Volume 16, Issue 1 Fall 2016

INTERFACES

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

From the Director

In last year's message I discussed the just-obtained NSF grant for the Nebraska Nanoscale Facility, part of the National Nanotechnology Coordinated Infrastructure (www.nnci.net). We have been hard at work in recruiting and hiring several new staff to serve as Coordinator-User Contact and Research Technologists. We also held the first Academic and Industrial User Workshop in March, and a set of Nanotech Mini-courses in June. These were well attended by industrial and academic potential users, about 65 and 40 attendees, respectively.

Dr. David J. Sellmyer

The draft "2016 National Nanotechnology Initiative (NNI) Strategic Plan" has just been published (www.nano.gov/2016strategy). The current signature initiatives are: Sustainable Nanomanufacturing: Creating the Industries of the Future; Nanoelectronics for 2020 and Beyond; Nanotechnology Knowledge Infrastructure: Enabling National Leadership in Sustainable Design; Nanotechnology for Sensors and Sensors for Nanotechnology: Improving and Protecting Health, Safety, and the Environment; and Water Sustainability through Nanotechnology: Nanoscale Solutions for a Global-Scale Challenge. The NNI is evolving from a major emphasis on fundamental research on nanomaterials and devices towards new efforts focused on using these materials and devices for nanotechnology-enabled systems. Thus, as we consider our future collaborative research directions, we should certainly be aware of new and broadened opportunities.

In the last year we have continued to upgrade and enhance our Central Facilities. Several new experimental systems include those for: ion milling, x-ray fluorescence, multipurpose deposition, high-field annealing, SQUID cryo-cooling, imaging, surface-area measure-

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Facility Focus

The NCMN Nanofabrication Cleanroom Facility provides faculty and students access to a comprehensive suite of tools and processes for nanofabrication. The facility is housed in the class 10,000 (ISO-7) clean room at the Voelte-Keegan Nanoscience Research Center, which spans an over 4,000 sq. ft. area in total, including 2,500 sq. ft. of work space. There are four separated functional areas (bays) based on the bay-and-chase configured framework, i.e. Lithography, Deposition, Characterization, and Etching. The state-of-the-art equipment is allocated in different bays accordingly. The real-time monitoring system (including hazardous gases, airborne particle concentration, temperature, air pressure, etc.) ensures the clean room runs smoothly and safely.

The lithography bay contains the direct-write electron beam lithography and laser lithography systems as well as an optical lithography machine. The electron beam lithography system is the primary choice for ultra-high-resolution patterning in the nanometer range. The integrated laser interferometer-controlled sample

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In This Newsletter

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University of Nebraska Lincoln

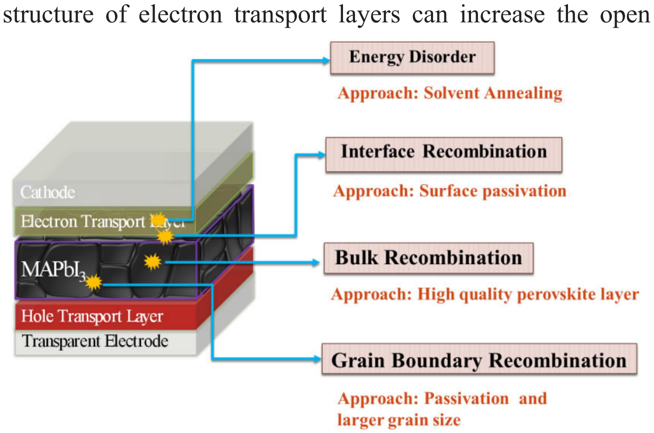
Research Spotlight: Jinsong Huang

High efficient and low-cost perovskite solar cells, photodetectors and radiation detectors

Increasing power conversion efficiency and reducing material and manufacturing cost have been the key avenues for photovoltaic researchers to attain a lower cost of renewable, clean energy source to compete with fossil fuels. Organic-inorganic hybrid perovskite solar cells, an emerging photovoltaic technique, have gained intensive attention in photovoltaic community in the past six years. Our research group has been leading this research area by developing solution-process strategies for device fabrication, boosting the power conversion efficiency, exploiting scalable fabrication techniques, and understanding the unique properties of this new family of materials.

It was challenging for the formation of continuous perovskite films by solution process. We developed an interdiffusion approach to reproducibly form perovskite films on eventually any type of substrate. We proposed that the size and crystallinity of hybrid perovskite grains in the thin polycrystalline films are crucial in determining the power conversion efficiency of perovskite solar cells. A thick perovskite light absorber layer (~500 nm) is needed to harvest most sunlight above its bandgap; however, if the electron/hole diffusion length is smaller than the film thickness, recombination of photo-generated charges will sacrifice the power conversion efficiency. We developed a solvent annealing process, and non-wetting assisted strategy to increase the grain size and corresponding electron/hole diffusion length of perovskite film from 300 nm up to 1 µm, which avoid the bulk recombination inside the grain and enable us to use thicker film for higher photovoltaic performance.

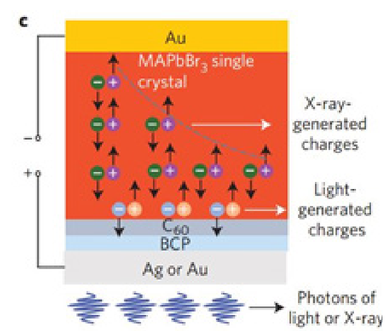
Besides the perovskite light absorber itself, which generates the charges, the charge transporter layers, which extract and collect the photo-generated charges, also play an important role for solar cells. We found that passivation of trap state on the surface and grain boundaries of the perovskite materials by fullerenes or tunneling layer can reduce interface charge recombination, thus improving the photovoltaic performance to as high as 21.3%. Recently, we also revealed that ordered structure of electron transport layers can increase the open-circuit voltage and efficiency of the perovskite solar cell.



Photodetectors and X-ray detectors

The research of perovskite materials has gone well beyond solar cell applications. Recently, we proposed utilizing the perovskite material as the photo-active layer for photodetector application. For a photodetector, the most important figure of merit is its sensitivity. To realize a high sensitivity, it requires the photodetector to possess a high signal-noise ratio. Here we increased the output signal of the perovskite photodetector by utilizing the microscopic defects on the surface of the perovskite polycrystalline thin film. In order to reduce the noise of the photodetector due to the repeated trapping and detrapping of the charge carriers by the defects during their transport process, we further deposited a fullerene double layer on top of the perovskite film to passivate these defects, so that the noise current was suppressed by nearly three orders of magnitude, and therefore the photodetectors can directly measure the light irradiance down to sub 1 pW cm-2, making it a promising candidate to replace the commercial high-cost Si photodiodes for weak panchromatic light detection.

Besides the wide spectrum photodetector, the narrow band photodetectors have wide applications in biomedical research and defense. The normal approach to realize the narrow band photodetection is by combining a wide band photodetector and a band-pass filter, which suffers from the requirement for high-cost filters as well as complicated optical system design and integration. Here we proposed a new design rule to realize the narrow band photodetection (smaller than 20 nm) by utilizing the surface defects of perovskite single crystals. Moreover, the response spectrum can be continuously tuned from blue to red by simply changing the chemical composition of the single crystals.



The perovskite single crystals are found to have excellent application for X-ray detection. For perovskite material, the heavy atoms like lead and bromide make it easy to attenuate most of the incident X-rays by a crystal thickness of only three millimeters. The fabricated perovskite X-ray detectors are four times more sensitive than the commercial amorphous Selenium X-ray detector, which can largely reduce the X-ray dose used during the medical inspection and security check and hence can minimize the risk of X-ray exposure to the human body.

Jinsong Huang
Susan J. Rosowski Professor
Mechanical & Materials Engineering

Faculty Awards and Honors

Promotions and Tenures

• Promoted to full professor: **Shireen Adenwalla**, **Jinsong Huang**, and **Young-Rak Kim**

• Promoted to associate professor and granted tenure: **Xia Hong**, **Srivatsan Kidambi**, and **Alexander Sinitskii**

Awards and Honors

• **Kirill Belashchenko**, NSF grant, "First-principles studies of relativistic spin interactions and torques."

• **David Berkowitz** was named an AAAS fellow.

• **Christian Binek** was elected an APS GMAG officer.

• **Bai Cui**, ACS grant, "Controlling stress corrosion cracking of alloys in chloride environments by laser shock peening."

• **Bai Cui** was named an Outstanding Reviewer for the *Journal of Alloys and Compounds*, 2015.

• **Bai Cui** and **Yongfeng Lu**, NCESR grant, "Novel irradiation and stress corrosion cracking resistant oxide-dispersion-strengthened alloys."

• **Bai Cui, Yongfeng Lu,** and **Michael Nastasi**, NSF grant, "Mechanisms of toughening structural ceramics by thermal engineered laser shock peening."

• **Peter Dowben** was named a Fellow of the Royal Society of Chemistry.

• **Peter Dowben**, DOE grant, "Controlling Structural, Electronic, and Energy Flow Dynamics of Catalytic Processes through Tailored Nanostructures;" NSF grant, "Collaborative Research: Spintronics without spin injection;" NSF grant, "Spin and Dipole Ordering at Molecular Film Interfaces."

• **Alexei Gruverman** has been elected an International Fellow of the Japan Society of Applied Physics.

• **Xia Hong** earned a DOE Early Career Award.

• **Yong Rak Kim**, NSF grant, "Identification and Modeling of Interphase in Cementitious Mixtures through Integrated Experimental-Computational Multiscale Approach;" NE Roads grant, "New Mixture Additives for Sustainable Bituminous Pavements;" NE Roads grant, "Nebraska Specific Slope Design Manual."

• **Sri Kidambi** won the NUtech Ventures Emerging Innovator of the Year award.

• **Yongfeng Lu** earned the 2016 Arthur L. Schawlow Award in recognition of his contributions to laser science.

• **Stephen Morin** earned an NSF early career award.

• **Mehrdad Negahban** was awarded an honorary doctorate from the University of Rouen.

• **Andrzej Rajca** was named an AAAS fellow.

• **Eli Sutter** was named an MRS 2017 spring meeting chair.

• **Jian Zhang** earned an NSF CAREER award.

Outstanding Papers

• **I. A. Zhuravlev**, V. P. Antropov, and **K. D. Belashchenko**. "Spin-Fluctuation Mechanism of Anomalous Temperature Dependence of Magnetocrystalline Anisotropy in Itinerant Magnets," *Phys. Rev. Lett.* 115, 217201 (2015).

• B. Das, B. Balasubramanian, P. Manchanda, P. Mukherjee, **R. Skomski**, G. C. Hadjipanayis, and **D. J. Sellmyer**, "Mn5Si3 Nanoparticles: Synthesis and Size-Induced Ferromagnetism," *Nano Lett.* 16, 1132−1137 (2016); DOI: 10.1021/acs.nanolett.5b04360.

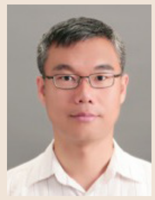
• C. Bi, Q. Wang, Y. Shao, Y. Yuan, Z. Xiao and **J. Huang**, "Nonwetting Surface Driven High Aspect Ratio Crystalline Grain Growth for Efficient Hybrid Perovskite Solar Cells," *Nature Communications* 6, 7747 (2015).

NCMN Welcomes New Faculty Members

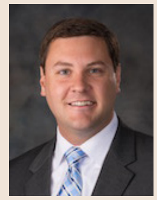
Shudipto Dishari (Chem/Biomol Engineering)

Jiong Hu (Civil Engineering)

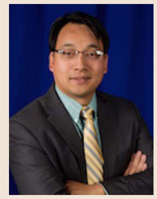
Siamak Nejati (Chem/Biomol Engineering)



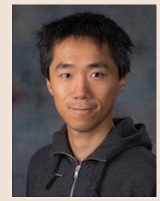
Sangjin Ryu (Mech/Mtrls Engineering)



Michael Sealy (Mech/Mtrls Engineering)



Jian Wang (Mech/Mtrls Engineering)



Qin Zhou (Mech/Mtrls Engineering)

• P. Karki, P. A. Yuya, **Y. Kim**, and **J. A. Turner**. "Nano-mechanical Properties of Constituent Phases in Bituminous Mixtures," *Journal of Materials in Civil Engineering*, DOI: 10.1061/(ASCE)MT.1943-5533.0001605 (2016).

• A. Rajapitamahuni, L. Zhang, M. A. Koten, V. R. Singh, J. D. Burton, **E. Y. Tsymbal**, **J. E. Shield**, and **X. Hong**, "Giant Enhancement of Magnetic Anisotropy in Ultrathin CMR Films via Nanoscale 1D Periodic Depth Modulation," *Phys. Rev. Lett.* 116, 187201 (2016).

• K. Du, K. Zhang, S. Dong, W. Wei, J. Shao, J. Niu, J. Chen, Y. Zhu, H. Lin, X. Yin, **S. H. Liou**, L. Yin and J. Shen, "Visualization of Ferromagnetic Metallic Edge State in Manganites Strips," *Nature Communications* 6, 6179 (2015); DOI: 10.1038/ncomms7179.

• **H. Li**, J. S. Francisco, and **X. C. Zeng**, "Unraveling the mechanism of selective ion transport in hydrophobic subnanometer channels," *Proc. Natl. Acad. Sci. USA* 112, 10851-10856 (2015). Also in UNL Today 8/28/15, Phys.Org 8/25/15, Chinese Academy of Sciences.

• A. D. Wang, L. Jiang, X. W. Li, Y. Liu, X. Z. Dong, L. T. Qu, X. M. Duan, and **Y. F. Lu**, "Mask-free patterning of high-conductivity metal nanowire in open air by spatially modulated femtosecond laser pulses," *Advanced Materials*, DOI: 10.1002/adma.201503289 (2015).

Patents

• J. Kelber, **C. Binek**, **P. A. Dowben**, and **K. Belashchenko**, "Magneto-Electric Voltage Controlled Spin Transistors," U.S. Patent 9,379,232 B2; issued June 28, 2016.

• B. Doudin, P. Braunstein, L. Routaboul, G. Dalmas, Z. Zhang, and **P. Dowben**, "Use Of Zwitterionic Molecules For Forming A Hole Or Electron Transport Layer," U.S. Patent 9,349,958 B2, issued May 24, 2016.

• A. Marshall, **P. A. Dowben**, and J. Bird, "Majority- and Minority-Gate Logic Schemes Based on Magneto-Electric Devices," U.S. Patent 9,276,040 B1, issued March 1, 2016.

• J. Kelber and **P. A. Dowben**, "Boron Carbide Films Exhibits Extraordinary Magnetoconductance and Devices Based Thereon," US Patent 9,324,938 B2, issued April 26, 2016.

• **P. A. Dowben** and Jeffry Kelber, "Novel Semiconducting Alloy Polymers Formed from Orthocarborane and 1,4- Diaminobenzene," U.S. Patent 9,324,960 B2, issued April 26, 2016.

Student Awards and Honors

Awards and Honors

Soroosh Amelian (Civil Engineering, Kim) was awarded the 2015 Othmer Fellowship from the College of Engineering.

Cheng Bi (Mechanical & Materials Engineering, Huang) was awarded a 2016 NCMN Graduate Research Fellowship.

Elena Echeverria (Physics, Dowben) won the 2015 AVS National Graduate Research Award.

Farshad Fallah (Civil Engineering, Kim) received a 2015 UNL Chancellor's Fellowship.

Hamzeh Haghshenas (Civil Engineering, Kim) was awarded the 2016 Milton E. Mohr Graduate Fellowship from the College of Engineering.

Lei Li (Chemistry, Zeng) was awarded a 2016 Outstanding Graduate Research Assistant Award from UNL Graduate Studies.

Spencer Prockish (Physics, Hong) received a $5,000 award for the Energy Sciences Research Summer internship.

Anil Rajapitamahuni (Physics, Hong) was selected as a finalist for the best student presentation at the 2016 Joint MMM-Intermag Conference.

Jack Rodenburg (Physics, Dowben) won a STARnet Undergraduate Research Internship (2016).

Ethiyal Wilson (Physics, Dowben) won a STARnet Undergraduate Research Internship (2016).

Ivan Zhuravlev (Physics, Kovalev) was awarded a 2016 NCMN Graduate Research Fellowship.

Ph.D. Graduates of NCMN Faculty Fall 2015 – Summer 2016

Chemical & Biomolecular Engineering

Daniela Gonzalez (Larsen), Stephen Hayward (Kidambi)

Chemistry

Lei Li (Zeng), Christopher McCune (Berkowitz), Kazuya Toyama (Takacs), Peter Wilson (Sinitskii)

Electrical Engineering

Lijia Jiang (Lu), Qinglei Ma (Ianno), Jinya Pu (Ianno)

Engineering

Bethany Lowndes (Hallbeck)

Mechanical & Materials Engineering

Shengmao Lin (Gu), Yong Liu (Dzenis), Celestin Nkundineza (Turner), Ehsan Rezaei (Turner), Bai Shao (Rajurkar), Yenan Wang (Bobaru), Yun Zeng (Feng)

Physics and Astronomy

Jingfeng Song (Ducharme), Alexander Stamm (Shadwick)

Masters Graduates of NCMN Faculty Fall 2015 – Summer 2016

Chemistry

Benjamin Enns (Dussault), Kyle Hill (Parkhurst), Jordan Veness (DiMagno)

Mechanical & Materials Engineering

Henry Ems (Ndao), Kevin Kreis (Ryu), Qiaofeng Lu (Cui), Jeremiah Meints (Bobaru), Farnaz Nourbakhsh (Rajurkar), Li Zhang (Shield)

Physics and Astronomy

Paulo Costa (Enders), Yang Liu (Dowben), Weiwei Zhao (Liou)

From the Director

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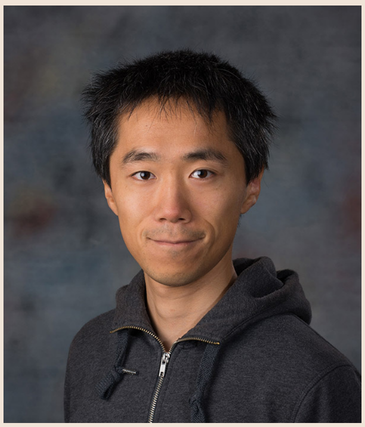
ment, and photon detecting. The total costs for these, $1.255 M, was provided by grants from NSF, ARO and NRI. We are fortunate to receive operating support for NCMN from NSF, NRI, Nebraska Program of Excellence, and Facility Charges. The POE grant, in particular, is important in that it supports the salaries of nine faculty, in whole or in part. Several new faculty in materials and nanoscience have joined UNL and NCMN in the last year. See p. 3 for their photos and departments.

In conclusion, I must acknowledge our great debt to our friend and colleague, Vice Chancellor Prem Paul, who passed on recently. Prem was my supervisor for fifteen years, and many of our best programs and initiatives would not have been possible without his strong support.

David J. Sellmyer

New Faculty Spotlight: Qin Zhou

Qin Zhou landed on the field of Cornhuskers in 2015. Previously he had lots of fun at Berkeley in living and research. The weather in the Bay Area is so nice that he enjoyed sitting in the backyard and listening to his music collection – where he got the idea of making earphones with graphene. Before coming to the US, he studied at Tsinghua University, China. His department is called Precision Instruments, which to many people means learning how a mechanical watch works. He thought so too as a freshman, because that is the most precise and smallest machine he knew. But soon he learned that you can make much smaller machines than watches by a technique called microfabrication, and the machines are called Microelectromechanical Systems (MEMS). That quickly drew his attention because at the micrometer scale many new phenomena emerge.

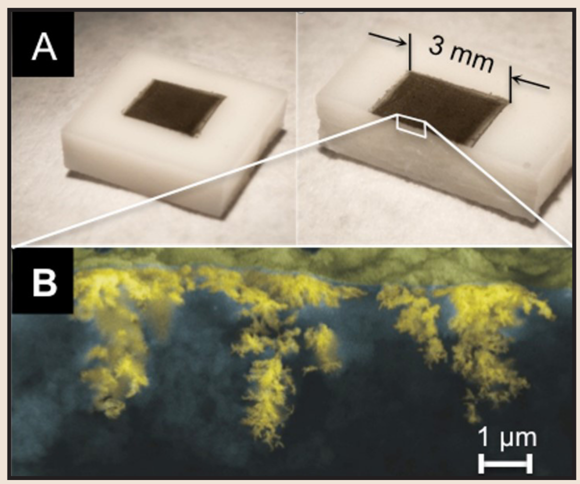


Dr. Qin Zhou

At Berkeley, he continued his work in building MEMS devices but became interested in even smaller objects: nanomaterials. Quantum confinement and large surface-to-volume ratio give birth to many exciting properties compared to their bulk counterparts. However, applications of these materials are still limited due to the lack of interfaces between their nanoscale size and the macroscopic world we live in. He would like to use his expertise, from traditional machinery and circuitry to MEMS and nanomaterials, to better understand the world and improve our life. One example is the graphene-based acoustic devices, where he used graphene membrane as a light-weight diaphragm to generate/perceive sound. Numerous engineering practices are implemented in this work to interface the atomically thin material with humans.

At UNL, his interest in acoustics and electronics initiated a collaboration with Dr. Li Tan's research group and quickly resulted in a hydrogel-based underwater sound detector. The work was published recently in *Nature Communications*. Currently he is working on the integration of hydrogel with graphene to further improve the sensor performance and use it directly as integrated flexible electronics.

Due to his mechanical engineering background, when working on graphene membranes he became extremely interested in the mechanics of materials. He microfabricated a family of MEMS-based nanomaterial testing platforms for studying material's behavior under loading. For example he found that, while a perfect graphene crystal exhibits the maximum material strength ever measured, small defects in the membrane usually result in material failures much earlier than the theoretical limit. However, graphene membranes synthesized with many more defects/grain boundaries are found to be much more resilient to fracture and local imperfections – the material is observed to possibly undergo plastic deformation instead of fracture failure.



Hydrogel-based acoustic sensor, *Nature Communications* 2016.

While working on material mechanics, he realized the testing platform can also controllably induce strain inside materials and induce much interesting physics in materials. Strain affects the possibility of electrons hopping from one lattice site to another, therefore changing material electrical/optical properties. For example, a strain gradient can create a spatially varied bandgap in semiconducting materials and therefore concentrate excitons to a local spot.

Facility Focus: Nanofabrication Cleanroom

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stage makes it possible to accomplish stitching applications and multilayer EBL with overlay accuracy better than 50 nm. Both laser and optical lithography systems can expose most photo-resists, which makes them widely used for MEMS and optoelectronics applications. Unlike the traditional optical lithography, the laser lithography system directly writes a pattern on substrates, which makes it an ideal choice for photo-mask making. In support of these major facilities, this bay also contains photo-resist application and baking equipment as well as optical inspection microscopes and a single-beam focused ion beam station.

The deposition bay houses an electron-beam evaporation system for UHV thin film deposition. The system contains four material pockets for deposition of single and multi-layer films without breaking vacuum. The substrate holder can handle substrates up to 4 inches in diameter and allows simultaneous rotation. It also can be heated up to 850 °C in a suitable environment.

The characterization bay includes a stylus profilometer, a reflective film thickness measurement system, and the four-probe resistivity measurement system. These systems enable researchers to conduct measurement not only on nanometer level thin film thickness but also the surface roughness or electronic conductivities.

In the etching bay, three advanced dry etching tools are equipped. The ion beam etching/deposition system is a versatile UHV thin film fabrication system that provides various processing methods, such as ion beam etching and sputtering, reactive ion beam deposition, and ion beam assisted deposition. Using Secondary Ion Mass Spectrometry (SIMS), this system allows the user to define etch end point and amount of over etch, thus increasing etch precision and repeatability. Except for the three ion beam sputtering targets, the system is also integrated with nine magnetron sputtering guns in the chamber, which makes it an ideal choice for complex multilayer thin-film fabrication such as MTJ junctions. The ICP/RIE high density plasma etching system is capable of employing chlorine-based process gases. The system has been designed to meet all the safety and equipment needs for the most challenging processes, including etch applications that require chlorine chemistries. The Deep RIE system offers ultimate flexibility in silicon etching, from smooth sidewall processes to high etch rate cavity etches. With the ability to run both Bosch and Cryo etch technologies in the same chamber, the system ensures that a wide range of MEMS applications can be realized successfully. These systems are complemented by the standard array of fume hoods, including hoods that are acid-compatible, base-compatible, and organic chemical-compatible.

The NCMN Nanofabrication Cleanroom Facility has been and will be providing researchers with a unique combination of a simple application process, extensive tool and process development, hands-on training, and access to expertise in nanoscience and nanotechnology. Research collaborations are welcome from all university research groups as well as companies in Nebraska and elsewhere.

Dr. Jiong Hua
Materials & Nanoscience Specialist
Nanofabrication Cleanroom

Outreach/Education Highlights

Nanotech Facilities Minicourse and Workshop

NCMN and the Nebraska Nanoscale Facility (NNF), part of the National Nanotechnology Coordinated Infrastructure, hosted a spring Nanotech Workshop for future users from industry, universities, and government entities and a three-day summer Minicourse for new regional users, taught by NCMN/NNF facility specialists and faculty. Visiting faculty, students, postdocs, and industry representatives learned more in-depth information about the NCMN/NNF structure, research thrusts, and operational procedures. These educational opportunities offered information about the equipment, processes, and opportunities at NCMN/NNF along with actual hands-on experiences.

Undergraduate Summer Research Program

NCMN, NNF, and UNL's Graduate Studies Office hosted faculty/student pairs and individual students from four-year colleges and universities to participate in our summer research program. The goal was to provide research experiences focused on nanoscience areas that benefited both the participants and NCMN/NNF projects. Selected students spent 8-10 weeks in research labs under faculty supervision and participated in a variety of activities designed for students that were participating in summer research.

Nano Goes International

We were very excited to travel internationally and share information and activities about nanoscience at SenEcole – Fête de la Science, a 3-day exhibition in Senegal, Africa. Over 300 students/visitors explored nanokits about Thin Films, Invisibility, Liquid Crystals, Nano Sand, Transmission Electron Microscopes, and 3D Imaging. Dr. Sidy Ndao, an NCMN faculty member, made presentations during the event, which supports future African engineers & scientists.

Native American Youth Leadership Camp

As part of a leadership camp, NCMN shared a variety of fun nanoscience activities with middle and high school youth at UNL's Innovation Campus. A 'nanostation' provided interesting demos and activities about nano and nature for student exploration which included information about DNA, light, self-assembly, and piezoelectricity.

NanoPhysics High School Camp

Upward Bound students from Lincoln high schools participated in a summer NanoPhysics camp presented by NCMN. The camp included tours of nano-related research in NCMN facilities and hands-on activities about the ever-growing area of nanoelectronics. Topics covered during the 4-day event included Squishy Circuits, Supercapacitors, Solar Cell Technology, Graphene, LEDs, Batteries, and how these can be incorporated into electrical circuits.

Nano and Discover Engineering Days

NCMN partnered with the College of Engineering to introduce middle school students and their teachers to the various fields in engineering and nanoscience at the University of Nebraska–Lincoln. Events were filled with hands-on activities that applied math, science, and creative thinking skills.

Nano and the Nebraska Robotics Expo

The annual Nebraska Robotics Expo provided a unique venue for NCMN to share what's happening in the Nano/STEM areas with Expo participants, spectators, and parents. Nebraska youth were given demonstrations and interactive activities about opportunities and careers in chemistry, physics, and engineering.

Preservice Teacher Training

Preservice teachers from education programs at UNL participated in the annual "Hands-On Nanoscience" NCMN workshop covering topics like "Planck's Constant with LEDs," "Organic Solar Cells," and "Squishy Circuits, Batteries and other Electronics." Participants were provided teaching and one-on-one coaching on how to use NSF STEM/Nano kits to enrich and support current nanoscience curriculum.

Sheldon Art Museum Gallery Night

The Sheldon Exhibition of "The Romance of the Moon: Science Fiction Invades Art" explored nanoscience and other themes by hosting activities around space exploration, environmental crisis, the relationship between human and machine, and creative invention. Visitors of all ages enjoyed a tour of the Voelte-Keegan Nanoscience Center and informative talks by faculty and staff.

NEBRASKA CENTER FOR
MATERIALS AND NANOSCIENCE

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Interfaces, the newsletter of the Nebraska Center for Materials and Nanoscience, is published periodically. Information, announcements, and research updates should be sent to: Interfaces Newsletter, c/o Jaimie Iuranich, 855 N 16th Street, 201 NANO, Lincoln, NE 68588-0298, jiuranich2@unl.edu.