2017 OSU MATERIALS WEEK

Hosted by the Institute for Materials Research (IMR) and its Materials and Manufacturing for Sustainability (M&MS) Discovery Theme program

TUESDAY, MAY 9 – FRIDAY, MAY 12, 2017
Welcome to 2017 OSU MATERIALS WEEK

Organized by the Institute for Materials Research (IMR) and the Materials and Manufacturing for Sustainability (M&MS) Discovery Theme focus area

The Institute for Materials Research provides vision, coordination and support to advance multi-college excellence and impact in materials-allied research. IMR is the gateway to materials-allied research at The Ohio State University.

IMR SUPPORTS OHIO STATE’S MATERIALS COMMUNITY THROUGH:

• Strategic leadership
• Intercollege coordination
• Multi-university relations
• Management of major research facilities
• Seed funding and facility access funding
• Promotion of industry partnerships
• Infrastructure support and development
• Development and administration of major research programs and centers
• Scientific educational programs and annual conference
• Faculty recruitment

IMR IS GRATEFUL TO THE FOLLOWING FOR THEIR GENEROUS SUPPORT TOWARDS 2017 OSU MATERIALS WEEK:

• Center for Emergent Materials (CEM), an NSF Materials Research Science and Engineering Center (MRSEC)
• Office of Energy and Environment
On behalf of the Institute for Materials Research, I’d like to welcome you to 2017 OSU Materials Week, our 9th annual showcase of materials-allied research at The Ohio State University!

OSU Materials Week is a very special event, as it is both a technical conference where researchers share the latest in innovative materials-allied research, and a celebration of Ohio State’s materials community and all of its accomplishments.

This year we are honored to welcome Dr. Ayodhya Tiwari as our 2017 IMR Keynote Address speaker. Dr. Tiwari is one of the world’s foremost and leading innovators and researchers in flexible thin film materials, devices and photovoltaics. He is the Head of the Laboratory for Thin Films and Photovoltaics, Empa – Swiss Federal Laboratories for Materials Science and Technology, a Professor at ETH-Zurich and Co-Founding Chairman of Flisom Co. His Keynote Address, “Solar Electricity: Advancements and Opportunities with Innovative Emerging Technologies” will kick off Materials Week on Tuesday, May 9.

Following Dr. Tiwari’s Keynote Address, we will host a Welcome Reception and the final round of an exciting new event, the Three Minute Thesis competition. The Three Minute Thesis is an academic competition that challenges Masters and PhD students to describe their research within three minutes to a general audience. We are eager to see the finalists pitch their research ideas and learn more about the important scientific exploration taking place on our campus.

The conference continues with three days of cross cutting and focus sessions featuring talks on a variety of topics demonstrating the depth and breadth of materials research. The two Cross Cutting Sessions on Wednesday and Thursday mornings will feature all nine of our newest faculty hires who have joined Ohio State through IMR’s Materials and Manufacturing for Sustainability (M&MS) program.

Our student poster sessions, always a highlight of Materials Week, take place Wednesday and Thursday evenings from 5-7 pm, and also present an opportunity to socialize amongst colleagues. Finally, we wrap up Friday afternoon with a pizza lunch featuring our student poster awards presentation.

We are very grateful for the generous sponsorship from our longtime partners at The Ohio State University – the Center for Emergent Materials, Ohio State’s NSF Materials Research Science and Engineering Center, and the Office of Energy and Environment. Many thanks also to our outstanding Technical Program Committee volunteers (listed on page 65) for all of their contributions to designing this year’s conference and making it a success.

Welcome!

Dr. Steven A. Ringel
Neal A. Smith Chair Professor
Executive Director, Institute for Materials Research (IMR)
Faculty Director, Materials and Manufacturing for Sustainability (M&MS)
## Agenda

### 2017 OSU MATERIALS WEEK

May 9 – 12, 2017

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<td>1:30 – 2:00 PM</td>
<td>Welcome and introductions</td>
<td>Blackwell Ballroom</td>
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<td>2:00 – 3:00 PM</td>
<td>IMR KEYNOTE ADDRESS: Ayodhya N. Tiwari, Empa–Swiss Federal Laboratories for Materials Science and Technology, ETH (Swiss Federal Institute of Technology) Zurich, and Flisom Company</td>
<td>Blackwell Ballroom</td>
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<td>3:00 – 4:00 PM</td>
<td>Welcome Reception</td>
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<td></td>
<td>4:00 – 5:00 PM</td>
<td>Finals for the Three Minute Thesis (3MT®) Competition</td>
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### Color Guide for Presenters Days

- **TUESDAY**
- **WEDNESDAY**
- **THURSDAY**
- **FRIDAY**
# Wednesday, May 10, 2017

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<td>Registration</td>
<td>Pfahl Hall Lobby</td>
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<td>8:45 – 9:00 AM</td>
<td>Introductions</td>
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| 9:00 – 11:45 AM| **Cross Cutting Session I:** MATERIALS AND MANUFACTURING FOR SUSTAINABILITY  
**Session Chair and Panel Moderator:** Glenn Daehn | 140 Pfahl Hall            |
| 9:00 AM       | Cross Cutting Speaker: Carolin Fink, The Ohio State University                                                 |                           |
| 9:30 AM       | Cross Cutting Speaker: Joerg Jinschek, The Ohio State University                                               |                           |
| 10:00 AM      | Cross Cutting Speaker: John Horack, The Ohio State University                                                 |                           |
| 10:30 AM      | Manufacturing Panel: Ned Hill, The Ohio State University; Farhang Pourboghrat, The Ohio State University; John Bair, The Ohio State University; Jay Sayre, The Ohio State University |                           |
| 11:45 AM – 1:00 PM | Lunch – on your own                                                                                           |                           |
| 1:00 – 4:45 PM| **Focus Session 1:** MATERIALS INNOVATION  
**Session Chair:** Sanjay Krishna  
**Panel Moderator:** Qirui Fan, Core Quantum Technologies | 140 Pfahl Hall            |
|               | Focus Session 2: MATERIALS & NANOSTRUCTURES FOR MAGNETIC SKYRMIONS  
**Session Chair:** Roland Kawakami | 302 Pfahl Hall            |
<p>| 1:00 PM       | Brian Korgel, University of Texas at Austin                                                                   | Geoffrey Beach, Massachusetts Institute of Technology |
| 1:45 PM       | Matthew Tirrell, University of Chicago and Argonne National Laboratory                                     | Axel Hoffmann, Argonne National Laboratory                  |
| 2:30 PM       | Break                                                                                                          | Break                     |
| 2:45 PM       | Katrina Cornish, The Ohio State University                                                                    | Mohit Randeria, The Ohio State University                   |
| 3:15 PM       | Wu Lu, The Ohio State University                                                                               | Fengyuan Yang, The Ohio State University                    |
| 3:45 PM       | Innovation &amp; Commercialization Panel: Steve Risser, Battelle Memorial Institute; William Benson, Worthington Industries; Rob Ellis, Lake Shore Cryotronics; Arfaan Rampersaud, Columbus Nanoworks, Inc.; Katrina Cornish, The Ohio State University | Adam Ahmed, The Ohio State University                       |
| 4:15 PM       | Discussion Panel                                                                                                |                           |
| 5:00 – 7:00 PM| Poster Session and Evening Reception                                                                             | Blackwell Ballroom and Patio                                  |</p>
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<td>9:00 AM</td>
<td>Cross Cutting Speaker: Sanjay Krishna, The Ohio State University</td>
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<td>9:30 AM</td>
<td>Cross Cutting Speaker: Chun Ning (Jeanie) Lau, The Ohio State University</td>
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<tr>
<td>10:00 AM</td>
<td>Cross Cutting Speaker: Marc Bockrath, The Ohio State University</td>
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<tr>
<td>10:30 AM</td>
<td>Cross Cutting Speaker: Jung Hyun Kim, The Ohio State University</td>
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<td>11:00 AM – 1:00 PM</td>
<td>Lunch – on your own</td>
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<td>1:00 – 4:45 PM</td>
<td>Focus Session 3: INTEGRATED DESIGN OF MATERIALS</td>
<td>140 Pfahl Hall</td>
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<tr>
<td>1:00 PM</td>
<td>Greg Fiete, University of Texas at Austin</td>
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<td>1:45 PM</td>
<td>N. Peter Armitage, Johns Hopkins University</td>
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<tr>
<td>2:30 PM</td>
<td>Break</td>
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<tr>
<td>2:45 PM</td>
<td>Peter Abbamonte, University of Illinois at Urbana–Champaign</td>
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<td>3:15 PM</td>
<td>Antonio Ramirez, The Ohio State University</td>
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<td>Tyler Grassman, The Ohio State University</td>
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<td>3:45 PM</td>
<td>Nandini Trivedi, The Ohio State University</td>
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<td>4:15 PM</td>
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<td>Poster Session and Evening Reception</td>
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# FRIDAY, MAY 12, 2017

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<tr>
<td>8:30 AM</td>
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<td>Pfahl Hall Lobby</td>
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| 9:00 – 11:45 AM | **Focus Session 5:** 140 Pfahl Hall NANOENGINEERED MATERIALS FOR MEDICAL APPLICATIONS  
                     **Session Chairs:** Natalia Higuita-Castro and Joao de Sousa Oliveira  
                     **Focus Session 6:** 302 Pfahl Hall WIDE BANDGAP (WBG) SEMICONDUCTORS  
                     **Session Chair:** Aaron Arehart |
| 9:00 AM  | Hsueh-Chia Chang, University of Notre Dame                           |
|          | James Speck, University of California, Santa Barbara                |
| 9:45 AM  | Sarah Heilshorn, Stanford University                                 |
|          | Joel Varley, Lawrence Livermore National Laboratory                 |
| 10:30 AM | Break                                                                |
|          | Break                                                                |
| 10:45 AM | Jed Johnson, Nanofiber Solutions, Inc.                               |
|          | Steven A. Ringel, The Ohio State University                          |
| 11:15 AM | Chandan Sen, The Ohio State University                               |
|          | Sriram Krishnamoorthy, The Ohio State University                    |
| 11:45 AM | Carlos Castro, The Ohio State University                             |
|          | Leonard Brillson, The Ohio State University                         |
| 12:15 PM | Jessica Winter, The Ohio State University                            |
|          | Siddharth Rajan, The Ohio State University                           |
| 12:45 – 2:00 PM | Closing and Poster Awards – Pizza Lunch  
                     **Blackwell Ballroom and Patio** |
Direct conversion of abundant solar light into electricity by means of “Solar Cell” or “Photovoltaic (PV)” devices is an elegant way for safe and clean generation of electricity and to meet the increasing global demand of electricity in a sustainable manner. Progress in research and manufacturing have shown remarkable progress in solar module production cost reduction and the proofs for low price of solar electricity. The trends show excellent merits of PV for numerous applications and multiple benefits to the societies on global scale.

Developments for next generation PV technologies require multidisciplinary approaches of materials science and technology. Advancements in the processing and engineering of device structures with thin films and applications of materials/device characterization methods are contributing to the progress of high efficiency “Thin Film Solar Cells.”

Research and development of single and multi-junction solar cells with novel materials and device structures have provided excellent results and they show promising potential for next generation of photovoltaic systems. Innovative roll-to-roll manufacturing processes – which revolutionized food packaging industry – can be applied for processing of high efficiency solar cells on plastic and metal foils. Lightweight and flexible solar modules offer numerous advantages for low cost solar electricity producing systems and they add smart functionalities for applications on roofs and facades of buildings, transport vehicles, and portable power systems.
BIOGRAPHY

Ayodhya Nath Tiwari is the head of the Laboratory for Thin Films and Photovoltaics, Empa-Swiss Federal Laboratories for Material Science and Technology, and a Professor at ETH (Swiss Federal Institute of technology) Zürich, Switzerland. He is the Chairman and founder of Flisom Company in Zürich. Dr. Tiwari founded Flisom together with his doctoral students for industrialization of a world record efficiency making photovoltaic technology developed in his research lab. Flisom has developed proprietary manufacturing equipment and processes for low cost production of flexible monolithic solar modules with roll-to-roll manufacturing processes.

Dr. Tiwari’s lab has contributed to numerous innovations and breakthroughs with novel concepts, especially in the field of thin film solar cells. His lab has achieved world record efficiencies for flexible thin film solar cells and for thin film polycrystalline tandem solar cells. Dr. Tiwari has more than 35 years of R&D experience in various photovoltaic technologies and is an internationally recognized leading scientist in the field of thin film solar cells. He is a co-author of more than 240 research publications and about 250 conference presentations including numerous invited papers and talks. He has co-chaired or co-organized several international conferences, co-edited special issues of leading journals on solar cells and thin films, and is serving on the editorial boards of several journals. He has been advisor to various institutions and an expert delegation member of EU and other national agencies.
Bose condensation has shaped our understanding of macroscopic quantum phenomena, having been realized in superconductors, atomic gases, and liquid helium. Excitons are bosons that have been predicted to condense into either a superfluid or an insulating electronic crystal. But definitive evidence for a thermodynamically stable exciton condensate has never been achieved. In this talk I will describe our use of momentum-resolved electron energy-loss spectroscopy (M-EELS) to study the valence plasmon in the transition metal dichalcogenide semimetal, 1T-TiSe$_2$. Near the phase transition temperature, $T_C = 190$ K, the plasmon energy falls to zero at nonzero momentum, indicating dynamical slowing down of plasma fluctuations and crystallization of the valence electrons into an exciton condensate. At low temperature, the plasmon evolves into an amplitude mode of this electronic crystal. Our study represents the first observation of a soft plasmon in any material, the first definitive evidence for exciton condensation in a three-dimensional solid, and the discovery of a new form of matter, “excitonium.”

**BIOGRAPHY**

Peter Abbamonte is a Professor of Physics at the University of Illinois at Urbana-Champaign. He is one of the originators of the technique of resonant soft x-ray scattering, which he has used, among other things, to discover a Wigner crystal in doped spin ladders, and to show that stripes in copper-oxide superconductors are charged. This technique is now in use at every major synchrotron facility in the world. Abbamonte is also known for his solution to the phase problem for inelastic x-ray scattering, permitting real-time imaging of electron motion in condensed matter with attosecond time resolution. He has recently used this approach, for example, to image the formation of excitons in insulators, and to measure the effective fine structure constant of graphene. Abbamonte is the founder of Inprentus, a premium optics manufacturer based at the University of Illinois Research Park. He received his Ph.D from the University of Illinois at Urbana-Champaign, having done his research with the then thriving Materials Physics Department at Bell Laboratories. He then went to the University of Groningen in The Netherlands on an IRFAP fellowship from the National Science Foundation. In 2001, he returned to the U.S. as a postdoc in biophysics at Cornell University, where he studied photosynthesis in *Rhodobacter sphaeroides*, and joined the scientific staff at Brookhaven National Laboratory in 2003 before joining UIUC in 2005.
Skyrmions are magnetic textures that are topologically protected and have real space Berry curvature. They hold promise for applications in magnetic memory with skyrmion sizes as small as ~1 nm. In this talk I will discuss our recent progress on skyrmion materials grown by molecular beam epitaxy. Previously, the stability of skyrmions was shown theoretically to depend on material parameters including bulk Dresselhaus spin orbit coupling (SOC), interfacial Rashba SOC, and magnetic anisotropy. Here, we establish the growth of a new class of artificial skyrmion materials, namely B20 superlattices, where these parameters could be systematically tuned. We report the successful growth of B20 superlattices comprised of single crystal thin films of FeGe, MnGe, and CrGe on Si(111) substrates. Additionally, I will be discussing our recent work mapping the phase diagram of FeGe/Si(111) thin films. Experiments have shown an enhanced region of skyrmion stability for sufficiently thin films. Through the use of magnetic measurements, we are able to identify a new class of chiral magnetic textures confined to the thin film surface. I will also present corresponding theoretical simulations showing that these new spin textures can be stabilized as the ground state of the system. This discovery enhances our understanding of skyrmion stability in the presence of Dresselhaus and Rashba SOC.

**BIOGRAPHY**

Adam Ahmed is a recent graduate from The Ohio State University, where he received his MS and Ph.D. in Physics (advisor: Dr. Roland Kawakami) with a thesis on molecular beam epitaxy of artificial B20 superlattices and the discovery of novel spin textures in skyrmion materials. His research interests are synthesis of novel materials and new phenomena in skyrmion materials for applications in magnetic memory. Ahmed received his BS from University of Illinois Urbana-Champaign (advisor: Dr. Laura H. Greene).
Topological insulators (TIs) are a recently discovered state of matter characterized by an “inverted” band structure driven by strong spin-orbit coupling. One of their most touted properties is the existence of robust “topologically protected” surface states. The optical response of topological insulators turns out to be one of their most distinguishing and interesting aspects as these materials can be seen not as surface conductors, but as bulk magnetoelectrics. I will review our work on the optical response of topological insulators thin films of Bi$_2$Se$_3$ and in particular emphasize our most recent work where we find evidence for Faraday and Kerr rotation angles quantized in units of the fine structure constant. This quantized rotation angle can be seen as evidence for a novel magnetoelectric of the TI’s surface states and modified Maxwell’s equations. This quantized rotation is a 3D analog of the quantized resistances seen in quantum Hall systems. The unique optical properties of these materials opens of new areas for photonics applications in the IR regime.

**BIOGRAPHY**

N. Peter Armitage has been on the faculty of the Department of Physics and Astronomy at Johns Hopkins University since 2006. He is a physicist whose research centers on material systems which exhibit coherent quantum effects at low temperatures, like superconductors and “quantum” magnetism. Dr. Armitage’s principal scientific interest is understanding how is it that large ensembles of strongly interacting, but fundamentally simple particles like electrons in solids act collectively to exhibit complex emergent quantum phenomena. He is exploiting (and developing) recent technical breakthroughs using very low frequency microwave and THz range radiation to probe these systems at their natural frequency scales. The material systems of interest require new measurement techniques as their relevant frequencies typically fall between the range of usual optical and electronic methods. He has been the recipient of a DARPA Young Faculty Award, an NSF Career Award, a Sloan Research Fellowship, was a three time Kavli Frontiers Fellow, the William Spicer Award from the Stanford Synchrotron Radiation Laboratory, the William L. McMillan Award from the University of Illinois and 2016 Genzel Prize. He was also the co-chair of the 2014 Gordon Research Conference in Correlated Electron Systems. He received his B.S. in Physics from Rutgers University in 1994 and his Ph.D. from Stanford University in 2002.
John D. Bair
Manufacturing Panel Discussion

BIOGRAPHY
John D. Bair an accomplished entrepreneur was the co-founder of Pinnacle Data Systems (PDSi), Inc. a full product lifecycle diversified integrated computer systems company focusing on designing, commercializing, manufacturing and supporting technology that integrated into Fortune 100 and 500 OEM product lines. Under his leadership, the company went public in 1996 (Nasdaq: PNS) and PDSi grew to $90 million in annual revenues. He served as the President, CEO, CTO and Chief Innovation Officer and as the Chairman of the Board of Directors since 1996. PDSi was acquired in early 2012 by Avnet Inc., a $25 billion technology distribution company, and Bair served as Sr. Vice-President of Avnet Lifecycle Solutions, Global from 2012 – 2014. Currently he is serving as the Executive Director of the College of Engineering’s Center for Design and Manufacturing Excellence (CDME), focusing on technology product ideation, design, manufacturing and commercialization. Previously, Bair served as chair of the College of Engineering’s External Advisory Committee, bringing a particular expertise in the areas of engineering, design, operations, strategic planning, and the technology industry. He holds a Bachelor of Science degree in Computer and Information Science from the College of Engineering at The Ohio State University.
Magnetic skyrmions [1-3] are particle-like chiral spin textures in the form of nanoscale vortices or bubbles that are topologically protected from being continuously ‘unwound’. Their topological nature gives rise to rich behaviors including ordered lattice formation, emergent electrodynamics and robust current-driven displacement at remarkably low current densities. However, magnetic skyrmions have until recently been restricted to just a few materials and observed only at low temperatures, limiting the experimental accessibility and technological application of these unique topological objects. This talk focuses on magnetic skyrmions in ultrathin ferromagnetic transition metal multilayers in which interfaces with heavy metals generate a strong Dzyaloshinskii-Moriya interaction (DMI) that can stabilize chiral magnetic order [4,5]. We show that in inversion-asymmetric multilayer stacks such as Pt/Co/Ta and Pt/CoFeB it is possible to realize isolated magnetic skyrmions and stable skyrmion lattices at room temperature, with sizes down to <50nm. We use pure spin currents to drive skyrmions in at speeds in excess of 100 m/s [6], demonstrating the shifting function of the recently-proposed skyrmion racetrack memories. Through high-resolution time-resolved imaging, we discover an analogue to the Hall effect, in which the skyrmion trajectory depends on its topological charge much as a particle moving in a field acquires a transverse velocity component due to its electrical charge. Finally, we demonstrate a mechanism to deterministically create skyrmions by short current pulses using engineered defects in thin-film heterostructures. These results demonstrate the promise of using skyrmions as topological bit carriers in spin-based devices for low-power memory and logic.


**BIOGRAPHY**

Geoffrey Beach is an Associate Professor of Materials Science and Engineering at Massachusetts Institute of Technology, where he directs the Laboratory for Nanomagnetism and Spin Dynamics, which designs advanced materials for spin-based memory, logic, and emerging applications. Many of his ongoing research efforts center on understanding and exploiting interfacial phenomena that provide new mechanisms with which to electrically control magnetism in nanoscale devices. His work has been recognized with numerous awards including most recently a Deshpande Center Award for Technological Innovation, the MIT Junior Bose Award for Excellence in Teaching, the MIT Class of 1958 Institute Chaired Professorship, and the Department of Energy (DoE) Early Career Award. He received a B.S. in Physics from Caltech, a Ph.D. in Physics from the University of California, San Diego, and conducted postdoctoral work at the University of Texas at Austin.
BIOGRAPHY
Bill Benson leads Worthington Industries in the search of new technology opportunities and intellectual property solutions to address strategic business and customer needs. He works with Worthington’s executive leadership to develop strategies and to exploit viable technology platforms for development and commercialization across the company.
Recently several research groups have demonstrated placing graphene on hexagonal BN (hBN) with crystallographic alignment. This not only creates a protected environment yielding high-mobility devices, but also due to the resulting superlattice formed in these heterostructures, an energy gap, secondary Dirac Points, and Hofstadter quantization in a magnetic field have been observed. In these systems, we observe a π Berry’s phase shift in the magneto-oscillations when tuning the Fermi level past the secondary Dirac points, originating from a change in topological pseudospin winding number from odd to even when the Fermi-surface electron orbit begins to enclose the secondary Dirac points. We also observe a distinct hexagonal pattern in the longitudinal resistivity versus magnetic field and charge density, resulting from a systematic pattern of replica Dirac points and gaps, reflecting the fractal spectrum of the Hofstadter butterfly. Finally, we study the properties of additional graphene/hBN layer electrostatically gated structures such as twisted trilayers that are comprised of AB-stacked bilayer graphene contacting a graphene monolayer through a twist angle, and hBN-encapsulated graphene bilayers with large applied perpendicular electric field.

In the twisted trilayers, which couple the massive bilayer spectrum to that of the massless monolayer spectrum, the interlayer interactions and screening produce a nonlinear monolayer graphene gate capacitance and renormalize the bilayer band structure. In the encapsulated bilayers, we perform Landau level spectroscopy, measure the layer polarizability of the electrons, and observe easy-axis quantum Hall ferromagnetism. Our latest results will be discussed.

**BIOGRAPHY**

Marc Bockrath recently joined The Ohio State University in early 2017 as a Professor of Physics. He works in the field of electronics and mechanics of systems that have critical dimensions on the nanometer scale. His research interests include both understanding the new and interesting transport phenomena that arise in nanostructured materials, and learning how to control and detect their mechanical motion. Bockrath received his Ph.D. in Physics from the University of California, Berkeley and was a postdoctoral fellow at Harvard University from 1999-2002. He began his career at the California Institute of Technology in 2002 as an Assistant Professor of Applied Physics and in 2009 he was appointed an Associate Professor of Physics at the University of California, Riverside.
Spatially-resolved spectroscopies are now available to characterize the electronic properties of advanced materials structures and devices on a nanoscale and in three dimensions. The lateral and depth-resolved capabilities of depth-resolved cathodoluminescence spectroscopy (DRCLS) enable researchers to probe native defects, impurities, chemical changes and local band structure inside state-of-the-art device structures on an unprecedented scale. This talk will include results from a diverse range of nanostructured materials and device structures with particular emphasis on the dynamic properties of GaN high electron mobility transistors.

**BIOGRAPHY**
Leonard Brillson is a Professor of Electrical and Computer Engineering at The Ohio State University, which he joined in 1996 as the Center for Materials Research Scholar. He received his A.B. from Princeton University and his M.S. and Ph.D. from the University of Pennsylvania. He has authored or co-authored over 350 journal articles and 4 books, and has delivered more than 130 invited lectures on these works at scientific conferences worldwide. He is a Fellow of the Institute of Electrical and Electronics Engineers, the Materials Research Society, the American Institute of Physics, the American Association for the Advancement of Science, and the AVS Science & Technology Society as well as a recipient of the Gaede-Langmuir Award. At Ohio State, he has received four College of Engineering Lumley Research Awards.
Structural DNA nanotechnology is a rapidly emerging field with great potential for applications such as single molecule sensing, drug delivery, and manipulating molecular components. Major advances in the last decade have enabled the precise design and fabrication of DNA nanostructures with unprecedented geometric complexity; however, relative to natural biomolecular machines, the functional scope of DNA nanotechnology is limited by an inability to design dynamic mechanical behavior such as complex motion, tunable stiffness, conformational dynamics, or force generation. Taking inspiration from methods used in macroscopic machine design, we have recently developed DNA nanostructures that exhibit tunable mechanical stiffness, well-defined 1D, 2D, and 3D motion including hinges, linear joints, and mechanisms with defined planar or spatial motion paths as well as reconfigurable nanostructures that can undergo triggered conformational changes. A major goal of this work is to develop devices where the structural, mechanical, and chemical properties of these nanodevices can be exploited to perform measurement, manipulation, or delivery functions in biological systems. I will highlight three ongoing projects in our lab to implement DNA nanodevices to probe the stability and conformational changes of biomolecular complexes, probe and control cell-cell interactions, and deliver small molecule drugs.

**BIOGRAPHY**

Carlos Castro is an Assistant Professor in the Department of Mechanical and Aerospace Engineering at the Ohio State University. His laboratory focuses on the self-assembly of DNA nanomechanical devices to probe biophysical function of molecular and cellular systems. He received his Bachelor’s and Master’s degrees in Mechanical Engineering from The Ohio State University and his PhD in Mechanical Engineering from the Massachusetts Institute of Technology. He then spent 1.5 years as an Alexander von Humboldt post-doctoral fellow at the Technische Universität München working in the field of DNA nanotechnology before returning to Ohio State in 2011. He has received an NSF CAREER award and a Fulbright Scholar Award, and his lab has published pioneering work in the design of DNA nanomachines with complex motion and mechanical behavior with applications in biological systems.
In this talk, we will discuss an integrated nucleic acid biochip platform that can identify and quantify short nucleic acids, like miRNA, in a heterogeneous sample, without PCR amplification, reporter labeling, extensive off-chip pretreatment and expensive optical sensors. The main components of the integrated biochips are nanoporous membranes and nanopores with pore radii smaller than the nm-scale Debye length. These nanoscale circuits exhibit ionic current rectification, inductance, memristor, and negative resistance features that result from ion concentration and charge polarization. Such phenomena allow us to control the on-chip ionic strength, actuate pH by splitting water, concentrate the analyte, separate and isolate molecules and detect specific nucleic acids at single-molecule resolution. The result is a sensitive integrated current sensing platform that can identify and quantify nearly identical multiple short nucleic acids with small copy numbers.

**BIOGRAPHY**

Hsueh-Chia Chang holds the Bayer Chair of Engineering at the University of Notre Dame and was the department chair from 1989 to 1995. Chang is known for his research in micro-fluidics, particularly in the areas of electro-kinetics, cell/nanocolloid manipulation and biochips with membrane pretreatment/sensing modules. Born in Taiwan and raised in Singapore, Malaysia and California, he received his BS from Caltech and PhD from Princeton, both in Chemical Engineering. He was awarded the Frenkkel award from the American Physical Society and was elected a fellow of that society. He was honored as the Distinguished Senior Fellow of the United Kingdom Royal Society of Engineering. Chang has mentored more than 60 PhD/Postdocs and half of them have landed academic positions at top universities on all six continents, including Imperial, Johns Hopkins, Technion, Missouri, Florida, UC San Diego, and Duke. He has successfully transferred some of his new technologies to two start-ups. One of them, FCubed LLC, now employs 20 employees and has attracted $20 million in investment. He is the senior author of “Electrokinetically Driven Microfluidics and Nanofluidics” (Cambridge University Press, 2009) and is founding editor of Biomicrofluidics, an American Institute of Physics journal.
Katrina Cornish

Valorized Biomaterials as Large-Scale Supplements and Replacements of Non-Sustainable Sources

Ever increasing utilization of green resources is needed to support a sustainable and resilience economy. In this report, replacements for some petroleum-based polymers and chemicals are discussed in concert with waste utilization, development of new industrial crops, 100% product, co-product and byproduct consumption, while broadening applications for bioplastics, and creating and exploiting novel elastomeric properties.

**BIOGRAPHY**

Katrina Cornish is the Ohio Research Scholar and Endowed Chair in Bioemergent Materials at The Ohio State University, and is Director of Research for the Program of Excellence in Natural Rubber Alternatives, a private/public consortium. She leads a program on alternate rubber production from biotechnological crop improvement to product development. Her program is coupled to conversion of nonrubber constituents to fuels, bioplastics and exploitation of opportunity feedstocks from agriculture and food processing wastes for value-added bioproducts/biofuels. Cornish has over 225 publications, more than 23 patents/patents pending, and is an elected Fellow of the National Academy of Inventors and of the American Association for the Advancement of Science. She serves member of The Biomass Research and Development Technical Advisory Committee for USDA and OE. She is also the CEO of four start-up companies: EnergyEne Inc., EnergyEne Australia Pty. Ltd, EnergyEne Africa, and DamSafe LLC.
Rob Ellis
Innovation & Commercialization
Panel Discussion

BIOGRAPHY
Rob Ellis, Vice President of Strategic Planning, Lake Shore Cryotronics, received his BSci in Electrical Engineering from the California Institute of Technology and his MBA from The Ohio State University. Before joining Lake Shore in 2010 as Director of Strategic Planning, Ellis held positions in technical product management, marketing, and business development with a variety of technology companies, including Director of Marketing with Pinnacle Data Systems (now part of Avnet) and Strategic Business Development Manager with Eaton Cutler-Hammer (now Eaton Electrical). He was appointed to his current role in 2011, and is responsible for leading the marketing and product management functions within Lake Shore.
Recent years have seen intensive experimental and theoretical research activity on topological phases. In spite of this effort, there are relatively few classes of material systems that have been experimentally verified to support topological phases, and most of these do not require electron interactions to underpin the topological properties. In this talk, I will describe some of our theoretical efforts aimed at expanding the known classes of topological materials to include transition metal oxides, which typically have non-negligible electron interactions.

**BIOGRAPHY**

Greg Fiete is an Associate Professor of Physics at The University of Texas at Austin. He received his PhD in theoretical physics from Harvard University, and did postdoctoral work at the Kavli Institute for Theoretical Physics at UC Santa Barbara. He was a Lee A. DuBridge Prize Fellow in Theoretical Physics at Caltech, and the recipient of the NSF CAREER Award, the DARPA Young Faculty Award, a DARPA Director’s Fellowship, and the Presidential Early Career Award for Scientists and Engineers (PECASE). He is also a Fellow of the American Physical Society.
Weldability is a key factor for manufacturing of advanced materials for structural components in energy production, chemical processing and lightweight vehicles. Advanced materials in such applications have specifically tailored properties that are attained by complex thermo-mechanical processing and carefully controlled alloying additions. Due to metallurgical changes and thermo-mechanical effects that occur during the welding process, weld failures and loss of properties are frequently experienced. This can be highly deleterious to fabrication and service-performance of welded metals and alloy components, limiting the implementation of advanced materials.

My research focuses on materials degradation and weld cracking in different advanced material systems. Each of these phenomena is a result of metallurgical as well as thermo-mechanical aspects influenced by material properties, welding processing and structural design. Using a variety of materials characterization and experimental and modeling techniques, my research aims to achieve a comprehensive understanding of the metallurgical processes, material properties and failure mechanisms during welding. In this talk, I will discuss material development approaches to mitigate cracking in repair and structural welding of nuclear power systems. Work is on-going to link the degradation in weld cracking resistance to changes in phase formation during the final stages of solidification due to interstitial and alloying element effects.

**BIOGRAPHY**

Carolin Fink is an Assistant Professor in the Department of Materials Science and Engineering and the Welding Engineering Program at The Ohio State University. Her research interests include weld cracking and materials degradation phenomena, in particular elevated temperature cracking and liquid metal embrittlement, welding metallurgy and weldability of nickel-base alloys, welding of dissimilar materials and weldability testing. Fink joined Ohio State in 2015 as a Postdoctoral Researcher in the Welding Engineering Group. In 2016, she was awarded the Henry Granjon Prize of the International Institute of Welding (IIW) in recognition of her Ph.D. research on ductility-dip cracking in nickel-base alloys. She received her Ph.D. in Mechanical Engineering from the Otto-von-Guericke University Magdeburg in Germany, and is a certified International Welding Engineer (IWE).
Incredible advances in transmission electron microscopy (TEM) based methods, and the scientific discoveries enabled by them, have garnered substantial attention over the last decade or so. Nonetheless, these methods are often wholly impractical and/or entirely unnecessary for many applications, especially when the length scales of interest extend across many orders of magnitude, from the nano up through the micro. While long a workhorse of materials research, the scanning electron microscope (SEM) has also undergone its own, albeit quieter, renaissance. In just the past few years, SEM instrumentation has evolved such that it can now support a significant portion of the work that was previously only tenable via TEM. Innovations and development across the gamut of SEM-based imaging and analysis techniques have enabled new modes of and opportunities for characterization that were previously difficult, if not impossible, to access. One such technique that has recently been gaining traction is electron channeling contrast imaging (ECCI), which provides diffraction-based imaging contrast similar to dark-field TEM, but without the need for specimen thinning. Indeed, a wide range of defects and crystallographic features can be visualized with ECCI—dislocations, stacking faults, antiphase borders, etc.—making it an exceptionally useful technique for rapid defect characterization within crystalline materials. Following an introduction to the method, we will discuss our use of ECCI as a powerful, and indispensable technique for TEM-like characterization of crystal defects within heteroepitaxial semiconductor materials and structures. We will then discuss examples of the development and application of ECCI toward a number of exciting new applications, including new materials systems, nanostructured materials (embedded quantum dots), compositional heterogeneity (phase separation), and the correlation of ECCI with other SEM and scanning probe based techniques to provide multi-modal analysis of structure-property relationships in functional materials.

BIOGRAPHY
Tyler Grassman is an Assistant Professor at The Ohio State University, with joint appointments in the Departments of Materials Science and Engineering and Electrical and Computer Engineering. His research interests focus on the epitaxy, integration, and characterization of novel semiconductor materials and structures for a range of (opto)electronics applications, with a particular focus on photovoltaics and clean energy technologies. Related efforts include band gap and lattice constant engineering, semiconductor surface and interface science, defect analysis and mitigation, and the development of rapid characterization techniques. Grassman earned his M.S. and Ph.D. in Materials Science and Engineering at the University of California, San Diego and his B.A. in Chemistry at the University of Oregon.
Stem cell transplantation is a promising therapy for a myriad debilitating diseases and injuries; however, current delivery protocols are inadequate. Transplantation by direct injection, which is clinically preferred for its minimal invasiveness, commonly results in less than 5% cell viability, greatly inhibiting clinical outcomes. We demonstrate that mechanical membrane damage results in significant acute loss of viability at clinically relevant injection rates. As a strategy to protect cells from these detrimental forces, we show that cell encapsulation within hydrogels can significantly improve transplanted cell viability. Building on these fundamental studies, we have designed a family of injectable, bioresorbable, customizable hydrogels using protein-engineering technology. By integrating protein science methodologies with simple polymer physics models, we manipulate the polypeptide chain interactions and demonstrate the direct ability to tune the material properties including hydrogel mechanics, cell-adhesion, and biodegradation. Through a series of in vitro and in vitro studies, we demonstrate that protein-engineered hydrogels may significantly improve transplanted stem cell retention and regenerative function. Furthermore, many of the lessons learned about designing injectable biomaterials can be extended to design new bio-inks for 3D printing applications. While 3D printing has enormous potential for tissue engineering, few bio-inks are currently available to facilitate the printing of complex, cell-laden constructs. We demonstrate the design of a new, customizable bio-ink that enables the printing of multiple cell types into distinct geometric forms.

**BIOGRAPHY**

Sarah Heilshorn is Associate Professor and the Lee Otterson Faculty Scholar in the Materials Science & Engineering Department at Stanford University. She holds courtesy faculty appointments in the Departments of Chemical Engineering and Bioengineering and is a Bass University Fellow in Undergraduate Education. Her laboratory integrates concepts from materials engineering and protein science to design new, bioinspired materials. These materials are being explored for applications in tissue engineering, regenerative medicine, and 3D bio-printing. She completed her PhD in Chemical Engineering at Caltech and was a postdoctoral scholar in Molecular and Cell Biology at the University of California, Berkeley. Heilshorn is a fervent supporter of diversifying the engineering community and serves in multiple leadership roles to help achieve this goal. She is a Fellow of the American Institute for Medical and Biological Engineering and serves as an Associate Editor for Science Advances.
We will report experimental data for the specific heat, magnetization, thermopower and Nernst coefficients of NbP.

BIOGRAPHY
Joseph P. Heremans is an Ohio Eminent Scholar and Professor in the Departments of Mechanical and Aerospace Engineering, Materials Science and Engineering, and Physics at The Ohio State University. His research interests focus on the experimental investigation of electrical and thermal transport properties and on the physics of narrow-gap semiconductors, semimetals, and nanostructures. In the last decade, his group has been focused on fundamental aspects of thermoelectric and thermal spin transport. He is a member of the National Academy of Engineering, and fellow of the American Associations for Arts and Sciences and the American Physical Society. Prior to joining OSU, he had a 21-year career at the General Motors Research Labs, and later at Delphi, as researcher and research manager. He graduated from the Catholic University of Louvain (Belgium) with Ph.D. in Applied Physics.
BIOGRAPHY
Ned Hill is Professor of Public Administration and City and Regional Planning at The Ohio State University’s John Glenn College of Public Affairs. He is also a member of the College of Engineering’s Ohio Manufacturing Institute. Hill came to Ohio State after serving as Dean of the Maxine Goodman Levin College of Urban Affairs and Professor and Distinguished Scholar of Economic Development at Cleveland State University. He was the editor of Economic Development Quarterly and Chair of the National Advisory Board of the Manufacturing Extension Partnership. The Ohio Manufacturers Association’s Board of Directors presented Hill with the Legacy Award in 2005 and again in 2016 for his work on behalf of Ohio’s manufacturers. Hill earned his Ph.D. in both urban and regional planning and economics from MIT. He teaches the doctoral seminar in public economics in the Glenn College as well as economic development and state and local public policy at both the Glenn College and in OSU’s City and Regional Planning program. Ned’s blog is the One-Handed Economist and can be found at: http://nedhillonehandedeconomist.com and he can be found on Twitter at: @AOneHandedEcon
Magnetic skyrmions are topologically distinct spin textures and can be stable with quasi-particle like behavior, such that they can be manipulated with very low electric currents. This makes them interesting for extreme low-power information technologies [1], where data is envisioned to be encoded in topological charges, instead of electronic charges as in conventional semiconducting devices. Using magnetic multilayers we demonstrated that inhomogeneous charge currents allow the generation of skyrmions at room temperature in a process that is remarkably similar to the droplet formation in surface-tension driven fluid flows [2]. Micromagnetic simulations reproduce key aspects of this transformation process and suggest a possible second mechanism at higher currents that does not rely on preexisting magnetic domain structures [3]. Indeed, we demonstrated this second mechanism experimentally using non-magnetic point contacts. Using this approach, we demonstrated that the topological charge gives rise to a transverse motion on the skyrmions, i.e., the skyrmion Hall effect [4], which is in analogy to the ordinary Hall effect given by the motion of electrically charged particles in the presence of a magnetic field. This work was supported by the U.S. Department of Energy, Office of Science, Materials Sciences and Engineering Division.

References:

BIOGRAPHY
Axel Hoffmann is currently the Senior Group Leader of the Magnetic Films Group within the Materials Science Division of the Argonne National Laboratory. His research interests encompass a variety of magnetism related subjects, including basic properties of magnetic heterostructures, spin-transport and magnetization dynamics in novel geometries, and biomedical applications of magnetism. He received his Ph.D. in Physics from the University of California, San Diego. He was a postdoctoral fellow at the Los Alamos National Laboratory and in 2001 he joined the Materials Science Division of the Argonne National Laboratory as a staff member. He has more than 100 publications with combined more than 6,000 citations (h-index: 45). In addition, he has published four book chapters, one book, and holds three magnetism related U.S. patents. He has presented more than 200 invited talks at conferences and research institutions, is currently an associate editor for the Journal of Applied Physics and a fellow of the American Physical Society and IEEE. Furthermore, in 2011 the IEEE Magnetics Society selected him as a Distinguished Lecturer and in 2015 he was awarded as “Outstanding Researcher” by the Prairie Section of the American Vacuum Society. In 2016 he received the President’s International Fellowship from the Chinese Academy of Sciences.
Human and scientific exploration of space has always been dependent on innovations in materials and manufacturing. Our ability to place humans and machines into space is limited by our launch capabilities, which themselves are critically reliant on cutting-edge materials development, manufacturing processes, and innovations in controls, management, and operability. Operating at the “edge of what we barely know how to do,” every ounce is critical, and every increase in reliability and robustness is highly desirable. Materials and manufacturing have been critical to our many successes, and yet also at the core of many of our most well-known failures in space. As we enter the new era of “Commercial Space,” and advancing human presence beyond low-Earth orbit, Dr. Horack will discuss significant challenges and opportunities, and their dependencies on innovations in materials and manufacturing techniques.

**BIOGRAPHY**

John M. Horack, Ph.D., holds the position of Professor and Neil Armstrong Chair in Aerospace Policy at The Ohio State University, an appointment shared between the College of Engineering’s Mechanical and Aerospace Engineering Department and the John Glenn College of Public Affairs. Horack is responsible for the execution of original scientific and engineering research, public policy research in space, student education, and connecting the policy and technical aspects of spaceflight, while enhancing the overall position of The Ohio State University in the global spaceflight community. In addition to his work at Ohio State, Horack is a Senior Advisor to the President of the International Astronautical Federation, serving as a member of their governing bureau. A global leader in Aerospace, he also provides expert analysis and work for a variety of aerospace companies and organizations around the world. Prior to joining The Ohio State University, Horack served as Vice President of Teledyne Brown Engineering’s Space Systems group, Vice President of Research for University of Alabama, Huntsville, and had an impressive career at NASA’s Marshall Space Flight Center (MSFC), having achieved the level of Senior Executive Service. He began his NASA career in 1987 after graduating from Northwestern University with a B.A. in physics and astronomy. He earned a M.A. and Ph.D. in physics from University of Alabama, Huntsville in 1992 and 1993, respectively. He has authored or co-authored more than 100 papers and conference presentations. Horack has spoken at numerous universities, research institutes, and industrial organizations. He is also a member of the American Association for the Advancement of Science, the American Astronomical Society, the American Institute for Aeronautics and Astronautics, and served as Co-Chair of the International Astronautical Federation’s Space Transportation Congress. In addition, Horack is an FAA licensed private pilot with instrument and commercial pilot ratings, and an FAA flight instructor.
Jinwoo Hwang
Structure-Property Relationships in Disordered Materials for Functional Applications

Structural characterization of amorphous and glassy materials is difficult due to the disordered nature of their atomic configuration. Despite the disorder, however, many of these materials have extended atomic order that dictates important electronic, photovoltaic, and mechanical properties of the material. We characterize such extended atomic order using coherent electron nanodiffraction in scanning transmission electron microscopy. Statistically reliable ordering information can be acquired using fluctuation microscopy and angular correlation analysis of the nanodiffraction data. Here we present three different disordered systems, boron carbide for low dielectric applications, metallic glasses for nanoscale structural applications, and organic semiconductors for flexible electronics, and show how we establish the connection between the nanoscale ordering and their important properties.

BIOGRAPHY
Jinwoo Hwang is an Assistant Professor in the Department of Materials Science and Engineering at The Ohio State University. His research interests include advanced structural characterization of materials, S/TEM technique development, and computational materials modeling. In particular, he has developed novel S/TEM techniques and simulation methods based on electron nanodiffraction and quantitative imaging, for nanostructured materials, oxide heterostructures, and non-crystalline materials. Hwang received his Ph.D. from the University of Wisconsin, Madison and prior to joining Ohio State he was a postdoctoral researcher at the University of California, Santa Barbara for three years. For his contributions to the field, he has received several honors and awards, including the Albert Crewe Award from the Microscopy Society of America.
The Office of Energy and Environment

Ohio State is developing durable solutions to today’s global energy, environment and sustainability challenges, and instituting a culture of sustainability through collaborative teaching, pioneering research, comprehensive outreach, and innovative operations, practices, and policies.

The Office of Energy and Environment strengthens Ohio State as a leader among sustainable campuses by:

- Employing renewable energy sources including wind, geothermal and solar to power campus
- Encouraging academic literacy in sustainability, energy and the environment for our students
- Supporting Ohio State’s Discovery Themes Initiatives, including Materials and Manufacturing for Sustainability

Ohio State’s Sustainability Goals establish our university as a model of sustainable operations and practices. Among the goals are plans to:

- Ensure that Ohio State has a carbon-neutral impact on the environment
- Establish a Comprehensive Energy Management plan that will modernize the university’s 485-building Columbus campus, create substantial academic benefits, and establish a major center for energy research and technology commercialization
- Expand learning opportunities for our students

Learn more at oee.osu.edu.

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Ongoing research focus on more efficient energy use and conversion, on more efficient transportation, and on environmental protecting technologies relies heavily on the advancement of (new) functional nanomaterials. At any stage in R&D, studies of these nanomaterials’ structure, properties, and function are critical, including detailed atomic-scale insights. To our advantage, atomic scale electron microscopy (EM) has become a powerful and indispensable tool for characterizing those nanostructures. Ongoing activities concentrate on methodological aspects of state-of-the-art EM and thereby open routes towards atom sensitive imaging. However, the actual state and function of nanomaterials ‘in operation’ cannot always be inferred from examination under standard EM conditions or from postmortem EM studies. In situ techniques enable visualization of structural evolution under operational / environmental conditions, thereby providing new insights in important materials science questions.

Applying atomic scale EM techniques in in situ studies is, however, extremely demanding. A key challenge is to establish in situ conditions in the close vicinity of the specimen while maintaining the microscope’s overall performance and stability. Recent research and development in atomic-scale in situ EM will be highlighted. New in situ stages - based on MEMS technology – enable more accurate knowledge of experimental in situ conditions. Fine temperature control enables quantitative atomic-scale studies at elevated temperatures. A gas-flow MEMS nanoreactor enables operando EM combining structural characterization of, e.g., catalytic materials with simultaneous measurement of its activity for gaseous reactions. These advancements open up for unprecedented experiments of dynamic phenomena in materials science.

**BIOGRAPHY**

Joerg Jinschek is an Associate Professor of Materials Science and Engineering at The Ohio State University. has strong expertise in aberration-corrected S/ TEM and in environmental TEM (ETEM) in particular. A theme in this work is the ability to extract materials’ structural information at the atomic scale using state-of-the-art electron microscopy. More recently his work has focused on the development of in-situ / environmental TEM, including the development of holders, to focus on extending atomic scale characterization capabilities from static to dynamic studies resulting in the ability to understand in more detail the link between structure and its evolution vs. unique properties on characteristic length scales. His most highly cited papers discuss methods for self-assembly of carbon nanotubes, TEM methods to visualize surface reconstruction in catalysts in-situ, and methods to determine atomic positions in gold crystals.
The dynamic state of nanomaterials ‘in operation’ cannot always be inferred from examination under standard electron microscope high vacuum conditions or from postmortem studies. For instance, the state of a heterogeneous catalyst and the catalyst’s properties are intimately dependent on the reaction environment. Direct observations under operating conditions are therefore of utmost importance. Besides having the effect of electron beam & sample interactions under control, a key challenge is to establish gaseous (reaction) environments inside an electron microscope in the close vicinity of the specimen while maintaining the EM’s overall performance and stability.

Progress in recent research is reviewed to highlight the potential of a differentially-pumped microscope platform, optimized for atomic scale in situ investigations. Also, gas-flow nanoreactor stages - based on MEMS technology – enable studies of gaseous reactions, combining structural characterization of, e.g., catalytic materials with simultaneous measurement of its activity. These methodologies can be expanded to probe gas-solid (or liquid-solid) interactions on nanostructures in general, such as in oxidation and corrosion studies, to understand the structure-property-function relationship on the (sub)nanometer length scale.

Using discrete electron tomography. Prior to joining Ohio State, Jinschek held various positions at FEI Company, Eindhoven (NL), including Sr. Application Scientist for aberration-corrected & in-situ / environmental electron microscopy (TEM), as well as Sr. Product Marketing Manager in the Materials Science BU responsible for advanced in-situ TEM solutions and solution development for Chemistry of Materials. From 2005 to 2007 he was a Research Assistant Professor and the Director of the Electron Microscopy Lab at Virginia Tech in Blacksburg, VA. Jinschek received his M.S. and Ph.D in Physics and Solid State Physics, respectively, from the Friedrich-Schiller-University (FSU) in Jena, Germany. He then was awarded with an Alexander-von-Humboldt Feodor-Lynen-Fellowship (2001-2003) and held a post-doctoral fellowship at the National Center for Electron Microscopy at LBNL in Berkeley, CA (2001-2005).
Materials and Manufacturing for Sustainability

The Materials and Manufacturing for Sustainability (M&MS) program enables Ohio State faculty, students and staff to focus on translational innovation and research in technology, science and manufacturing as they apply to future energy systems and sustainability from the nano-scale to the macro-scale.

With the goal to become pre-eminent in the field of advanced materials and technologies for sustainability, our program connects, creates, and delivers value to solve the world’s most pressing problems in the 21st century.

M&MS builds on the foundation of discovery in the Institute for Materials Research, hiring faculty to advance materials discoveries, developing strategic industrial and global relationships, and accelerating the research process to enable a paradigm of discovery-to-deployment at Ohio State.

Materials Innovation is the interface that connects, creates and delivers value in a collaborative, innovation ecosystem that spans the continuum from discovery to deployment to meet the grand challenges of our world. We are accomplishing this by building an enhanced innovation culture to perform translational R&D that complements our existing research base, where innovation is defined by connecting ideas to the market as a tangible business outcome for our partners.

The Materials Innovation Lab is an innovation space that translates science and engineering discoveries into economic and societal benefits through strategic partnerships. The Materials Innovation Lab consists of both an innovative physical space and an operational model that allow ideas to collide while fostering collaboration to maximize innovation impact. It is a place where partners have access to the university and engage with students and faculty in an innovative ecosystem at the nexus of technology, market, and execution.
Developing a Faculty Cohort

The strength of our faculty is central to the success of our materials community. The M&MS program is advancing a new vision for materials innovation through investments in select faculty dedicated to the value of interdisciplinary research. As of January 2017, nine new faculty have joined Ohio State through the M&MS program, with four more joining during academic year 2018 and several additional faculty searches currently underway. Strategic recruitment has focused on three discovery areas: energy harvesting, storage and systems; high-performance materials and structures; and low-energy information systems.

CROSS CUTTING SESSION 1
Wednesday, May 10, 2017 • 9:00 – 11:45 AM
Materials Degradation and Cracking Phenomena in Welding of Advanced Materials, Carolin Fink, Assistant Professor, Materials Science and Engineering and Welding Engineering
Atomic Scale In Situ Electron Microscopy: Challenges and Opportunities, Joerg Jinschek, Associate Professor, Materials Science and Engineering
Materials and Manufacturing: Challenges and Opportunities in Sustainable Space Exploration, John M. Horack, Professor and Neil Armstrong Chair in Aerospace Policy, Mechanical and Aerospace Engineering Department and John Glenn College of Public Affairs
Manufacturing Panel Discussion: Includes panelists Ned Hill, Professor, Public Administration and City and Regional Planning and Farhang Pourboghrat, Professor, Integrated Systems Engineering and Mechanical and Aerospace Engineering

CROSS CUTTING SESSION 2
Thursday, May 11, 2017 • 9:00 – 11:00 AM
Antimonide Based Infrared Detectors and Focal Plane Arrays: From Materials to Manufacturing, Sanjay Krishna, George R. Smith Professor of Engineering, Electrical and Computer Engineering
Quantum Transport and Electron Interactions in Few-Layer Atomic Membranes, Chun Ning (Jeanie) Lau, Professor, Physics
Nanoscale Electronics in Low-Dimensional Material Systems, Marc Bockrath, Professor, Physics
Crystal Structure – Composition – Property Relationships of Li(Ni,Mn,A)2O4 Spinel for Lithium-Ion Batteries, Jung-Hyun Kim, Assistant Professor, Mechanical and Aerospace Engineering
Nanofiber Solutions is a regenerative medicine company developing a new class of implants with unrivaled performance for the $20B soft tissue repair/regeneration market. Our technology is used to build off-the-shelf scaffolds that are critical in the development of life-saving and life-changing, tissue engineered implants. We are developing a large pipeline of life-saving medical implants in partnership with world-leading clinical institutions for artificial organs and other regenerative medicine applications based on this proven platform technology.

**BIOGRAPHY**
Jed Johnson co-founded Nanofiber Solutions Inc. in the spring of 2009 based upon state-of-the-art nanofiber scaffolds for cell culture and tissue engineering applications as an extension of his thesis work. He currently serves as the Chief Technology Officer. He led the team that won 1st Place in the 2009 Deloitte Business Plan Competition and has served as principal investigator on numerous NIH and NSF SBIR/STTR grants, in addition to Ohio Third Frontier grants. Johnson received his Ph.D. in Materials Science and Engineering with a focus on biomaterials from The Ohio State University.
LiNi$_{0.5}$Mn$_{1.5}$O$_4$ (LNMO) high voltage spinel is a promising candidate for the next-generation cathode material because of its high operating voltage (4.75 V vs. Li), potentially low material cost, and excellent rate capability. LNMO crystallizes into two different symmetries depending on the occurrence of disordering/ordering of Ni$^{2+}$ and Mn$^{4+}$ in the lattice. For example, the ordering between Ni and Mn (1:3 ratio) lowers the symmetry from Fd3-m (disorder) to P4$_3$32 (order). The order-to-disorder transition in LNMO has been reported to occur at around 700 °C in air. However, recent experimental and first-principle calculation demonstrated a local deviation from the perfect ordering behavior of Ni/Mn from polycrystalline samples.

Firstly, I will qualify and quantify the disorder-to-order transition and the formation of integrated order/disorder nano-domains in LNMO by annealing at 700°C. Detailed structural study performed by neutron diffraction and transmission electron microscopy (TEM), in combination with extensive electrochemical testing, demonstrates that such partially ordered sample (composite order/disorder nano-domains) retains advantages from both disordered and ordered spinels as the first-principle calculation predicted.

Secondly, I will present a further optimization of chemical composition of LNMO by partial substitution of Ni and/or Mn with multivalent cations(A). Tuning the chemical composition perturbs the cation orderings and formation of Ni-based rock-salt secondary phase, which can improve kinetic performance. More importantly, doped cations(A) segregate on the surfaces and alleviate unwanted reactions of the spinel surface with the electrolytes. From the results, I will discuss about the crystal structure – composition – property relationships of Li(Ni,Mn,A)$_2$O$_4$ spinel as positive electrodes for Li-ion batteries.

**BIOGRAPHY**

Jung-Hyun Kim is an Assistant Professor of Mechanical and Aerospace Engineering at The Ohio State University. His research focuses on the designing, synthesis, and characterization of advanced ceramic and polymer materials, with significant current efforts devoted to Li-ion batteries, solid-oxide fuel cells, and gas-permeation membranes. Prior to joining the OSU faculty, he was a senior researcher in the General Motors Global Research and Development Center from 2011 to 2016, and a postdoctoral fellow at Spallation Neutron Source in the Oak Ridge National Laboratory in 2010. He received a Ph.D. in Materials Science and Engineering from the University of Texas at Austin.
I joined the faculty at The University of Texas at Austin in the summer of 1998 as an Assistant Professor. I founded my first company in 2001 – Innovalight – while I was still an Assistant Professor. I had no idea what was in store for me. Perhaps ironically, I had not taken my academic position with the intention of ever starting companies. But that time period was an exciting one for nanotechnology, and private investors were seemingly roaming the halls of universities looking for ways to invest in nanotech startups. During the first couple of years at UT Austin, my work had focused on the synthesis and self-assembly of gold and silver nanocrystals, but I had become interested in silicon. This was an extremely challenging synthetic system. So, we gained a lot of interest when we published a paper in Science in 2000 on the colloidal synthesis of silicon nanowires and a year later, a promising method for preparing silicon nanocrystals in the Journal of the American Chemical Society. This fundamental work created the conceptual platform for Innovalight, which boldly set out to displace the incandescent lightbulb with silicon quantum dot light-emitting diodes (LEDs). Ten years after its inception, the company had grown to 85 employees, shifted its research focus to solar cells and was acquired by DuPont. I will talk about some of things I learned by taking a leap to start a company.

**BIOGRAPHY**

Brian A. Korgel is the Edward S. Hyman Chair in Engineering and T. Brockett Hudson Professor of Chemical Engineering at the University of Texas at Austin. He directs the Industry/University Research Center (I/UCRC) for Next Generation Photovoltaics, the Emerging Technologies area of the UTIPortugal program and serves as Associate Editor of the journal *Chemistry of Materials*. He works at the intersection of nano and mesoscopic materials chemistry and complex fluids, tackling problems in lithium ion batteries, photovoltaic devices and medicine. Korgel received his PhD in Chemical Engineering from UCLA and was a post-doctoral fellow at University College Dublin, Ireland, in the Department of Chemistry. He has given more than 260 invited talks and has published 240 papers and was a Visiting Professor at the University of Alicante in Spain, the Université Joseph Fourier in France and the Chinese Academy of Sciences in Beijing. Korgel has co-founded two companies, Innovalight and Piñon Technologies, and received various honors including the 2012 Professional Progress Award from the American Institute of Chemical Engineers (AIChE) and election to Fellow of the American Association for the Advancement of Science (AAAS).
Infrared imaging (3-25μm) has been an important technological tool for the past 60 years since the first report of infrared detectors in 1950s. There has been dramatic progress in the development of infrared antimonide based detectors and low power electronic devices in the past decade with new materials like InAsSb, InAs/GaSb superlattices and InAs/InAsSb superlattices demonstrating very good performance. One of the unique aspects of the 6.1A family of semiconductors (InAs, GaSb and AlSb) is the ability to engineer the bandstructure to obtain designer band-offsets. Our group investigates fundamental challenges in antimonide based infrared detectors and explores new avenues for next generation infrared detectors, arrays and imagers. In this talk, I will describe three research thrusts of our group. This include (a) Antimonide based materials and detectors, (b) Next Generation focal plane arrays and (c) Applications of Infrared imaging. In this talk, I will provide an example from each of the research thrusts. I will describe some of the material science and device physics of the antimonide systems. The use of “unipolar barrier engineering” to realize high performance infrared detectors and focal plane arrays will be discussed. I will also explore the possibility of realizing the 4th Gen infrared imaging systems. Using the concept of a bio-inspired infrared retina, I will make a case for an enhanced functionality in the pixel. The key idea is to engineer the pixel such that it not only has the ability to sense multimodal data such as color, polarization, dynamic range and phase but also the intelligence to transmit a reduced data set to the central processing unit. I will also discuss some commercial applications of infrared imaging including the early detection of skin cancer.

BIOGRAPHY
Sanjay Krishna is the George R Smith Professor of Engineering in the Electrical and Computer Engineering department at The Ohio State University. His group is involved with the development of next generation infrared detectors, arrays and imagers. He was previously the Director of the Center for High Technology Materials and Professor and Regents Lecturer in the Department of Electrical and Computer Engineering at the University of New Mexico. He is the co-founder and CTO of SK Infrared, a start-up involved with the use of IR imaging for dual use applications including early detection of skin cancer. Krishna received the Gold Medal from IIT, Madras, Ralph Powe Junior Faculty Award, IEEE Outstanding Engineering Award, ECE Department Outstanding Researcher Award, School of Engineering Jr Faculty Teaching Excellence Award, NCMR-DIA Chief Scientist Award for Excellence, the NAMBE Young Investigator Award, IEEE-NTC, SPIE Early Career Achievement Award and the ISCS Young Scientist Award. He is a Fellow of IEEE, OSA and SPIE. He has more than 200 peer-reviewed journal articles (h-index=45), two book chapters and ten issued patents, and was also awarded the UNM Teacher of the Year and the UNM Regents Lecturer award. Krishna received his M.S. in Electrical Engineering and PhD in Applied Physics from the University of Michigan.
\( \beta\text{-Ga}_2\text{O}_3 \) is an emerging ultra-wide band gap semiconductor \((E_g = 4.5 \text{ eV})\) with potential for high frequency and high power switching device applications. Availability of high quality bulk substrates grown using melt-based approaches and the tunable n-type conductivity can enable high performance unipolar devices. We will discuss plasma-assisted molecular beam epitaxy growth of \( \beta\text{-Ga}_2\text{O}_3, \text{Ga}_2\text{O}_3 / (\text{AlGa})_2\text{O}_3 \) heterostructures and strategies for n-type doping of \( \text{Ga}_2\text{O}_3 \) using Si dopants in a highly oxidizing ambient. Delta doping is a critical ingredient for modulation-doped heterostructure devices. We fabricated a silicon delta-doped field effect transistor with \( I_{D, \text{MAX}} = 300 \text{ mA/mm}, \ g_{M, \text{MAX}} = 26 \text{ mS/mm}, \) and low contact resistance \((0.4 \text{ ohm.mm})\). Using a delta-doped \((\text{AlGa})_2\text{O}_3 \) barrier layer, we demonstrate a modulation-doped \((\text{AlGa})_2\text{O}_3 / \text{Ga}_2\text{O}_3 \) FET with complete modulation of \(7 \times 10^{12} \text{ cm}^{-2} \) charge in the \( \text{Ga}_2\text{O}_3 \) layer. These results introduces a new paradigm in wide band gap electronics and indicate the promise of \((\text{AlGa})_2\text{O}_3 / \text{Ga}_2\text{O}_3 \) heterostructures for high performance \( \beta\text{-Ga}_2\text{O}_3 \)-based high frequency devices.

**BIOGRAPHY**

Sriram Krishnamoorthy is currently a post-doctoral researcher in the Electrical and Computer Engineering department at The Ohio State University. He received his doctoral degree from the ECE department at The Ohio State University in 2014. His doctoral work focused on demonstration of state-of-the-art Gallium Nitride-based interband tunnel junctions for optoelectronic applications. His research interests include wide band gap materials (Gallium Oxide, III- Nitrides) and devices.
Two dimensional materials constitute an exciting and unusually tunable platform for investigation of both fundamental phenomena and electronic applications. Here I will present our results on transport measurements on high mobility few-layer graphene and phosphorene devices. In bilayer and trilayer graphene devices with mobility as high as 400,000 cm²/V, we observe intrinsic gapped states at the charge neutrality point, arising from electronic interactions. This state is identified to be a layer antiferromagnetic state with broken time reversal symmetry. In another few-layer graphene system, ABA-stacked trilayer graphene consists of multiple Dirac bands, where crystal symmetry protects the spin degenerate counter-propagating edge modes resulting in \( \sigma_{xx} = 4e^2/h \) and \( 2e^2/h \). Our findings indicate the role of crystal and spin symmetry in generation of topological phases in multiple Dirac bands. Finally, I will present our recent results on weak localization and quantum Hall effect in air-stable, few-layer phosphorene devices. Our results underscore the fascinating many-body physics in these 2D membranes.

**BIOGRAPHY**

Chun Ning (Jeanie) Lau is a Professor of Physics at The Ohio State University. Her research focuses on electronic, thermal and mechanical properties of nanoscale systems, in particular, graphene and other two-dimensional systems. Before joining Ohio State in January 2017, she was a Professor in the Department of Physics and Astronomy at University of California, Riverside and a research associate at Hewlett Packard Labs in Palo Alto from 2002 to 2004. Lau has published ~100 papers and given more than 120 invited talks worldwide. She is the recipient of the NSF CAREER award and the PECASE award (Presidential Early Career Award for Scientists and Engineers). Lau received her BA in physics from University of Chicago and PhD in physics from Harvard University.
Among a variety of biosensors, field effect transistors (FET) based devices are the ideal ones for bio-detection systems since they can directly convert the specific binding between receptors on the gate surface and target analytes to an electrical signal for low-cost, rapid, and sensitive detection, and enabling the integration with signal acquisition and processing units. In this talk, I will introduce GaN-based immunological field effect transistors (ImmunoFET) that can fundamentally exhibit higher sensitivities than devices based on low dimensional nanomaterials with excellent biocompatibility. By deploying specific receptors on the active gate surface, we demonstrate that these devices can be used for detection of DNA hybridization, proteins, bacteria, and toxins as well as monitoring of up-taking processes of drugs into cells. Applications of these devices for in situ and in vivo detection of clinically-relevant protein, bacterial detection in fresh produce, toxin detection for environmental monitoring, and drug screening for cancer therapy will be discussed.

BIOGRAPHY
Wu Lu is currently a professor in the Department of Electrical and Computer Engineering at The Ohio State University. His current research interests include semiconductor physics and devices, nanofabrication and nanomanufacturing, nanobiotechnology, chemical and biosensors, and nanomaterials for energy storage. Before joining Ohio State in 2002, Lu held a number of research positions at the Electronics and Telecommunications Research Institute, Nanyang Technological University, and University of Illinois at Urbana-Champaign. He also held a World Class University (WCU) Professorship at Gwangju Institute of Science and Technology (GIST) supported by the National Research Foundation, South Korea, from 2009 to 2014. Lu is a visiting/guest professor at GIST, Fudan University, and Southeast University, and he has received many awards including the Lumley Research Award in 2006 and Lumley Collaborative Research Award in 2013 and 2017. He received his Ph.D in physical electronics and optoelectronics from Southeast University, has published over 120 papers in international journals and delivered numerous plenary and invited talks at international conferences.
Perovskite oxides are one of the most abundant natural materials on Earth. The flexibility of the perovskite structure allows to accommodate cations of different sizes and valences. Wide variety of properties have been demonstrated in bulk perovskites, at their interfaces, or heterostructures made from them including room-temperature ferroelectricity, giant piezoelectricity, quantum oscillation, two-dimensional superconductivity, and many more. The elemental diversity, stability even under off-stoichiometry conditions, and variety of crystal symmetries in the perovskite structure make it a natural host for a range of defects as well. While several point and planar defects have been reported in perovskites with some of them quite unique for perovskites, no new line defect, other than standard dislocations, has been observed until recently. We discover and characterize this new line defect, observed in perovskite NdTiO$_3$ films, using a combination of high-resolution analytical scanning transmission electron microscopy imaging, atomic-scale energy dispersive X-ray spectroscopy and electron energy-loss spectroscopy, and ab initio calculations.

**BIOGRAPHY**

K. Andre Mkhoyan is the Ray D. and Mary T. Johnson Chair Associate Professor in the Department of Chemical Engineering and Materials Science at the University of Minnesota, Twin Cities. He graduated from Yerevan State University with B.S. in Physics and from 1998 to 1999 worked as a researcher at Bell Laboratories of Lucent Technologies in Murray Hill, NJ. He received his Ph.D. in in Applied Physics from Cornell University, and from 2004 to 2008 he was a Postdoctoral Researcher at Cornell and a Visiting Scientist at the IBM T.J. Watson Research Center. He joined the Department of Chemical Engineering and Materials Science at the University of Minnesota in 2008.
Farhang Pourboghrat
Manufacturing Panel Discussion

BIOGRAPHY

Farhang Pourboghrat is a Professor at The Ohio State University with a joint appointment in the Integrated Systems Engineering and Mechanical and Aerospace Engineering departments. His research interests are in the multi-scale characterization of engineered materials and modeling of advanced forming processes, including warm forming of sheet metals, tube hydroforming, and composite thermo-hydroforming. His research has a strong emphasis on the computational modeling of forming processes using micro-structure-sensitive material models such as crystal plasticity and advanced phenomenological yield functions. Pourboghrat is a member of the American Society of Mechanical Engineers (ASME), and the Sigma Xi technical honor society. He has served as a member of the steering and scientific committee for the Numerical Simulation of 3D Sheet Forming Processes (NUMISHEET) conference since 2005. He co-organized the 2005 Numisheet conference in Detroit, MI. Prior to joining Ohio State, he served on the faculty in the Mechanical Engineering Department at Michigan State University and was a staff scientist at the Alcoa Technical Center. Pourboghrat received his BS and MS degrees from the University of Iowa, and his PhD degree in Mechanical Engineering from the University of Minnesota.
Siddharth Rajan
Next-Generation Wide Band Gap Materials and Devices

Wide band gap semiconductor materials, and in particular gallium nitride and its alloys, have achieved significant commercial and technological impact in the last two decades, with applications including solid state lighting, wireless communication, radar, and energy-efficient power switching. In this presentation, I will discuss our work on developing new material and device technologies that could extend the performance and functionality of these materials beyond the current state-of-art: tunneling-based ultraviolet light emitting diodes (LEDs), AlGaN-based mm-wave heterostructure field effect transistors, and heterogeneous integration of 2D semiconductors and gallium nitride for vertical transistors.

BIOGRAPHY
Siddharth Rajan is Associate Professor in the Electrical and Computer Engineering and Material Science and Engineering departments at The Ohio State University, where he joined the faculty in 2008. His research interests include semiconductor devices and materials, molecular beam epitaxy, transport and heterostructure phenomena, and high frequency transistors. He received his PhD in Electrical and Computer Engineering in 2006 from University of California, Santa Barbara, and has held research positions in UC Santa Barbara and GE Global Research, NY. He has co-authored over 100 journal papers.
The understanding of nanostructured systems and their outstanding properties requires advanced techniques that allow unveiling the morphological, chemical, stress/strain state characteristics of such systems in a 3D fashion. The development of tomographic techniques based on transmission electron microscopy (TEM and STEM) deserve special attention due to its spatial resolution and the vast range of information that they can provide. Conventionally, STEM tomography provides morphology even at the atomic scale; chemical composition can be obtained using EFTEM and EELS; electro-magnetic potentials can be addressed by holographic tomography; and diffraction contrast tomography has made possible the study of crystalline defects.

Non-conventional tomographic techniques based on high resolution TEM and STEM, have been used to study ceramic and semiconductor nanostructured systems. Strained and alloyed epitaxial Ge-Si islands grown on Si(100), antimony-doped tin oxide Sb:SnO₂ (ATO) and cerium oxide CeO₂ nanoparticles are presented. Such approach has provided for the alloyed Ge-Si islands its chemical distribution and stress/strain state in a 3D fashion using HRTEM images obtained from two different zone axes, [100] and [110]. On the other hand the combination of reconstruction techniques have unveil the morphology and dopant segregation of very small (2-4 nm) Sb:SnO₂ nanoparticles. Finally, the developed processing techniques have made possible to obtain the 3D morphology of CeO₂ nanocrystals from just one STEM image.

**BIOGRAPHY**

Antonio J. Ramirez is a Professor in the Welding Engineering Program at the Materials Science and Engineering Dept. at The Ohio State University, where he teaches welding metallurgy and leads the Manufacturing and Materials Joining Innovation Center (Ma²JIC). His research ranges from joining of structural materials to the exploration of fundamental aspects of bulk and nanostructured materials down to the atomic scale. He has worked with the technological and fundamental aspects of materials science, using advanced modeling and characterization tools. In recent years, he has devoted his efforts to the study of friction stir welding and the development and application of advanced in-situ techniques associated with electron microscopy and synchrotron x-ray diffraction to unveil the fundamentals of phase transformations on structural and functional materials. Ramirez received his degree in Mechanical Engineering from the National University of Colombia, and his M.Sc. and Ph.D. in Materials Science from São Paulo University (Brazil). After a postdoc at Ohio State (2001-2003), he continued his scientific career at the Synchrotron Light National Laboratory (LNLS) and Nanotechnology National Laboratory (LNNano) in Brazil (2004-2015) as researcher, group leader and deputy-director.
BIOGRAPHY

Arfaan Rampersaud received his BS in Chemistry from Defiance College and his PhD in Biochemistry from Kent State University. After working in academics and in several biotechnology companies, he started Columbus Nanoworks in 2004 to produce magnetic nanoparticles for biomedical applications. The company later began producing gold and silica particles and developed bioconjugation methods for attaching antibodies to the particle surfaces. In 2011, Rampersaud changed the company’s focus and began to develop novel fluorescent (NV-center) nanodiamonds for biomedical applications. In 2012 Columbus NanoWorks received an NIH Phase I SBIR contract to produce fluorescent nanodiamonds on a commercial scale. The company currently has a Phase II SBIR contract to continue this work and a Commercialization Readiness Pilot (CRP) grant to evaluate the IP landscape for fluorescent nanodiamonds. The company has expanded the types of fluorescent nanodiamonds that it produces as well as bioconjugation capabilities for proteins, antibodies, nucleic acids and small molecules.
I will describe our recent theoretical results on two aspects of magnetic skyrmions. First, I will describe how skyrmion phases are much more robust in two-dimensional systems (2D) compared to 3D and present Monte Carlo results on the field-temperature phase diagram of 2D skyrmion systems. Second, I will describe bulk systems that break surface inversion or mirror reflection symmetry, in addition to bulk inversion. This leads to two distinct Dzyaloshinskii-Moriya interaction (DMI) terms, Rashba DMI [1,2] and Dresselhaus DMI. We show [3] how skyrmions become progressively more stable with increasing ratio of Rashba to Dresselhaus DMI, and extend into the regime of easy-plane anisotropy. We find that the spin texture and topological charge density of skyrmions develops a nontrivial spatial structure with quantized topological charge given by a Chern number. Our results give a design principle for tuning Rashba SOC and magnetic anisotropy to stabilize skyrmions in thin films, surfaces, interfaces, and bulk magnetic materials that break reflection symmetry.

BIOGRAPHY
Mohit Randeria is a Professor of Physics at The Ohio State University. His research interests in the general area of condensed matter physics, whose goal is to gain insights into the complex behavior of macroscopic systems of many interacting particles. His current research focuses on strongly correlated systems, many-body physics in cold atomic systems, complex oxides and magnetism in double perovskites, high temperature superconductivity, and photoemission spectroscopy. Randeria is a Fellow of the American Physics Society and was awarded the 2007 Distinguished Alumni Award from IIT New Delhi and the 2002 ICTP Prize for Condensed Matter Physics. Randeria received his B.Tech from the Indian Institute of Technology, Delhi, his M.S. from the California Institute of Technology, and Ph.D. from Cornell University.

Beta-phase Ga$_2$O$_3$ is capturing global interest as a potentially revolutionary wide bandgap semiconductor for future high voltage switching applications, ultra-violet optoelectronics and other applications. The interest stems from advantageous intrinsic properties compared to current wide bandgap materials such as SiC and GaN, but perhaps even more so by the fact that beta-Ga$_2$O$_3$ is available as a bulk crystal, thereby providing a native substrate that can be available in large areas to support dislocation-free epitaxy of device structures. This directly counters the primary, historic issue for III-Nitride semiconductors, which is that they must contend with dislocations and their subsequent deleterious effects on device performance and reliability. This talk will focus on two critical aspects that must be understood as beta-Ga$_2$O$_3$ develops as a technology – detection and quantitative characterization of electrically-active defects and detailed studies of current transport mechanisms in Schottky barriers. Results of ongoing, comprehensive investigations on beta-Ga$_2$O$_3$ bulk crystals and epitaxial layers grown by molecular beam epitaxy will be presented, including the influence of doping and crystal orientation on electronic material properties.

**BIOGRAPHY**

Steven A. Ringel is the Neal A. Smith Endowed Chair Professor in Electrical and Computer Engineering and the Founding, Executive Director of the Institute for Materials Research (IMR) at The Ohio State University. Over the past few decades, his research group has focused on electronic materials and devices based on a range of semiconductor materials, including III-AsP, SiGe, III-N and more recently wide bandgap oxides. Within this space of materials, Ringel has been exploring the science and applications of heterogeneously integrated materials for applications ranging from photovoltaics to next generation electronics, properties of electronic defects and their relation to materials growth, processing and device stressing, and development of advanced defect characterization methods at multiple length scales. With his students and postdocs, Ringel has produced more than 300 publications and proceedings and given 150 invited talks in these areas, and he and his students have received numerous recognitions for his contributions to these areas. He has been an ardent advocate for translational R&D at the interface of academic and industrial interests at Ohio State and around the globe and his group strives to make contributions that are meaningful to such translations.
BIOGRAPHY
Steven Risser is the Chief Scientist for Battelle’s Advanced Materials group and has been working in materials-related research for more than 30 years. He manages the materials IP platform, which includes more than 35 portfolios and multiple active licenses. Risser was also a founding member of Optimer Photonics, an optical materials and device start-up company, that was spun out from Battelle. His technical expertise includes materials, medical materials and devices, energy storage, optical and electronic devices, sensors, and modeling. A major component of his recent work has been technology assessment and commercialization. Some recent programs include commercializing a client’s IP in new markets, assessment of a company’s core capabilities to enter the medical materials market, determining potential new markets for a company’s metal etching technology, creating a development roadmap for a nanotechnology startup, and evaluating a company’s sensors for subsea development. His work has been part of several R&D100 awards for various clients, more than 30 publications, and has resulted in 24 US patents.
BIOGRAPHY

Jay Sayre is the Assistant Vice President and Director of Materials Innovation within the Institute for Materials Research and an Adjunct Professor in Materials Science and Engineering at The Ohio State University. His interdisciplinary research interests are in translating science and technology into products within the fields of applied mechanics and materials engineering. Specifically, his focus is on fuel cells, polymer composites, failure analysis, dynamic mechanical analysis, multifunctional materials, and energy absorbing materials. His work on polymer composites is focused on multifunctional composites (energy generation and survivability), electrochemical composites (fuel cells and electroactive polymer actuators), and survivability (advanced threat armor composites). Prior to joining Ohio State, Sayre held the positions of Director of Advanced Materials and Internal Research and Development for Energy, Health, and Environment at Battelle Memorial Institute in Columbus, Ohio. He has held numerous security clearances, including a Department of Defense Top Secret. He holds a PhD in Materials Engineering Science and a BS in Chemical Engineering from Virginia Tech, as well as a Master of Science in Polymer Engineering from the University of Tennessee.
The objective of this presentation is to highlight the significance of engineering partnerships in nanoscale solutions towards tissue repair and regeneration. Wound infection is a common complication. While planktonic bacteria may be managed by antibiotics, formation of biofilm bacterial aggregates renders them recalcitrant to antibiotic as well as host immune defenses. Nanoscale Focus Ion Beam Scanning Electron Microscopy (FIBSEM) is powerful to elucidate critical features of biofilm ultrastructure. Such knowledge helps design novel intervention platforms. To circumvent bacterial drug tolerance, our group has developed Ag/Zn electrochemistry based wound dressing. Such dressing, now FDA cleared, can disrupt biofilm infection. This fabric can also be used for power harvesting applicable to fuel wearable sensor technologies. Peripheral vasculopathy is another common wound complication, especially in diabetics as well as in those suffering from other disorders of metabolic syndrome. We reported that such hypoxia leaves behind a genetic ischemic memory that possess barrier to resumption of healing. Our group has developed lipid nanoparticles for cell specific sequestration of such genetic memory resuming wound healing. Finally, partnership with NSEC has resulted in an in vivo tissue nanotransfection hardware (TNT chip) enabling direct reprogramming of organ/resident fibroblasts to vasculogenic as well as neurogenic cells. This has helped rescue critical limb ischemia as well as provides autologous neural cells to manage brain injury. Success in the application of nanoengineered solution to health care relies on effective partnership across cultural domains in academia. This work in the author’s laboratory is funded by NIH, DoD, VA, industry as well as philanthropic gifts.

**BIOGRAPHY**

Chandan K Sen is the John H & Mildred C Lumley Chair of Medical Research and Professor of Surgery, Executive Director of The Ohio State University Comprehensive Wound Center, and Director of the Ohio State University’s Center for Regenerative Medicine & Cell Based Therapies. He is also the Associate Dean for Strategic Industry Partnership at The Ohio State University Wexner Medical Center. Sen serves as a program director (Innovation & Collaboratory) for The Ohio State University’s Center for Clinical and Translational Science. Sen’s current research focuses on tissue injury and repair and ranges from molecular and cell biology, small animal, large animal to clinical studies. After completing his Masters of Science in Human Physiology from the University of Calcutta, India, Sen received his PhD in Physiology from the University of Eastern Finland. He trained as a postdoctoral fellow at the University of California at Berkeley’s Molecular and Cell Biology department and his first faculty appointment was in the Lawrence Berkeley National Laboratory in California. In the fall of 2000, Sen moved to The Ohio State University where he established a program on tissue injury and repair. Currently, Sen is a Professor and Vice Chair of Research of Surgery. He is the PI of 15 clinical studies and his research has been continuously extramurally funded by prestigious agencies such as five different institutes of the National Institutes of Health, US Department of Defense, US Department of Veteran Affairs and industry. Sen serves on the editorial board of numerous scientific journals and he is the Editor in Chief of Antioxidants & Redox Signaling (www.liebertpub.com/ars) with a current impact factor of 7.1. Sen and his team have published over 300 scientific publications. He has a H-index of 81 and is currently cited over 24000 times with approximately 2000 citations every year.
GaN based light emitting diodes have revolutionized lighting and display. In this presentation I review our recent work on understanding the origins of the diminishing efficiency of LEDs with increasing drive current density (droop); development of high performance green LEDs; and the role of intrinsic alloy disorder in LED performance.

**BIOGRAPHY**

James S. Speck is a Professor in the Materials Department at the University of California Santa Barbara. His early work focused on epitaxial oxide films on semiconductors, ferroelectric thin films, and strain relaxation in highly misfitting epitaxial systems. He has worked extensively on the materials science of GaN and related alloys. Major aspects of his work on nitrides include elucidating basic growth modes and defect generation, the development of MBE growth of GaN, and the development of nonpolar and semipolar GaN. Speck received the Quantum Device Award with Umesh Mishra from the International Symposium on Compound Semiconductors in 2007, was named an inaugural MRS Fellow in 2008, and received the JJAP Best Paper Award in 2008. In 2009 he received became an APS Fellow. In 2010 he received the IEEE Photonics Society Aron Kressel Award with Steve DenBaars for their work on nonpolar and semipolar GaN-based materials and devices. In 2007, Speck and his longtime collaborators Steve DenBaars and Shuji Nakamura founded Santa Barbara-based start-up companies Kaai and Soraa to commercialize their work on nonpolar and semipolar nitrides. In 2016 he was elected as a Fellow of the National Academy of Inventors. Speck has over 750 publications in the referred archival literature. He received his B.S.M.E. degree in metallurgical engineering from the University of Michigan and his S.M. and Sc.D. in materials science from the Massachusetts Institute of Technology.
In creating a new engineering program from scratch at the University of Chicago, we have made two distinctive choices. One, we focus exclusively on small-scale systems engineering (that’s what we mean by molecular engineering, engineering systems from the molecular level up, not just engineering molecules). Two, we organize our research and graduate education around technology problem areas, rather than around disciplines. Nanolithography, Quantum Information Devices, Energy Storage, Water Purification and Immuno-Engineering are our current problem foci. We encourage invention disclosures, interactions with industry, and, where appropriate, new venture formation. There are currently four IME-spawned companies underway. The aim is to lead in selected fields where we can develop significant competitive advantage.

Matthew Tirrell

Engineering Systems from the Molecular Level Up: Changing Academic Engineering Research and Education from Discipline-Focused to Problem-Focused

Focus Session 1: Materials Innovation

BIOGRAPHY

Matthew Tirrell is the founding Pritzker Director of the Institute for Molecular Engineering at the University of Chicago, and Deputy Laboratory Director for Science and Chief Research Officer at the Argonne National Laboratory. Immediately prior to joining the University of Chicago in 2011, he was the Arnold and Barbara Silverman Professor and Chair of Bioengineering at the University of California, Berkeley, with additional appointments in chemical engineering and materials science and engineering, and as a Faculty Scientist at the Lawrence Berkeley National Laboratory. From 1977 to 1999, Tirrell was on the faculty of Chemical Engineering and Materials Science at the University of Minnesota, where he served as department head from 1995 to 1999. He completed ten years as Dean of Engineering at the University of California, Santa Barbara in 2009. Tirrell has co-authored about 350 papers and one book and has supervised about 80 Ph.D. students. He is a member of the National Academy of Engineering, the American Academy of Arts & Sciences and the Indian National Academy of Engineering, and is a Fellow of the American Institute of Medical and Biological Engineers, the AAAS, and the APS. Tirrell has extensive consulting and scientific advisory board experience in both the materials science and biotech/biomedical sectors. He received a B.S. in Chemical Engineering at Northwestern University and a Ph.D. in Polymer Science from the University of Massachusetts.
We will discuss unusual “conveyor belt” transport of entropy and its effect on thermal conductivity for a magnetic field applied perpendicular to the plane of the Fermi arcs. We will also investigate the effect of Berry monopoles on the field and temperature dependence of the anomalous Nernst effect.

**BIOGRAPHY**

Nandini Trivedi is a Professor of Physics at The Ohio State University. Her research interests include the search for novel phenomena in quantum materials and ultra-cold atomic gases. She has developed quantum Monte Carlo and self-consistent mean field techniques to investigate strongly correlated and disordered systems. After post-doctoral research at University of Illinois at Urbana-Champaign and State University of New York, Stony Brook, she joined Argonne National Laboratory as a staff scientist. In 1995 she joined the faculty of the Tata Institute of Fundamental Research, Mumbai before joining Ohio State in 2004. Trivedi her undergraduate degree from the Indian Institute of Technology, Delhi and a Ph.D in from Cornell University.
Transparent conducting oxides (TCOs) are ubiquitous, appearing in windows, flat-panel displays, solar cells, solid-state lighting, and transistors that all exploit TCOs’ combination of high electrical conductivity and optical transparency. Thanks to this large and growing list of applications, there has been a surge of interest in the science of these materials, focusing on the fundamental properties and doping opportunities in traditional TCOs as well as the exploration of promising new candidate materials. Hybrid density functional theory (DFT) has proven instrumental in elucidating the physics of TCOs, owing to improved descriptions of the electronic structure and charge localization as compared to conventional DFT methods based on (semi-)local functionals. One example is the study of dopants and defects that are responsible for the “unintentional” conductivity in these materials: for SnO$_2$, In$_2$O$_3$, and Ga$_2$O$_3$, we demonstrate that this is not due to native defects such as oxygen vacancies, but must be attributed to unintentional incorporation of impurities. We can also provide guidelines for achieving higher doping levels, suggesting several impurities as donors with high solubility. Limitations on doping due to the formation or incorporation of compensating centers are also addressed. Lastly, we discuss the prospects of the more elusive $p$-type doping in the prototypical $n$-type TCOS as well as alternative candidates. We find the formation of hole polarons, i.e., the self-trapping of holes, is an inherent limitation to $p$-type doping of many oxide materials, but identify exceptions and promising ambipolar oxides.

**BIOGRAPHY**

Joel Basile Varley is a staff scientist at Lawrence Livermore National Laboratory, where his projects include the development of next-generation photovoltaics, catalysts, batteries, and radiation detectors. He joined LLNL in 2011 as part of the Quantum Simulations Group to study the interfacial properties of state-of-the-art thin-film solar cells for engineering improved photovoltaics. Varley received a BS in physics at University of North Carolina at Chapel Hill and a PhD in physics at University of California Santa Barbara, where his work focused on understanding defects in semiconductors with an emphasis on wide-band-gap semiconducting oxides. He later worked in the SUNCAT Center for Interface Science and Catalysis at Stanford University on electrochemical CO$_2$ reduction by metallic alloys and biologically-inspired catalysts for sustainable fuel production.
Semiconductor nanoparticles, known as quantum dots, were first discovered in the early 1980s. Because of their narrow bandwidth, broad excitation spectra, and high absorbance cross-sections, quantum dots were projected to revolutionize biomedical imaging, replacing organic dyes. However, nearly 20 years after their first demonstration as biomedical imaging agents, quantum dots have yet to be widely adopted in clinical pathology laboratories. This presentation will describe the potential benefits of quantum dots for biological imaging and difficulties in translation to clinical research. Barriers to commercialization will also be discussed. These challenges and potential methods to surmount them will be evaluated in the context of quantum dot development for liquid and solid biopsies. Perhaps the greatest challenge in this application is poor stability of quantum dots in biological environments, particularly in response to bioconjugation protocols. Modification of quantum dots for stability in biological environments, potential methods to reduce quantum dot toxicity, and methods to manufacture at scale will be discussed. Examples of quantum dot based detection of biomarkers ranging from cell surface receptors to DNA will be provided, including the limits of label-based detection and steric challenges unique to nanoparticles versus molecular dyes. The challenges of quantum dot application in solid tissue immunohistochemistry and flow cytometry will be evaluated, and possible paths forward will be discussed. Although quantum dots have not yet realized their full potential, advances in technology continue to improve the outlook for these biomaterials.

**BIOGRAPHY**

Jessica Winter is a Professor in the William G. Lowrie Department of Chemical and Biomolecular Engineering and the Department of Biomedical Engineering and Associate Director of the MRSEC Center for Emergent Materials at The Ohio State University. Her research interests include nanoparticle synthesis and assembly for biological applications and development of polymeric materials for the brain. She received her PhD in Chemical Engineering from the University of Texas at Austin, and completed a postdoctoral fellowship at the Center for Innovative Visual Rehabilitation at the Boston VA Hospital.
Nanoscale growth and assembly phenomena are ubiquitous to many important natural and synthetic systems. If their mechanisms and dynamics are understood fundamentally, synthetic nanomaterials can be assembled into complex structures with applications in catalysis, sensors, and optical materials. In the last decade, liquid cell electron microscopy has emerged as a powerful tool for observing nanoscale dynamics in real-time with nanometer spatial resolution. Due to its overwhelming effect on liquid samples, the electron beam has been used as a stimulus for both nanoparticle growth and assembly; however, the detailed effects of the beam on the radiation chemistry and internal fields in liquid samples has gone relatively unstudied. In this talk, I will discuss the fundamental chemistry and physics behind electron beam induced nanoparticle growth, diffusion, and self-assembly, and suggest methods for defining the reactive environment induced by the electron beam. I will cover aqueous and non-aqueous solvent radiolysis, use of radical scavengers, and effects of imaging parameters on radiation chemistry, specifically aimed at establishing one-electron reducing or single radical oxidizing conditions during liquid cell electron microscopy. I will discuss the effect of membranes and electron beam charging on diffusion and assembly in the liquid cell, and propose a general diffusion mechanism for surface bound particles. The overall goal of this work is to enable control of the beam induced reactive and physical liquid cell environment, either mitigating or harnessing beam effects depending on the experiment.

BIOGRAPHY
Taylor J. Woehl is an Assistant Professor of Chemical and Biomolecular Engineering at University of Maryland, College Park. His lab focuses on problems related to nanoscale assembly and colloidal physics, including protein stability and aggregation, electrocatalyst degradation, radiation chemistry, and non-equilibrium assembly of nanoparticles for optical materials. He received his B.S. in Ceramic Engineering from Missouri University of Science and Technology and his Ph.D. in Chemical Engineering from the University of California-Davis. In 2014, Taylor received the Zuhair Munir award for the best doctoral dissertation in the College of Engineering. Following graduate school, he was an Assistant Scientist III in the Division of Materials Science and Engineering at Ames DOE Laboratory. From 2014-2016 Taylor was an NRC Postdoctoral Fellow in the Material Measurement Laboratory at NIST-Boulder, where his research focused on development of new low voltage transmission electron and ion microscopy techniques and atomic resolution electron microscopy characterization of electrocatalyst nanomaterials.
Fengyuan Yang
Robust Zero-Field Skyrmion Formation in FeGe Epitaxial Thin Films

Magnetic skyrmions are topological spin textures, which have attracted significant interests in recent years due to their intriguing magnetic interactions and attractive attributes for magnetic storage and other spintronic applications. B20 phase magnetic materials, such as FeGe and MnSi, enable magnetic skyrmions due to the spin-orbit coupling and non-centrosymmetric structure. One major effort in this emerging field is the stabilization of skyrmions at room temperature and zero magnetic field. We grow phase-pure, high crystalline quality FeGe epitaxial films on Si(111) by ultra-high vacuum off-axis magnetron sputtering. The FeGe films were characterized by x-ray diffraction, scanning transmission electron microscopy (STEM) and Hall effect measurements. The topological Hall effect (THE) signals were extracted by subtracting out the anomalous Hall effect and ordinary Hall effect, demonstrating the existence of the skyrmion phase in FeGe films between 5 and 275 K. In particular, substantial topological Hall effect was observed at zero magnetic field, showing a robust skyrmion phase without the need of an external magnetic field.

BIOGRAPHY
Fengyuan Yang is a Professor in the Department of Physics at The Ohio State University, where he is also currently an Associate Director of the Institute for Materials Research and a co-leader of Interdisciplinary Research Group (IRG) 3 of the Center for Emergent Materials, an NSF MRSEC at OSU. The research interests of his group include the growth of single-crystalline epitaxial films and the study of their magnetic/magnetotransport, dynamic spin transport, and topological properties. Yang received his Ph.D degree in Physics from the Johns Hopkins University and completed postdoctoral research at the same institution from 2001 to 2003.
Local Lunch Options

**AREA A**

**Buffalo Wild Wings**  
Table Service, American  
614-291-2362  
2151 High Street

**Diaspora**  
Counter Service, Korean  
614-458-1141  
2118 High Street

**Donatos**  
Table Service, Pizza  
614-294-5371  
2084 High Street

**Moe's**  
Counter Service, Mexican  
(614) 928-9005  
2040 High Street

**Noodles & co.**  
Counter Service, Multi  
614-453-1095  
2124 High Street

**Panda Express**  
Counter Service, Chinese  
614-299-0029  
1952 High Street

**Starbucks**  
Counter Service, Cafe  
614-291-5692  
1880 High Street

**Waffle House**  
Table Service, American  
614-297-8879  
1712 N High Street

**AREA B**

**Buckeye Donuts**  
Counter Service,  
614-291-3923  
1998 High Street

**McDonald's**  
Counter Service, American  
614-291-8123  
1972 High Street

**Moy’s**  
Table Service, Chinese  
614-297-9840  
2004 N High St

**Wendy's**  
Counter service, burgers  
614-299-9840  
2040 High Street

**AREA C**

**Penn Station**  
Counter Service, Sandwich  
614-586-1491  
1980 High Street

**Qdoba Mexican Grill**  
Counter Service, Mexican  
614-299-9449  
1956 N High Street

**Starbucks**  
Counter Service, Cafe  
614-291-5692  
1782 N High Street

**AREA D**

**Berry Blendz**  
Counter Service, Smoothies  
614-299-4682  
1585 N High Street

**Five Guys**  
Counter Service, Burgers  
614-299-5555  
1603 High Street

**Fusian**  
Counter service, Asian  
614-294-2333  
14 E 11th Ave

**Jersey Mikes**  
Counter service, sandwiches  
614-972-6126  
1666 High Street

**Mad Mex**  
Table Service, Mexican  
614-586-4007  
1542 High Street

**Mark Pi’s**  
Counter Service, Chinese  
614-298-8115  
1610 High Street

**Raising Cane’s**  
Counter Service, Sandwich  
614-298-8713  
10 E 11th Ave

**Ugly Tuna Saloon**  
Table Service, American  
614-297-8862  
1546 N. High Street

**AREA E**

**Bistro 2110 (inside the Blackwell)**  
Table Service, American  
(614) 247-4000  
2110 Tuttle Park Place

**Tommy’s**  
Counter Service, Italian  
614-294-4669  
174 Lane Ave

**Varsity Club/Varsity Pizza**  
Table service, American  
614-291-5029  
278 W Lane Ave

**AREA F**

**Oxley’s Cafe**  
Counter Service, Cafe  
2035 Milikin Road

**AREA G**

**Faculty Club**  
Table Service, Multi  
614-292-2262  
181 South Oval Mall

**OHIO UNION**

**Woody's Tavern**  
Table Service, American  
1739 High Street  
First Floor

**Sloppy’s Diner**  
Table Service, American  
1739 High Street  
First Floor

**Union Market**  
Counter Service, Multi  
1739 High Street  
First Floor
Current Research Activities

1: Spin-Orbit Coupling in Correlated Materials: Novel Phases and Phenomena

Creating novel materials designed to tune the delicate interplay between electron correlations arising from Coulomb interactions and spin-orbit interactions that are enhanced in heavier elements, with focus on 5d materials where tuning by chemistry, structure and epitaxial strain can enable topological phases, quantum phase transitions and novel magnetism.

2: Control of 2D Electronic Structure and 1D Interfaces by Surface Patterning Group IV Graphane Analogues

Creating single atom thick 2D materials reminiscent of graphene but composed of heavier group IV atoms, allowing tuning of electronic properties by covalently attaching surface species to enable novel electronic phases and spin physics. Spatially-patterning in 2D creates the exciting possibility of novel 1D interfaces.
3: Spin Flux Through Engineered Magnetic Textures: Thermal, Resonant, and Coherent Phenomena

Pushing spin transport studies into the nonlinear regime with a program that aims to understand spin fluxes interacting with magnetic textures. Nonlinear response could move beyond diffusive spin currents to enable novel approaches to spin manipulation and control for next generation spintronics.

Education, Outreach and Diversity

CEM Education Human Resources and Development (EHRD) activities are guided by the National Research Council’s recommendations that MRSECs should focus resources on programs with proven high impact that leverage participant expertise and interest, and address local needs.

At the elementary level, the Center makes sustained and regular (approximately bi-weekly) visits to classrooms at a local inner city school to work with teachers to provide their students with hands-on science experiences with OSU scientists. CEM seeks to integrate materials-related topics into the high school science curriculum by developing curricula and resources and supporting teachers across the state of Ohio in their use.

This program is developed in partnership with materials scientists, education researchers, and other engineering and STEM professionals and is guided by regular assessments of effectiveness provided by a quasi-experimental design that evaluates its impact on both teachers and their students.

CEM builds on local expertise in Physics Education Research to employ best-practices to develop, implement, and rigorously assess methods to improve STEM and materials education at the undergraduate and graduate levels. This is accomplished at the graduate level through a set of guided group work sessions for graduate quantum mechanics developed by CEM EHRD. CEM EHRD employs proven education research methods to iteratively design advanced laboratory experiences for undergraduate physics majors. These lab experiences will replace several outdated laboratory activities.
Since inception, CEM has played a vital role in strengthening materials research facilities at OSU. The NanoSystems Laboratory (NSL) is closely aligned with CEM which provides partial staff support. CEM members have historically been instrumental in the acquisition of equipment through either federal or internal OSU grants. CEM augmented NSL’s impact this year by funding the acquisition of an inductively coupled plasma reactive ion etching system and a compact ultra-high temperature tube furnace. The addition of these tools directly benefits CEM research, as well as the OSU materials and central Ohio community at large.

**SEED PROGRAM**

CEM interdisciplinary research endeavors are augmented by a vigorous seed program that supports new ideas with the goal of becoming the basis for effective multidisciplinary teams. The seed program is operated in partnership with two Centers: the Institute for Materials Research (IMR) and the Center for the Exploration of Novel Complex Materials (ENCOMM). This partnership broadens the impact of all three centers in the OSU materials community and better leverages resources. Components of the current IRGs were incubated by the CEM seed program. The program strongly encourages proposals from junior and underrepresented faculty.

**COLLABORATIONS AND INDUSTRIAL INTERACTIONS**

Established collaborations with industrial partners and national laboratories add further breadth and diversity to CEM scientific endeavors and improve the productivity of center research activities. CEM continues to build relationships that provide industry-support for graduate students and to provide resources to assist in moving technologies from the lab to the commercial sector and preparing students for this career option. A particularly dynamic center-to-center collaboration with the Leibniz Institute for Solid State Research (IFW) in Dresden, Germany, continues be fruitful.

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A big thank you to the many faculty and staff who dedicated their time to planning this year’s Materials Week conference!

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