Volume 17, Issue 1 Summer 2019

INTERFACES

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

From the Director

It is a pleasure to give a brief report on recent activities of NCMN and the NSF-supported Nebraska Nanoscale Facility (NNF), which is administered by NCMN. A most positive development is that the university administration has supported our proposal to hire four faculty members in Quantum Materials and Technologies (QMT). This cluster-hiring initiative conforms perfectly with one of the NSF's Big Ideas, the Quantum Leap. Four hires were approved, in the departments of Physics, Electrical and Computer Engineering, Chemistry, and Mechanical and Materials Engineering, and the searches are underway now. These new faculty are expected to give a big boost to our research activities in the coming years.

Dr. David J. Sellmyer

NCMN faculty continue to excel in research productivity and funding. In fiscal year 2018, funding was $22.8 M, the largest value obtained thus far. From 2001 to 2017, the cumulative research funding was $260 M and this has provided significant financial benefits to the university in return of overhead costs and the state in economic activity. In addition, in calendar year 2017, 245 papers were published – many in high-ranking journals. We have continued to enhance our Central Facilities by adding about $6.2 M of new equipment since the start of NNF in 2015. The most recent additions are an Intlvac ultra-high-vacuum, multi-source sputtering system, and an Attocube low-temperature, high-field scanning probe system. The latter was obtained through an NSF-major research-equipment grant.

NNF is part of a national network, the National Nanotechnology Coordinated Infrastructure (NNCI), that provides nanofabrication and characterization facilities at universities across the nation. Sites include Harvard, Cornell, Penn, Northwestern, Washington, UCSD and others. NNF has worked diligently to expand its outreach to regional universities and companies. It now has about 380 unique users per year including some 76 external users. Dr. Jacob John, the NNF Facility Coordinator, has led the outreach effort.

We are pleased to report on recent promotions in 2018 and 2019. These include new Full Professors: Jian Wang (MME), Angela Pannier (BSE), Linxia Gu (MME) and new Associate Professors: Sidy Ndao (MME), Sangjin Ryu (MME), Ozan Ciftci

continued on page 9

NCMN Welcomes New Faculty Members

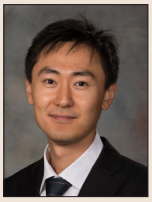
Martin Centurion (Physics)

Ozan Ciftci (Food Science & Technology)

David Hage (Chemistry)

Jongwan Eun (Civil Engineering)

Forrest Kievit (Bio Systems Engineering)



Seunghee Kim (Civil Engineering)

Prahalado Rao (Mech/Mtrls Engineering)

Mahmoud Shakouri (Industrial Technology, UNK)

**Not pictured: Eric Carnes, Office of Research & Economic Dev.*

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University of Nebraska Lincoln

Research Spotlight: Kirill Belashchenko

Magnetic Anisotropy Goes on a Roller-Coaster

I'd like to train the spotlight on a remarkable example showing how the electronic structure of a magnetic material can influence its properties in ways that are quite unexpected, at least at first sight.

In order to make a usable permanent magnet, a ferromagnetic material should have a sizeable magnetocrystalline anisotropy to align its magnetization with a crystallographic direction. In simple cases this anisotropy can be explained by the combined effect of the crystal field and spin-orbit coupling on the ionic energy levels. This works for insulators and such metals where magnetocrystalline anisotropy is dominated by rare-earth atoms.

The situation in transition metals and alloys is complicated by the dispersion of the electronic bands, and the states around the Fermi level are often crucial. Spin-orbit *hot spots*, the locations in the Brillouin zone where spin-orbit coupling lifts the degeneracies near the Fermi level, may be especially important and sensitive to alloying, disorder, and temperature changes. Therefore, figuring out why anisotropy behaves in a certain way, or how to improve it, requires a careful analysis of the band structure and spin-orbital selection rules based on first-principles calculations. For substitutional alloys, this can be done very efficiently using the coherent potential approximation (CPA), which we have implemented in the Questaal software package (http://www.questaal.org). Fig. 1 illustrates some of the useful analysis tools applied to the $(Fe_{1-x}Co_x)_2B$ alloy; more on it in a moment.

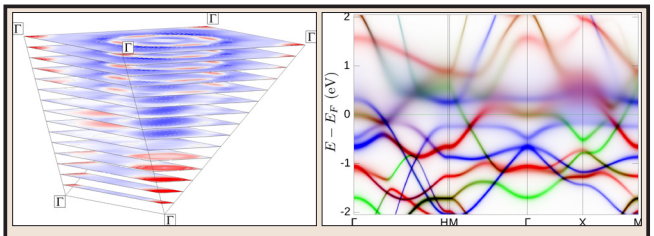

Figure 1. k-resolved minority-spin contribution to the magnetocrystalline anisotropy (left; positive and negative contributions shown in red and blue, respectively) and the Bloch spectral function (right; contributions from *xy* and $x^2–y^2$, *xz* and *yz*, and z^2 orbitals are resolved by red, blue, and green colors) in the $(Fe_{0.2}Co_{0.8})_2B$ alloy. Published in: Belashchenko *et al.*, *Appl. Phys. Lett.* 106, 062408 (2015) © 2015 AIP Publishing LLC

The CPA method can also be used to include the effects of spin disorder at finite temperatures. This is where things can get very interesting. When a magnet is heated up, its magnetic anisotropy usually declines monotonically, but there are systems where it exhibits anomalies or even changes sign. Some of these spin-reorientation transitions (SRT) can be attributed to prosaic origins, such as thermal expansion (as in hcp cobalt and MnBi) or multi-sublattice effects (as in some rare-earth-based hard magnets). However, as Ivan Zhuravlev, a physics graduate student at UNL, has discovered in the above-mentioned $(Fe_{1-x}Co_x)_2B$ alloy, the SRTs and other anomalies can also occur in itinerant magnets due to a purely electronic mechanism: thermal spin fluctuations directly modify the electronic spectrum. Fig. 2 shows an almost quantitative agreement between Ivan's calculations and experiment. Note the SRT in Fe_2B and a nonmonotonic temperature dependence in Co_2B.

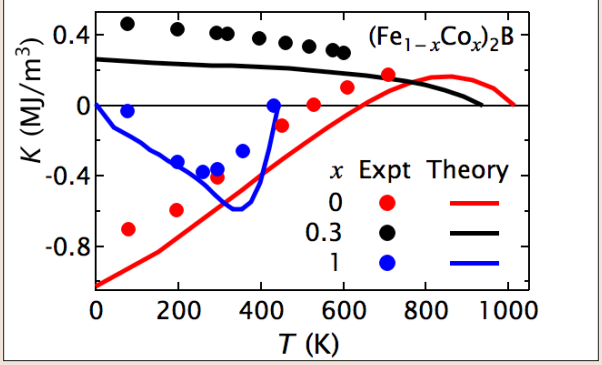

Figure 2. Anomalous temperature dependence of magnetocrystalline anisotropy in $(Fe_{1-x}Co_x)_2B$ alloys.

Remarkably, these unusual features can be fully understood by analyzing the shifts and disorder-induced broadening of the electronic bands as shown in Fig. 1. The (Fe-Co)$_2$B alloy is by no means a unique example: Po-Hao Chang, a postdoctoral associate in my group, has found that the SRT in the MnPt antiferromagnet is also driven by thermal spin disorder. What is surprising is that such anomalies appear to be uncommon.

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Faculty Awards and Honors

Promotions and Tenures

• Promoted to full professor: **Shannon Bartelt-Hunt** and **Kirill Belashchenko** (2017); **Angela Pannier** (2018)
• Promoted to full professor and granted tenure: **Jian Wang** (2018)
• Promoted to associate professor and granted tenure: **Jian Zhang** (2017); **Sidy Ndao** and **Sangjin Ryu** (2018)

Awards and Honors

• **Shireen Adenwalla** - UNL Parents Recognition Award (2018)
• **Christos Argyropoulos** - received Office of Naval Research Fellowship (2017); received the Young Scientist Award from the International Union of Radio Science (2017); elevated to status of Senior Member of the Optical Society of America (2018)
• **Eveline Baesu** - UNL Parents Recognition Award (2018)
• **David Berkowitz** - DoD Grant (2017)
• **Barry Cheung** - Parents Recognition Award (2018)
• **Bai Cui** - Elected to Vice Chair of the Corrosion and Environmental Effects Committee in the Minerals, Metals & Materials Society (TMS) 2017 meeting; lead organizer for the "Environmentally Assisted Cracking: Theory and Practice" symposium in TMS 2018 meeting; awarded a grant, "Processing of Ti_2AlC ceramics," for $15,866 from Exxon Mobil
• **Shudipto Dishari** - NSF CAREER Award (2018)
• **Timothy Gay** - named a Willa Cather Professor (2017)
• **Nicole Iverson** - received the Junior Faculty Teaching Excellence Award, part of the Holling Family Awards for Teaching Excellence in IANR
• **Srivatsan Kidambi** - UNL Parents Recognition Award (2017)
• **Rebecca Lai** - Received the Location Section Outreach Volunteer of the Year Award from the American Chemical Society's Committee on Community Activities (2017)
• **Yusong Li** - Holling Family Master Teacher Award/UNL University-Wide Teaching Award (2017)
• **Yongfeng Lu** - NU Outstanding Research and Creative Activity Award (2017)
• **Mehrdad Negahban** - UNL Parents Recognition Award (2017)
• **Sidy Ndao** - Named 10 of the Young Scientists Shaping the Future by the World Economic Forum
• **Angela Pannier** - NIH New Innovator Award "Using Cell Priming and Telecommunications Modeling to Enhance Gene Delivery for Stem Cell Therapies" (2017); UNL Outstanding Undergraduate Research Mentor Award (2017); UNL Parents Recognition Award (2018)
• **Prahalada Rao** - NSF CAREER Award (2018)
• **K.P. Rajurkar** - M. Eugene Merchant Manufacturing Medal of ASME/SME (2018)
• **Michael Sealy** - UNL Parents Recognition Award (2017), (2018)
• **Alexander Sinitskii** - College Distinguished Teaching Award (2017)
• **David Sellmyer** - Honored during the 5-day symposium "Nanoscale Magnetic Structures and Materials," organized by friends and colleagues to celebrate his contributions to the field (2018)
• **Joseph Turner** - College Distinguished Teaching Award (2017); UNL Parents Recognition Award (2018)
• **Jian Wang** - DoE Grant, "Bridging microscale to macroscale mechanical property measurements and predication of performance limitation for FeCrAl alloys under extreme reactor applications" (2018); Materials Today 2018 Rising Star Award in the Materials Genome division (2018)
• **John Woollam** - R.F. Bunshah Award (2017); Prem S. Paul Innovator of the Year Award (2018)
• **Xiaoshan Xu** - DoE Early Career Research Award for work in spintronics (2018)
• **Xiao Cheng Zeng** - Royal Society of Chemistry Surfaces and Interfaces Awards for 2017; 2019 Materials Research Society Fellow
• **Jian Zhang** - UNL Parents Recognition Award (2018)
• **Bai Cui**, **Jeffrey Shield**, **Qin Zhou** and **Michael Nastasi** were awarded a grant "Creating Education and Outreach Programs in Ceramic and Glass at University of Nebraska-Lincoln" for $9,090 from the Ceramic and Glass Industry Foundation

Outstanding Papers

• X. Chen, X. Zhang, M. A. Koten, H. Chen, Z. Xiao, L. Zhang, **J. E. Shield**, **P. A. Dowben** and **X. Hong**, "Interfacial Charge Engineering in Ferroelectric-Controlled Mott Transistors", Adv. Mater. 29, 1701385 (2017).
• Z. Xiao, J. Song, D. K. Ferry, **S. Ducharme**, **X. Hong**, "Ferroelectric Domain Patterning Controlled Schottky Junction State in Monolayer MoS2", Phys. Rev. Lett. 118, 236801 (2017).
• S. Cao, Z. Xiao, C. Kwan, K. Zhang, J. P. Bird, L. Wang, W.N. Mei, **X. Hong**, **P. A. Dowben**, "Moving towards the Magnetoelectric Graphene Transistor", Appl. Phys. Lett. 111, 182402 (2017).
• M. Montazeri, **P. Rao**, Heterogeneous Sensor-based Build Condition Monitoring in Laser Powder Bed Fusion Additive Manufacturing Process using a Spectral Graph Theoretic Approach, ASME Transactions, Journal of Manufacturing Science and Engineering, Accepted, In-Press, 2018
• **M. Sealy**, G. Madireddy, R. Williams, **P. Rao**, M. Toursangsaraki, Review Article - Hybrid Processes in Additive Manufacturing. ASME Transactions, Journal of Manufacturing Science and Engineering, Accepted, In-press, 2017. doi:10.1115/1.4038644.

Books and Chapters Published

• **B. Balasubramanian** and **D. J. Sellmyer**, "Nanostructuring, Orientation, Annealing," in *Gas Phase Synthesis of Nanoparticles*, Ed. Y. Huttel (Wiley-VCH, Berlin, 2017), pp. 287-303.
• Y. Hou and **D.J. Sellmyer**, Eds. *Magnetic Nanomaterials: Fundamentals, Synthesis and Applications*, Wiley-VCH Weinheim (2017).
• **R. Skomski**, **B. Balamurugan**, **D.J. Sellmyer**, "Magnetism of Nanomaterials," in *Magnetic Nanomaterials: Fundamentals, Synthesis and Applications*, Y. Hou and **D.J. Sellmyer**, Eds., Wiley-VCH, Verlag (2017), pp. 29-80.

Patents

• **Jinsong Huang** and Qingfeng Dong, "Systems and Methods for Fabricating Single Crystal Photovoltaic Perovskite Materials and Devices Incorporating the Same," U.S. Patent 9,812,660; issued: November 7, 2017
• **Patrick Dussault, Rebecca Lai,** Thomas Fisher, Anita Zaitouna, "Self-assembled Monolayers and Methods for Using the Same in Biosensing Applications," U.S. Patent 9,829,487; issued November 28, 2017

Student Awards and Honors

Awards and Honors

Donghee Lee - 2nd Place Poster in the biomedical engineering division of the 2017 US-Korea Conference of the Korean-American Scientists and Engineers Association

Yunlong Jin - Best Poster Award at the 2017 62nd Annual Conference on Magnetism and Magnetic Materials

Ali Ubeyitogullari - 2018 American Oil Chemists' Society (AOCS) Honored Student Award; 2018 AOCS Manuchehr (Manny) Eijadi Award

Junsi Yang - 2018 UNL Center for Biotechnology Milton E. Mohr Fellowship

Yang Hong - 2019 NCMN Graduate Research Fellowship Award; 2017 Pill-Soon Song Outstanding Graduate Research Assistant Award

Seema Pande - 2018 Edward P. Rack Outstanding Graduate Teaching Assistant Award; 2017 UNL Milton E. Mohr Scholarship in the Science of Biotechnology and Engineering

Jie Zhong - 2018 UNL Milton E. Mohr Scholarship in the Science of Biotechnology & Engineering; 2018 Pill-Soon Song Outstanding Graduate Research Assistant Award

Mahmoud Elzouka - 2017 UNL College of Engineering Outstanding Doctoral Dissertation Award

Ph.D. Graduates of NCMN Faculty

Chemistry

Matt Beio (2017, Berkowitz), Dave Nelson (2017, Berkowitz), Greg Applegate (2016, Berkowitz), Hamid R. Lofti Zadeh Zhad (2018, Lai), Arin L. Sutlief (2017, Lai), Yao Wu (2017, Lai), Mikhail Shekhirev (2017, Sinitskii), Veronika Shoba (2018, Takacs), Gia Hoang (2017, Takacs)

Food Science & Technology

Ali Ubeyitogullari (2018, Ciftci), Henok Belayneh (2017, Ciftci)

Mechanical & Materials Engineering

Donghee Lee (2017, Ryu), Mahmoud El-Zhouka (2017, Ndao)

Physics and Astronomy

Xin Zhang (2016, Dowben), Iori Tanabe (2017, Dowben), Elena Echeverria (2017, Dowben), Shi Cao (2017, Dowben), Bhaskar Das (2017, Sellmyer), Yunlong Jin (2017, Sellmyer), Mike Street (2018, Binek), Junlei Wang (2017, Binek), Omid Zandi (2017, Centurion), Anil Rajapitamahuni (2017, Hong), Zhiyong Xiao (2017, Hong), Wenlong Li (2018, Negahban), Xiaoqian Dang (2017, Tsymbal)

Masters Graduates of NCMN Faculty

Chemistry

Alex Boson (2017, Sinitskii), Shuyang Zhang (2017, Takacs)

Food Science & Technology

Steven Kaiser (2018, Ciftci), Lisbeth Vallecilla Yepez (2017, Ciftci)

Mechanical & Materials Engineering

Ziyad Smoqi (2017, Cui), Farbod Sedaghati (2018, Gu), Anton Hassebrook (2017, Ndao), Ethan Davis (2017, Ndao)

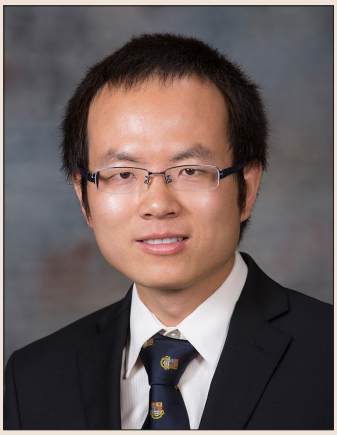
J. Ping Liu Receives Distinguished Achievement Award

Professor J. Ping Liu, former postdoc and Research Assistant Professor in NCMN received the Distinguished Achievement Award at the 2018 Rare-Earth Permanent Magnet Conference in Beijing. Ping has made many contributions to the study of magnetic materials, including at Nebraska, how exchange-coupled hard-soft nanocomposites can produce

very high energy products. Professor Liu was the lead editor for recent books on nanoscale magnetic materials (Springer) and skyrmions (CRC Press). He has more than 270 publications, h-index=50, more than 50 students and postdocs supervised, and is an APS Fellow and Distinguished University Professor at the University of Texas-Arlington. Liu is shown above between Professors George Hadjipanayis of Delaware and Jinbo Yang of Peking University.

Faculty Spotlight: Bai Cui

No other summer has been as unique and exciting as that of 2014 for my career. I accepted the offer made by Prof. Jeffrey Shield to join the department of Mechanical and Materials Engineering at UNL, and started to build up the Materials for Extreme Environments (Me^2) Lab. We develop advanced metallic and ceramic materials that can survive and work in extreme environments, such as high-temperature, nuclear irradiation, corrosive gas or liquid. These materials are very important for many applications, such as in Generation-IV nuclear power systems, advanced petrochemical systems, and aeronautic turbine engines. We use electron microscopy techniques (in-situ and three-dimensional) and macroscale testing to build a bridge between the microstructures and properties during corrosion, irradiation, and high temperature environments.



Dr. Bai Cui

My academic career started at Tsinghua University in Beijing, China, with Bachelor and Master Degrees in Materials. When I went to Imperial College in London, England, for my PhD study, I found my real research interests, which have since accompanied my life for about nine years. At Christmas of 2011, we moved to the US for an unknown journey to continue my career as a postdoc at the University of Illinois at Urbana-Champaign. There was a huge difference between life in big cities and small towns, between China, England and the US. However, we try to feel the loveliness of each place in the weather, culture, food, friends, and more.

A research highlight of my lab at UNL is laser shock processing (LSP, see Figure 1). It is a magical approach which has already helped us to defeat many important challenges for materials in extreme environments, such as the stress corrosion cracking (SCC) of stainless steels in the water coolant pipelines. SCC is a complicated and difficult problem as though a Tower of Babel for the petrochemical and nuclear industry, as a premature failure of many alloys in a corrosive environment. LSP provides the hope to conquer this problem by generating compressive residual stress – as deep as more than 1 mm – to prevent crack propagation. With important help from my collaborators Prof. Yongfeng Lu and Prof. Michael Nastasi and the funding from the Petroleum Research Fund and Nebraska Public Power District, we have made significant progress in understanding the mechanisms.

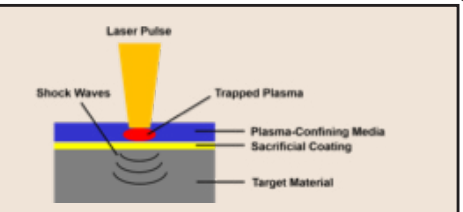


Figure 1. The diagram of laser shock processing.

What is more amazing is that recently we made a new discovery that a modification of this LSP process could potentially inhibit the crack propagation on the surface of structural ceramics, such as α-Al_2O_3 and SiC (Figure 2). Ceramics are so important for cutting tools, turbine engines, armors, and nuclear fuel cladding, but they have an innate low fracture toughness. We are pioneers in this virgin territory to develop an innovative technique, which we believe will ultimately lead to novel mechanisms of toughening ceramics, with support from the National Science Foundation.

We will continue to search for new materials that have better performance in extreme environments, and develop advanced manufacturing technologies using lasers and spark plasma sintering. Our scientific adventure is as a neutron irradiating into a metal, with high energy and passion, getting lost in a dark sea of matter, eventually colliding with a lonely atom nucleus, and glittering a flashing cascade.

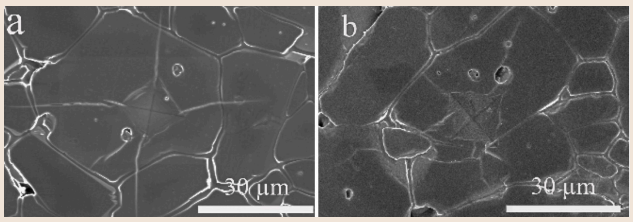
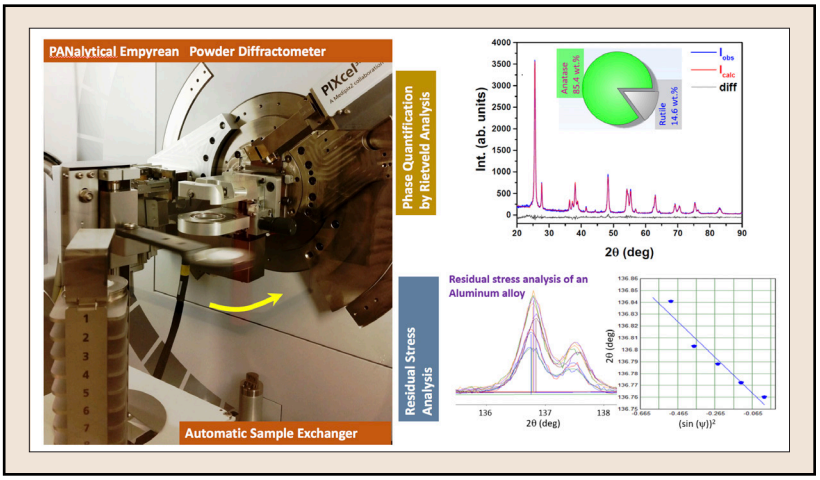


Figure 2. Comparison of the Vickers indentation in (a) untreated α-Al_2O_3; (b) LSP-treated α-Al_2O_3. Laser shock processing of polycrystalline alumina ceramics, Wang, et al., Journal of American Ceramic Society, 100 (3), Copyright ©2017, Wiley Blackwell.

Facility Focus: X-Ray Structural Characterization

X-Ray Structural Characterization Facility (XRSCF) of the NCMN provides characterization tools to perform in-depth analysis including elemental trace analysis and quantification, phase identification and quantification, thin film thickness and interface roughness, nanoparticle size and distribution, residual stress, reciprocal space mapping, pole figures, film-substrate epitaxy relationship, percentage crystallinity analysis and absolute structure determination. The NCMN XRSCF is equipped with five powder diffractometers, a single crystal diffractometer and a Wavelength Dispersive X-ray Fluorescence (WDXRF) Spectrometer to fulfil various structure and elemental analysis needs of academic researchers and industrial clients in Nebraska and beyond. The diffractometers are located in Jorgensen Hall 006, 008 and 009 and Voelte-Keegan Nanoscience. Powder x-ray diffraction (PXRD) is one of the most routinely used techniques in materials research.



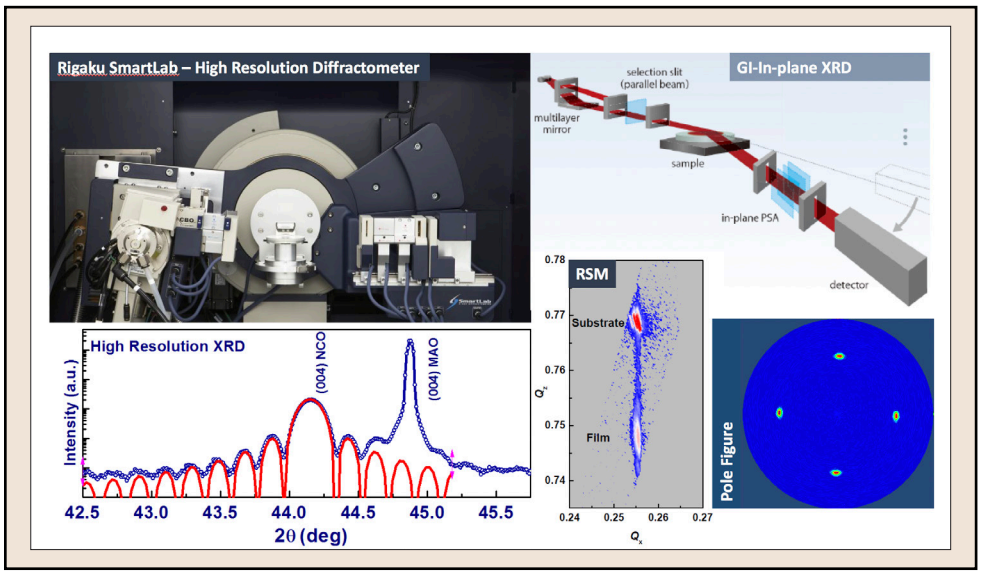
PXRD patterns are unique IDs of the chemical phases and the scattered intensity is proportional to the relative abundance of the individual chemical phases in a mixture, thereby facilitating phase quantification. PXRD is highly sensitive to detect sub-Angstrom distances very precisely that would reveal complete crystallographic structure information including lattice symmetry, atomic coordinates, bond distances and bond angles, etc. Microstructural features of the samples such as crystallite size, strain, etc., influence the shape of diffraction peaks and the presence of residual stress in the samples may cause the diffraction peaks to shift. From the analysis of PXRD patterns, crystallite size, strain and residual stress, etc., can be determined. In addition, by calculating the relative areas of the diffraction peaks, percentage crystallinity in a sample can be estimated.

XRSCF hosts PANalytical Empyrean for dedicated powder diffraction experiments. 45-position sample exchanger facilitates automatic sample exchange and data collection. Reflection-transmission spinner stage provides continuous spinning of the sample during the data collection to reduce the relative intensity variations due to texture, large crystallites, etc. Rigaku D/ Max B is equipped with Co x-ray target. X-rays produced by Co source is beneficial for investigating samples with high concentrations of Fe and Co since those ferrous samples produce less fluorescence by absorbing Co radiation compared to Cu radiation and hence a better signal to noise ratio is achieved. Element tracing and composition analysis provides complementary information to phase identification and a recently installed WDXRF Spectrometer Supermini 200 provides the ability to detect elements Fluorine thru U, both in solid and liquid samples.

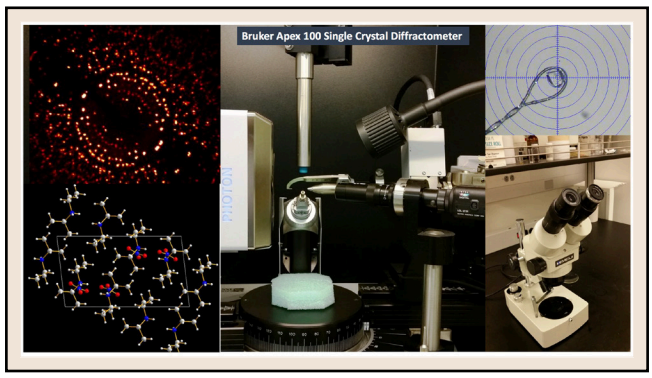
From sub-nanometers, the range of the correlation lengths investigated by the x-rays can be expanded to about a couple of hundred nanometers by specialized small angle scattering techniques such as X-ray reflectivity (XRR) and Small Angle X-ray Scattering (SAXS). These techniques specifically target the investigation of thin film thickness and interface roughness studies and determination of nanoparticle size and their distributions, etc. SAXS experiments at grazing incidence angles (GISAXS) explores the nanostructure formation on the surface of substrates.

High / Ultrahigh Resolution (HRXRD) techniques are essential for the study of quality single crystalline samples / epitaxial grown thin films. Substrate

Facility Focus: X-Ray Structural Characterization



- overlayer orientation relationship (Grazing Incidence In-Plane Diffraction), distribution of the crystallite orientation (Pole-Figure), strain, lattice-relaxation and composition of the film (Reciprocal Space Mapping) can be facilitated by using several additional high-resolution optic components. Residual stress generated in materials due to different processing techniques causes expansion or contraction of the lattice planes and x-ray diffraction is a well established, non-destructive technique to quantify the residual stress in materials.



Rigaku SmartLab and Bruker D8 Discover diffractometers are equipped with state-of-the-art hardware (e.g., Ge(220) x 2 and 4 bounce monochromators, in-plane diffraction arm, 2D-detector, high temperature sample chamber, etc.) in order to support a variety of user base.

Discovering new materials and solving their crystal structure is a key issue in materials science and x-ray crystallography by single crystal diffraction is a most widely used technique to determine the absolute structure. NCMN XRSC Facility has a dedicated single crystal diffractometer (Bruker AXS Photon) for small molecular crystallography using Mo K_{α} radiation. Temperature of the crystal can be stabilized at T = 100 – 500 K during the data collection.

On-site, licensed software analysis tools for phase quantification, solving nanostructures, and x-ray crystallography as well as subscription to comprehensive inorganic structural database (International Center for Diffraction Data (ICDD PDF -4+)) are available at the XRSCF facility. NCMN XRSCF has been serving the interdisciplinary research community at the University of Nebraska as well as other educational institutions and industries in Nebraska and neighboring states. The facility dispenses a wide variety of advanced experimental and analysis tools to the user community to fulfill their micro and nano-structural characterization needs. Consultation, hands-on training and access to the facilities are provided to prospective users and research collaboration could be provided in these areas of expertise.

Shah Valloppilly, Ph.D.
Materials & Nanoscience Research Specialist II

Outreach/Education Highlights

Traveling Nanoscience Exhibits

Our 400-sq.ft. hands-on exhibit was viewed in three Nebraska museums this past year by over 52,000 people. The museums partnered with NCMN to reach thousands in underserved populations

with the Nano mini-exhibit, including rural populations and the growing number of ethnic minorities in those communities. The NanoArt exhibit, which includes images captured during nanoscience research, continues to provide a combination of science and art in a variety of venues.

K-16 Diversity Programs to Title 1 Schools

NCMN's K-16 Diversity programs focused on Title 1 schools and included 1) After School and Summer Camps and 2) Teacher Conferences and Workshops. The After School camps were presented to diverse middle school student populations and the Summer Nano Camps to 1st generation, college-

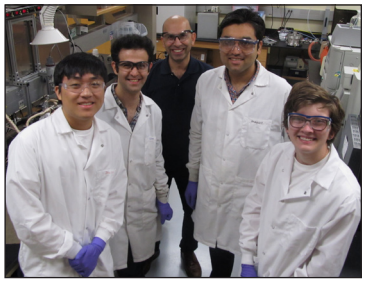
bound high school students (120 total). Part of these camps included hands-on activities and tours of nano-related research in NCMN facility labs and facility tours of NCMN equipment. The high school students are part of science/math focus programs that encourage high school graduation and pursuit of a post-secondary degree. At the Teacher Conference and Workshops, NCMN provided free conference registration scholarships and Nano/STEM activity kits for Native American and Title 1 teachers.

Teacher Conferences/Workshops

NCMN had the opportunity to train and provide resources to hundreds of K-12 teachers with STEM/Nano-related information at teacher science fairs/conferences, preservice teacher workshops, and through online educational videos, lesson plans, and other materials. The events NCMN participated in were the University of Nebraska-Lincoln Preservice Teacher Workshop, Science Matters Workshop, Nebraska Association for the Gifted, and Project Lead the Way Engineering Conference.

Educational Research Programs

NCMN's educational research programs annually provide 12-15 junior and senior high school students an opportunity for summer research in faculty labs, as well as undergraduate REU students and prof/student pairs to train on advanced NNF equipment aimed at giving participants valuable skills and a broader view about the materials research area, interdisciplinary coorperation, and professional development.



New User Outreach & Educations

Education for New Users included our annual Workshop which introduced future users from industry, university, and government entities to NCMN resources. Our annual three-day Minicourse for new users, both local and external, was taught by NCMN's Facility Specialists. Faculty and attendees learned in-depth information about the NCMN's structure, research thrusts, and operational procedures. Nanotech Courses hosted regional and local university students and were designed to promote nanoscience understanding

Outreach/Education

through use of NCMN equipment. Development of equipment training videos provided new facility users with an effective and efficient method of learning information needed to work in NCMN labs.

NCMN Special Events

NCMN sponsored a variety of events throughout the year. NanoDays, a nationwide festival of educational programs about nanoscale science and engineering, was held at our local mall and attended by 400 students and interested general public. Student Conferences included the Conference for Undergraduate Women in Physical Sciences (WoPhyS, where NCMN partnered with MRSEC along with other sponsors), to bring together outstanding student researchers in Physics. Students from across the US attended to build on their current research experiences, interact with physics students from other universities, and attend scientific talks given by scientists who are leaders in their field. We also participted in the Nebraska Women in Science Conference (attended by over 100 high school women and their teachers from across Nebraska), Nebraska Math Day (where we had the opportunitiy to talk with 1,700 of the best and brightest high school students from across Nebraska at the 27th Annual Nebraska Math Day), the annual Robotics Expo at the Strategic Air and Space Museum, and the Eclipse Celebration in August to mention a few.

From the Director

...continued from page 1

(FST), Alexey Kovalev (PHY), Stephen Morin (CHM), and Xiaoshan Xu (PHY). Professor Evgeny Tsymbal was honored recently by receiving an Outstanding Research Creativity Award (ORCA). We also welcome the new NCMN faculty shown on the first page of this Newsletter.

I have been promoting NCMN, materials and nanoscience, and STEM in general with talks to the NU Board of Regents, the State Legislators at a Policymaker Research Summit, and with the NU lobbying firm, Cassidy and Associates in Washington, DC. Our faculty also are hard at work at preparing proposals to renew NSF grants for the Nebraska Materials Research Science & Engineering Center and the Nebraska Nanoscale Facility. We welcome visits and comments by any of our former or present colleagues.

David J. Sellmyer

Research Spotlight

...continued from page 2

Needless to say, thermal spin fluctuations influence all observable properties of a magnetic material, not just its magnetic anisotropy. For example, using similar methods we found an unexpected role of the misplaced Mn atoms on Sb sites in the NiMnSb half-metal: the spins on these Mn atoms easily disorder and destroy the half-metallic gap at finite, but still fairly low temperatures. Surprises await at every turn.

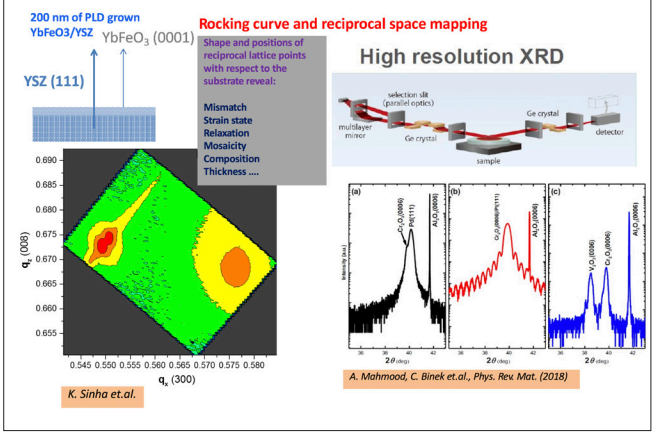
Kirill Belashchenko
Professor
Physics & Astronomy

NCMN/NNF Staff

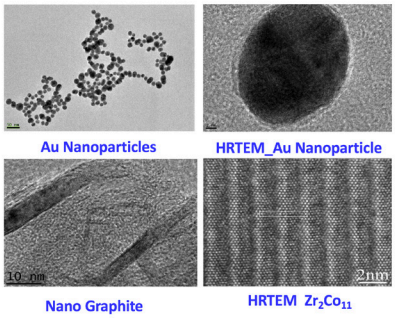
Nebraska Companies Using NCMN/NNF Facilities

Facility Results Gallery

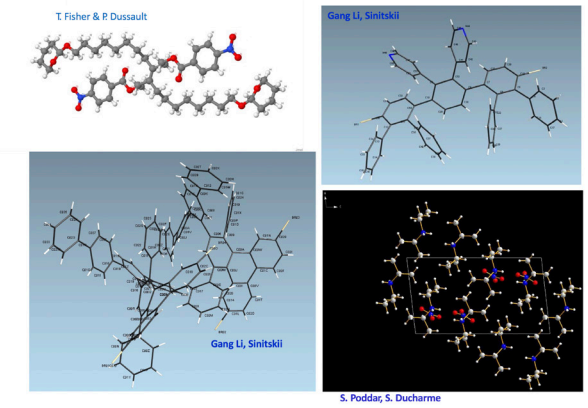
XRD and Reciprocal-Space Mapping



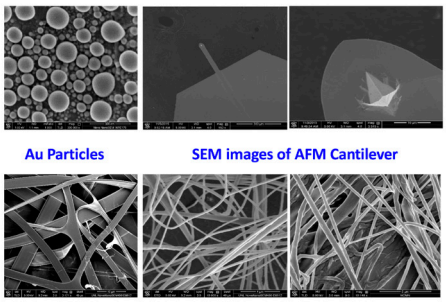
TEM Results



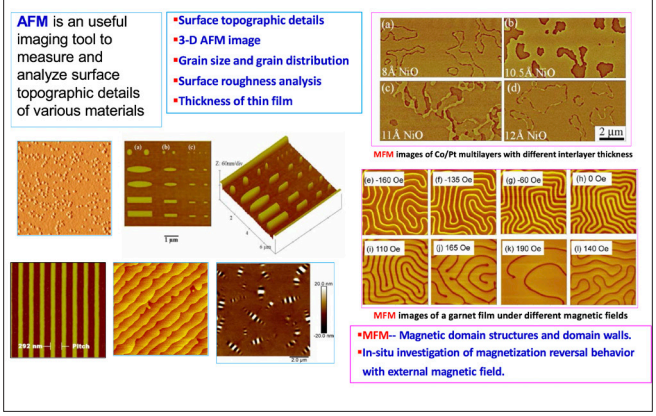
X-Ray Crystal Structures



SEM Results



Scanning Probe Microscopy

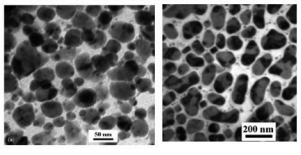


Sputtered Films

ATC 2000-F (AJA International)

- Base pressure ~ $5 \cdot 10^{-8}$ Torr
- Gas environment: Ar & O2
- 2RF (300 W) and 2DC (750 W) supplies.
- Substrates up to 4 inches in diameter with a 6 sample Load lock
- Substrate heater: 850° C max
- Substrate rotation and RF bias
- Quartz crystal thickness monitor

TEM image of $L1_0$ (Fe,Co)Pt-based magnetic films deposited by AJA sputtering system



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