$—is 64 MGOe for anisotropic materials and 16 MGOe for isotropic materials.

To overcome this limitation, and to push the maximum energy products toward 100 MGOe, researchers began taking advantage of intergranular exchange interactions, ultimately forming two-phase structures combining high-magnetization, low coercivity phases with high coercivity, lower magnetization phases. In order to maximize the exchange interactions, this approach requires the phases to be assembled at the nanoscale. While this approach has led to materials

with higher energy products compared to single-phase materials, the properties achieved thus far have been less than projected.

It turns out that the performance of these nanocomposite permanent magnets is limited largely by the demagnetization process. Normally, magnetization reversal in materials with small grains is controlled by nucleation of reverse domains, and ideally each grain or particle reverses its magnetization direction independent of other grains or particles. In highly interacting systems, however, magnetic domains involving tens, hundreds or thousands of individual grains or particles develop, with the domain boundaries following along grain boundaries (termed "interaction domains"). In these highly interacting materials, the magnetic reversal is controlled by expansion of the interaction domains and the movement of domain walls. Unfortunately, in the nanocomposite permanent magnets the motion of domain walls is much easier than the nucleation of reverse domains, and there is a dramatic loss of coercivity that limits the energy product.

A possible solution to this dilemma is to eliminate the development of interaction domains. Then, magnetic reversal could again be controlled by nucleation events, resulting in high coercivity. The approach that we took to eliminate interaction domains was to make Fe-Pt nanoclusters isolated from each other in a non-magnetic matrix. The nanoclusters were designed to have a composition in the two-phase region involving the soft magnetic Fe_3Pt that provides the high magnetization and hard magnetic FePt that provides the high coercivity. The clusters were produced by inert gas condensation, a highly tunable process that allows monodispersed, sub-10 nm clusters (Figure 2).

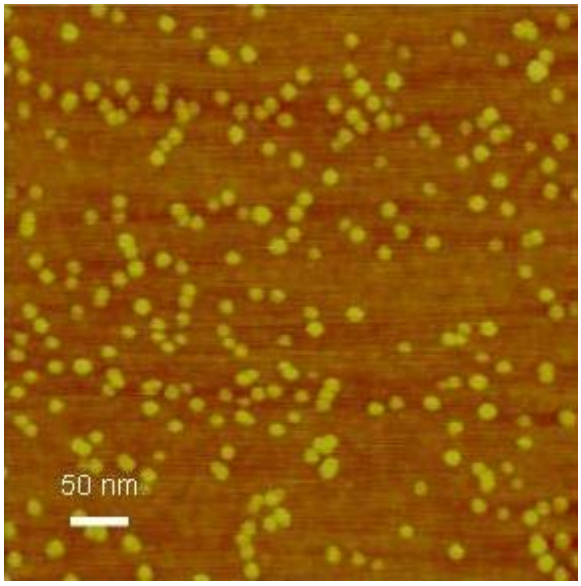

Figure 2. Inert-gas condensation very effectively produces monodispersed, nanoscale clusters. Shown here are Fe clusters, imaged using atomic force microscopy. The ratio between the standard deviation to the average size is a good measure of uniformity; this ratio for clusters produced by inert gas condensation can be less than 0.1, which is considered monodispersed.

The Fe-Pt alloy clusters form in the solid-solution face-centered cubic phase, and therefore required heat treatment to force the formation of the appropriate phases. X-ray diffraction after heat treatment revealed the presence of both Fe_3Pt and FePt, and that the percentage of soft magnetic phase was more than 50 volume percent. This is in comparison to the ~20 percent soft phase content common in previous nanocomposite permanent magnets. Transmission electron microscopy of samples after heat treatment (Figure 3) revealed some agglomeration and Ostwald ripening, but also that the scale of the Fe-Pt regions remained on the order of 10 nm. Internal features were also consistent with dissolution to the Fe_3Pt and FePt phases. The scale of the system—less than 10 nm—ensures that the dimension of the phases, particularly Fe_3Pt, enables excellent exchange coupling. Hysteresis loops of the two-phase structures revealed a dramatic increase in remanence compared to single-phase FePt, although a lower coercivity was also observed (Figure 4). However, the energy product is most sensitive to remanence in these hard magnetic materials, and the two-phase nanocomposite had a significantly higher energy product. The maximum energy product for two-phase clusters was 25.5 MGOe. For comparison, single-phase FePt clusters were found to have an energy product of 12 MGOe, very close to the theoretical value of 12.4 MGOe for single-phase FePt. The values are more than 25 percent higher than that previously achieved for isotropic Fe-Pt-based permanent magnets.

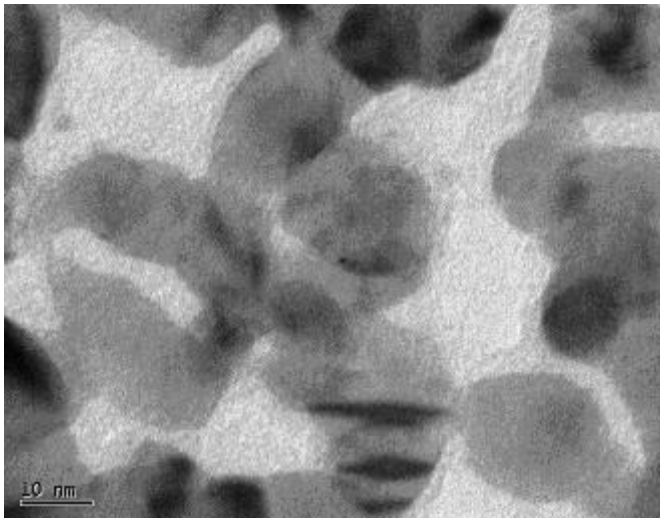

Figure 3. Transmission electron microscopy image of the heat-treated Fe-Pt clusters. Even after heat treatment, Fe-Pt regions remain on the order of 10 nm, and internal features show possible dissolution into the Fe_3Pt and FePt phases.

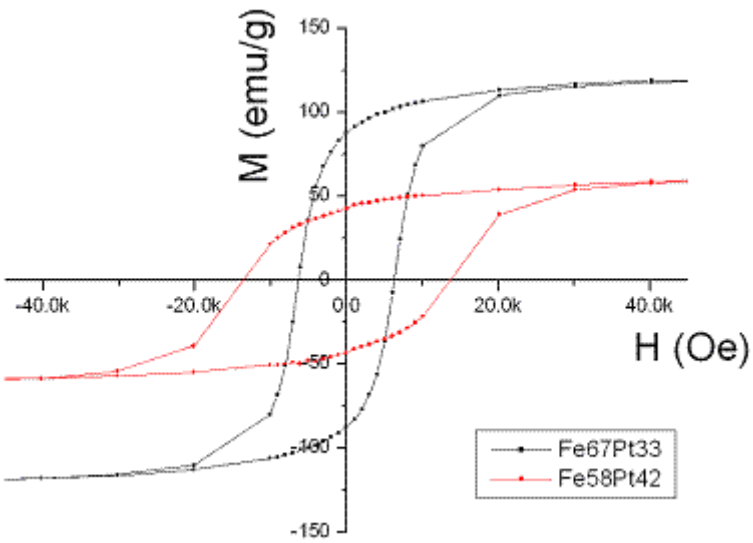

Figure 4. Hysteresis loops of single-phase (Fe58Pt42) and two-phase (Fe67Pt33) Fe-Pt clusters after heat treatment.

The dramatic improvement in the maximum energy product achieved here shows that the early projections of very high energy products for exchange-coupled permanent magnets can be realized. The key will be to construct materials and systems that have nanoscale features to ensure effective exchange coupling but that have particles or grains that reverse independently of one another.

NCMN Welcomes Mathias Schubert

Dr. Mathias Schubert has joined the University of Nebraska Lincoln in January 2006 as associate professor in the Department of Electrical Engineering and as a new member of the Nebraska Center for Materials and Nanoscience. Prior to Dr. Schubert's association with UNL he was at the assistant professor level within the Faculty of Physics and Geosciences at the University of Leipzig, Germany, where he received his physics diploma (1994), doctoral degree (1997), Habilitation and Privatdozent (2003).

Dr. Schubert takes an electromagnetic perspective on the vast realm of new materials in the nanotechnology era. "Albeit a century passed since the electron theory of Paul Drude, understanding the physics behind optical observations from these new materials is of highest importance and still most challenging to us," Dr. Schubert said. The interrelation between electrical and optical properties of matter has spurred many researchers to use optical tools for understanding and subsequent tailoring of materials properties. Brought upon recent progress in fabrication techniques three-dimensional nanostructures, which may incorporate inorganic and organic materials with highly anisotropic dielectric, semiconducting, ferroelectric, and magnetic properties, for example, are now at hand.

The Leipzig group of Dr. Schubert has progressed an advanced polarization spectroscopy technique: Generalized Ellipsometry. Part of this development occurred during long-term collaborations between the University of Leipzig and Professor John Woollam's group here at UNL, and which started in 1993 when Dr. Schubert visited Nebraska for the first time as graduate student. "We envisioned ellipsometry as a tool for understanding material properties and physics of nanostructure composites – inaccessible so far to micro- and nanostructure characterization tools."

The first successful applications of their new technique were chiral liquid crystals, the working horse of today's display technology. "With ellipsometry we can read the kinetics and orientation of the nanometer-sized molecules, for example, without physically contacting or destroying the sample." If brought into magnetic fields free charge carriers within the nanostructures reveal

their mobility and inertial mass parameters by using Far-infrared Magneto-optic Generalized Ellipsometry, a tool which Dr. Schubert's group had just recently invented. Presently the group is building a unique Terahertz Ellipsometer at UNL, which will enable them to investigate charge carriers in their quantum limit. Nanostructures combining ferroelectric with semiconducting and ferromagnetic properties for new device applications in data storage and display vision comprise another research area of his group. “I am very glad about the opportunity to collaborate with the NCMN researchers and I look forward to very exciting research work.”

Dr. Schubert has published one textbook, three book chapters, 130 peer-reviewed journal papers and 170 presentations in international conferences including 17 invited talks. He serves as topical editor for the Optical Society of America. He received research fellowships from the German Merit Foundation, the Swedish Foundation for International Cooperation in Research and Higher Education, the Université Pierre et Marie Curie in Paris, and UNL. He is a member of the German Physical Society, the German University Lecturer Society, and the Materials Research Society. Dr. Schubert participated in 7 international conference committees, and he is an organizer of the next International Ellipsometry Conference in Stockholm. He is a founder and executive board member of the German Ellipsometrie Association. So far, Dr. Schubert has received research grants from the German National Science Foundation, Department of Education and Research, and industry, with a total amount over $1.200,000.

Beginning Spring 2006, Dr. Schubert offers a new course, Optics in Complex Mediums, which covers the area of Optics and Electromagnetism related to nanostructure materials and measurement techniques.

Research Spotlight: Evgeny Tsymbal

The research of Evgeny Tsymbal's group is centered on the theory of electronic spin-dependent transport in magnetic nanostructures. The discovery of giant magnetoresistance (GMR) in magnetic multilayers in 1988 stimulated tremendous progress in the field of spin transport, which was later called "spin electronics". Nowadays spin electronics has developed into a vigorous field of research. The tremendous worldwide interest is stimulated by the fact that exploiting the electronic spin degree of freedom in solids could enable a revolutionary enhancement of the capabilities of electronic devices.

Tsymbal has been involved in the research on spin electronics for the past 11 years. While working at the University of Oxford he developed a novel theoretical approach to GMR in magnetic metallic multilayers which emphasized the role of the electronic band structure as the origin of this effect. His seminal GMR work was recognized by an invitation by Professor Ehrenreich of Harvard University to write a review article for the famous annual *Solid State Physics* series. Tsymbal's article "Perspectives of Giant Magnetoresistance" co-authored by Prof. Pettifor, FRS appeared in 2001.

Since his arrival in Lincoln in 2002, Tsymbal has built a very productive condensed matter theory group which currently includes two research assistant professors, one visiting research associate and two graduate students. This became possible due to the secured funding from the National Science Foundation, Seagate Corporation, and the Nebraska Research Initiative, in addition to the NSF Materials Research Science and Engineering Center (MRSEC) and the W.M. Keck Foundation. Some of these funds were used to establish a high-power multiprocessor computer cluster which is heavily used by Tsymbal's group and collaborators. The highlights of Tsymbal's group research are four publications in *Physical Review Letters* in 2005 devoted to (i) interlayer exchange coupling across a tunnel barrier; (ii) ballistic anisotropic magnetoresistance; (iii) giant electroresistance in ferroelectric tunnel junctions; (iv) tunneling magnetoresistance in SrTiO3-based tunnel junctions. This research work was recognized by numerous invitations of Tsymbal to international conferences such as APS and MRS meetings and a Gordon Research Conference. Tsymbal's review article "Spin-dependent tunneling in magnetic tunnel junctions"

co-authored by Dr. Mryasov and Dr. LeClair and published in *Journal of Physics: Condensed Matter* was highlighted in *Top Paper 2003 Showcase*.

Tsymbal is a coordinator of the MRSEC Interdisciplinary Research Group, one of the two research groups within the NSF MRSEC established at UNL in 2002. An important ingredient of Tsymbal's research is collaboration with his colleagues, both experimentalists and theorists. In particular, cooperation with Prof. Jaswal strengthens the theory group due to his expertise in the electronic band structure of solids. Another condensed matter theorist, Prof. Belashchenko, who had made a major contribution to the group's research on spin-dependent tunneling, has started this academic year at the UNL Physics and Astronomy Department in the new capacity of Assistant Professor. Partnership with experimentalists, in particular, with Prof. Doudin has led to the understanding of the magnetoresistance reversal in nanoscale magnetic tunnel junctions. Collaboration with Prof. Dowben made it possible to elucidate the mechanism of bonding of thiol-terminated molecules to cobalt and gold surfaces.

External collaborations of Tsymbal's group include a number of universities and research laboratories in United States and Europe. Also partnership with industry, such as Seagate Corporation, plays an important role in Tsymbal's research activities. "Continuous technological effort to further miniaturize electronic devices brings industry to the nanoscale world where properties of materials are controlled by quantum phenomena. Further progress may only be possible if these phenomena can be understood and fully exploited. This puts unprecedented demands on theory and modeling", says Tsymbal.

Ion Beam Assisted Deposition at UNMC

By Fereydoon Namavar

The Nanotechnology Laboratory (NanoLab) of the Department of Orthopaedics and Rehabilitation at the University of Nebraska Medical Center, located in the Scott Technology Center, 6825 Pine Street, Omaha, was inaugurated in June 2004. The mission of this laboratory is to produce materials with exceptional chemical, physical, mechanical and nano-structural properties that nature does not allow to occur in equilibrium conditions.

The core technology of the NanoLab is ion beam assisted deposition (IBAD). IBAD combines physical vapor deposition with concurrent ion beam bombardment in a high vacuum environment. IBAD is performed in a 41”x45”x37” (2” thick) stainless steel water cooled ultralow vacuum chamber. The chamber reaches a base pressure range of 10-8 torr after a few hours of operation using: (a) an oil-sealed mechanical pump (b) a cryogenic 10” pump: (c) and a Polycold 550HC system with a maximum pumping speed of 52,000 liters per second.

IBAD system at the Nanotechnology Laboratory of the University Nebraska Medical Center (UNMC)
Orthopaedic Department at Scott Technology Center.

This IBAD system is unique in its characteristics, such as its power, size, vacuum ability, and potential. To our knowledge, it is **unparalleled in any academic institution in the United States and is comparable or better than most systems used by high technology companies**. IBAD can deposit nano-crystalline metals, alloys, semiconductors, ceramics and bioceramics from room temperature to 600°C. Energetic ions are employed to produce “**engineered nano-crystals**” with superior properties that are then “stitched” to any substrate by ion bombardment. This state of art system can operate in a unique twin IBAD mode to produce multi-nano-layer (super lattice structure) coatings with superb surface properties that are not possible through conventional techniques.

The IBAD system is comprised of a RF Ion Gun that supplies ions at energies up to 1500 eV with a total current density of 500 mA, a DC ion Gun with an ion density of 3A at energies up to

150 eV, a thermal evaporation source, and a programmable sweep multi pocket four electron beam evaporation source. Nanolayers can be deposited simultaneously on both sides of eight silicon wafers. Thickness of nano-layers can be controlled by synchronizing the evaporation rate and the rotation (velocity) of a 26" diameter substrate holder.

The NanoLab is available to NCMN members, students, and the scientific community for interdepartmental projects, joint proposals, and research. Please contact Prof. Namavar for further information.

For the Ages
Book Projects at NCMN

by Ralph Skomski

The internet has lead to a redefinition of literature, and many tasks of books are now performed electronically. For example, mathematical tables used to occupy much space in printed media, but this is no longer necessary. Will the new media replace archival literature? The answer lies in the average decay time of stored information. Societies based on oral tradition require an immense social effort to ensure communication beyond one or two generations, and the same is true for internet information. One may joke that "my information went three times around the world, because it was 0.4 s on the net" and, types of electronic data storage change about once very 10 years, each time interrupting the tradition of information. Here the advantages of book literature come into play.

Fig. 1. Early textbook on medicine (3rd millennium BC).

The invention of the book dates back to the Sumerians in present-day Iraq, who developed the first fully functional script around 3500 BC. They created a rich cuneiform literature, from political and religious works to scientific discourses. This enabled the Sumerians to become the first advanced urban society in human history and to advance scientific progress in a previously unknown pace. Some other Sumerian inventions are the wheel, water clocks and sun dials, soap, sexagesimal units (1 h = 60 min, 1 min = 60 s), school education, irrigation, and algebra. Figure 1 shows a part of an early textbook on medicine.

They compiled big mathematical tables containing the squares of numbers and then used $ab = [(a + b)2 - (a - b)2]/4$ to perform multiplications ab. They knew how to solve quadratic equations and used approximations such as $\pi \approx 3$ and $\pi \approx 3+1/8$. Better known examples of Sumerian literature are the Flood story, later included in the Bible, and the written law, epitomized by the phrase "an eye for an eye, a tooth for a tooth". This approach is now considered obsolete in most countries, because it replaces the protection of society by revenge, but the fight against arbitrary justice and scapegoating has remained a cornerstone of modern civilization.

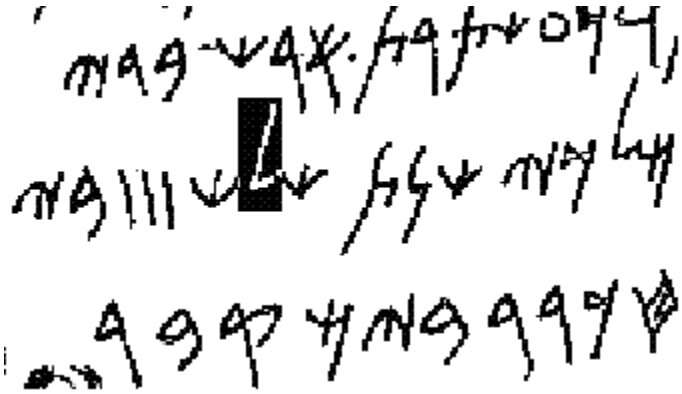

Fig. 2. Part of a Phoenician inscription. The shadowed character (Lamed) corresponds to the Hebrew ל, the Arabic ل, and the Greek λ , the Latin L, and the Russian л.

The impact of the Sumerian inventions on present society and technology are based on durable written information. Another example of durability is the alphabetic script, developed by the Phoenicians about 1200 BC (Fig. 2). Even today, these documents are fairly easy to read, in spite of bridging about 3000 years. It is quite likely that early societies possessed wheel-like functional structures made from wood or stone. However, developments coupled to very specific tasks are usually forgotten after one or two generations, and the absence of written records excluded the development from precursors to mature technology by later generations.

What is our humble contribution to the book literature? Very recently, two book projects were published by Springer in Berlin: Handbook of Advanced Magnetic Materials, edited by Y. Liu, D. J. Sellmyer, and D. Shindo, and Advanced Magnetic Nanostructures, edited by R. Skomski and D. J. Sellmyer. A third book, Biomedical Applications of Nanotechnology, edited by V. Labhasetwar and D L. Leslie-Pelecky, will be published soon Wiley, New York. These books deal with magnetic nanostructures, which is a key research thrust at NCMN. Another book, "Simple Models of Magnetism" by R. Skomski, is to be published by Oxford University Press in 2006 and focuses on the physical understanding of magnetism.

Future generation will decide about the literature printed in there early years of the 21st century!

R.S.

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