**Final Report: 2018 Materials Research Society (MRS) Spring Meeting**

**Report Type:** Final Report

**Dates Covered:** 09-08-2018 to 2-Sep-2018

**Performing Organization:** Materials Research Society
506 Keystone Dr.
Warrendale, PA 15086-7573

**Sponsoring/Monitoring Agency:** U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709-2211

**Distribution Availability Statement:**
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**Supplementary Notes:**
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**Abstract:**

**Subject Terms:**

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**Security Classification:**
- a. Report
- b. Abstract
- c. This Page

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**Limitation of Abstract:**

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**Number of Pages:**

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**Name of Responsible Person:**
J. Ardie Dillen
724-779-2711
Major Goals: The MRS meeting is the world's foremost international scientific gathering for materials research that showcases leading interdisciplinary research in both fundamental and applied areas and is coordinated by over 200 scientists from both academia and industry in many countries around the world. The Army Research Office grant enabled the symposia organizers to provide travel reimbursements for invited speakers, early career researchers and students to participate in the meeting. It also provided students and postdocs the opportunity to network with preeminent senior researchers both domestic and international.

Symposia receiving Army Research Office support are:
Symposium EN15, Novel Materials Physics of Perovskite Semiconductors
Symposium EP06, Materials, Devices and Systems for Machine Learning and Neuromorphic Computing
Symposium NM11, Deformable Atomically-Thin Materials -- Mechanics, Materials and Devices

Accomplishments: Symposium EN15: The quick growth of research on lead halide perovskites in the past several years not only offers an interesting class of materials for photovoltaic application, but it also demonstrates high defect tolerance in these materials. Understanding the mechanisms behind the defect tolerance and transplanting the mechanisms to other stable perovskite semiconductors would potentially lead to a transformative leap in semiconductor research. This symposium was dedicated to dissemination and discussion of novel materials physics of perovskite semiconductors.

Symposium EP06: The goal was to provide an overview of current active topics of research in materials science targeted at developing new materials for analytics and neuromorphic computing. It featured invited talks from researchers who provided high-level views of machine learning trends, requirements from systems development perspectives, as well as cutting-edge developments in new materials systems such as memristors, chalogenides, magnetic and ferroelectric materials. It brought together researchers who are developing new materials and novel nanoscale device structures aimed to design a new generation of information processing engines that are not limited by the constraints of conventional (von Neumann) architecture.

Symposium NM11: This symposium covered fundamental mechanics theory and modeling of atomically-thin materials and devices, elucidating how controlled deformation and strain engineering can enable new materials properties and device functions. On the experimental side, it covered advances in material synthesis and assembly/processing as well as controlled deformation and straining of atomically-thin materials. Interdisciplinary topics related to mechanics, physics, and materials science and engineering were presented by invited speakers in order to accelerate the development of new forms of materials and applications. The presentations were also
aimed to motivate synergistic research collaboration in the field of deformed and strained atomically-thin materials.

**Training Opportunities:** Nothing to Report

**Results Dissemination:** 2018 MRS Spring Meeting program and abstracts are posted to the MRS website: www.mrs.org

Papers that have been submitted and approved are published in MRS Advances (e-Proceedings): https://www.cambridge.org/core/journals/mrs-advances

**Honors and Awards:** Nothing to Report

**Protocol Activity Status:**

**Technology Transfer:** Nothing to Report

**PARTICIPANTS:**

- **Participant Type:** Other Professional  
  **Participant:** Yi-Yan Sun PhD  
  **Person Months Worked:** 1.00  
  **Funding Support:**

- **Participant Type:** Other Professional  
  **Participant:** Bipin Rajendran PhD  
  **Person Months Worked:** 1.00  
  **Funding Support:**

- **Participant Type:** Other Professional  
  **Participant:** SungWoo Nam PhD  
  **Person Months Worked:** 1.00  
  **Funding Support:**

**ARTICLES:**
**Article Title:** Crystal Lattice Dynamics of the Substitutional Solid Solutions in the Bi(Gd) - Fe - O and Bi(Nd) - Fe - O Systems

**Authors:** Valery Sobol, Barys Korzun, Cheslav Fedorcov, Olga Mazurenko, Temirkhan Bizhigitov, Sabit Tomaev, Bibara Nushnimbaeva, Sofia Egemberdieva, Altynbek Nauryzbaev

**Keywords:** chemical substitution x-ray diffraction (XRD) infrared (IR) spectroscopy

**Abstract:** The substitutional solid solutions in the Bi(Gd) - Fe - O and Bi(Nd) - Fe - O systems of the Bi1-xGdxFeO3 and Bi1-xNdxFeO3 types with x up to 0.20 were synthesized by the solid-state reaction method and investigated using X-ray diffraction analysis and infrared reflective spectrometry in the wavelength range from 12.5 to 24 ?m. It was determined that the Bi1-xGdxFeO3 and Bi1-xNdxFeO3 crystal structure is a distorted form of perovskite, R3c space group. Two extremums at 18.2 ?m (strong extremum) and 22.5 ?m (rather weak extremum) on the infrared reflection spectra of the Bi1-xGdxFeO3 and Bi1-xNdxFeO3 solid solutions were discovered. The extremum at 18.2 ?m corresponds to the Fe – O stretching vibrations and the extremum at 22.5 ?m corresponds to the O - Fe – O bending vibrations of the FeO6 groups.

**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

Acknowledged Federal Support: N

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**Article Title:** The effect of an improved density functional on the thermodynamics and adsorption-controlled growth windows of chalcogenide perovskites

**Authors:** Stephen A. Filippone, Yi-Yang Sun, R. Jaramillo

**Keywords:** thermodynamics molecular beam epitaxy (MBE) perovskites physical vapor desposition (PVD) phase equilibria

**Abstract:** Ternary sulfides and selenides in the distorted-perovskite structure ("chalcogenide perovskites") are predicted by theory to be semiconductors with band gap in the visible-to-infrared and may be useful for optical, electronic, and energy conversion technologies. Density functional theory can be used in combination with computational thermodynamics to predict the pressure-temperature phase diagrams for chalcogenide perovskites. We report results using the Strongly Constrained and Appropriately Normed (SCAN) and the rVV10 density functionals, and compare to previously-published results using the PBEsol functional. We highlight the windows of thermodynamic equilibrium between solid chalcogenide perovskites and the vapor phase at high temperature and very low pressure. These phase diagrams can guide adsorption-limited growth of ternary chalcogenides by molecular beam epitaxy (MBE).

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Acknowledged Federal Support: N
**Enhanced Grain Size and Crystallinity in CH3NH3PbI3 Perovskite Films by Metal Additives to the Single-Step Solution Fabrication Process**

**Authors:** Zahrah S. Almutawah, Suneth C. Watthage, Zhaoning Song, Ramez H. Ahangharnejhad, Kamala K. Subedi, Niraj Shrestha, Adam B. Phillips, Yanfa Yan, Randy J. Ellingson, Michael J. Heben

**Keywords:** perovskites Cd crystalline grain size Zn

**Abstract:** Methods of obtaining large grain size and high crystallinity in absorber materials play an important role in fabrication of high-performance methylammonium lead iodide (MAPbI3) perovskite solar cells. Here we study the effect of adding small concentrations of Cd2+, Zn2+, and Fe2+ salts to the perovskite precursor solution used in the single-step solution fabrication process. Enhanced grain size and crystallinity in MAPbI3 films were obtained by using 0.1% of Cd2+ or Zn2+ in the precursor solution. Consequently, solar cells constructed with Cd- and Zn-doped perovskite films show a significant improvement in device performance. These results suggest that the process may be an effective and facile method to fabricate high-efficiency perovskite photovoltaic devices.

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**Acknowledged Federal Support:** N

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**Thermal Evaporated Bismuth Triiodide (BiI3) Thin Films for Photovoltaic Applications**

**Authors:** Natália F. Coutinho, Rafael B. Merlo, Nelson F. V. Borrero, Francisco C. Marques

**Keywords:** perovskites photovoltaic physical vapor deposition (PVD) thin film optical properties

**Abstract:** Bismuth triiodide (BiI3) is a potential candidate for application in solar cell due to its good optoelectronic properties and because it is free of toxic elements. It can be used as the absorber material in solar cells or converted into the perovskite-like material MA3Bi2I9, suitable also for photovoltaic applications. Bismuth triiodide has been prepared by physical vapour transport (PVT) and by solution process through spin coating. In this work we present optical and structural/topological properties of BiI3 deposited by thermal evaporation under high vacuum. The films are slightly tensile, polycrystalline, homogenously distributed and with good adherence on several substrates, with an indirect bandgap of 1.81 eV, index of refraction of 3.3 (630 nm), photoluminescence centered at 1.74 eV and a Raman peak at 118 cm⁻¹ associated with the Ag mode.

**Distribution Statement:** 1-Approved for public release; distribution is unlimited.

**Acknowledged Federal Support:** N
Dynamics, Design, and Application of a Silicon-on-Insulator Technology Based Neuron

Authors: S. Dutta, T. Chavan, S. Shukla, V. Kumar, A. Shukla, N. Mohapatra, U. Ganguly

Keywords: electrical properties Si

Abstract: Spiking Neural Networks propose to mimic nature’s way of recognizing patterns and making decisions in a fuzzy manner. To develop such networks in hardware, a highly manufacturable technology is required. We have proposed a silicon-based leaky integrate and fire (LIF) neuron, on a sufficiently matured 32 nm CMOS silicon-on-insulator (SOI) technology. The floating body effect of the partially depleted (PD) SOI transistor is used to store “holes” generated by impact ionization in the floating body, which performs the “integrate” function. Recombination or equivalent hole loss mimics the “leak” functions. The “hole” storage reduces the source barrier to increase the transistor current. Upon reaching a threshold current level, an external circuit records a “firing” event and resets the SOI MOSFET by draining all the stored holes. In terms of application, the neuron is able to show classification problems with reasonable accuracy. We looked at the effect of scaling experimentally.

Distribution Statement: 1-Approved for public release; distribution is unlimited.

Acknowledged Federal Support: N

The Internal Buckling Behavior Induced by Growth Self-restriction in Vertical Multi-walled Carbon Nanotube Arrays

Authors: Quan Zhang, Guo-an Cheng, Rui-ting Zheng

Keywords: structural stress/strain relationship plasma-enhanced CVD (PECVD) (deposition) interface nanostructure

Abstract: The internal buckling is a common phenomenon in the as-grown carbon nanotube arrays. It makes the physical properties of carbon nanotube array in experiment lower than that in theory. In this work, we analyzed the formation and evolution mechanism of the internal buckling based on quasi-static compression model, which is different from collective effect of the van der Waals interactions. The self-restriction effect and the different growth rate of carbon nanotubes verify the possibility of the quasi-static compression model to explain the morphology evolution of vertical carbon nanotube arrays, especially the phenomenon of the quasi-straight and bent carbon nanotubes coexisted in the array. We generalized the Euler beam to wave-like beam and explained the mechanism of high-mode buckling combined with the van der Waals interaction.

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Acknowledged Federal Support: N
A New Subcritical Nanostructure of Graphene—Crinkle-Ruga Structure and Its Novel Properties

Abstract: Here, we report an experimental characterization of a new subcritical graphene nanostructure termed a crinkle ruga. Multilayer graphene forms crinkles as a periodic mode of buckling if the ratio of periodic buckling span to thickness is smaller than a critical value. Otherwise, it forms wrinkles. The crinkles have sawtooth-shaped profiles with their faces perfectly flat and the tips of the peaks and valleys highly curved. Our AFM measurements show that the width of the curvature focusing band at the tip is very narrow, e.g. smaller than 16 nm for a 6o crinkle, indicating a strong influence of flexoelectric coupling in crinkle formation. We also found that concavity or convexity of crinkle tips, i.e. parity of the crinkle, can be controlled. Due to the flexoelectric coupling, the concave tip at the crinkle valley is positively charged, and the convex tip at the crinkle peak negatively charged.

Fabrication and Surface Engineering of Two-Dimensional SnS Toward Piezoelectric Nanogenerator Application

Abstract: Mechanical exfoliation is performed to fabricate ultrathin SnS layers, and chemical/thermal stability of SnS layers is discussed in comparison with GeS, toward piezoelectric nanogenerator application. Both SnS and GeS are difficult to be exfoliated under 10 nm using tape exfoliation due to strong interlayer ionic bonding by lone pair electrons in Sn or Ge atoms. Au-mediated exfoliation enables to fabricate larger-scale ultrathin SnS and GeS layers thinner than 10 nm owing to strong semi-covalent bonding between Au and S atoms, but GeS surface immediately degrades during Au etching in an oxidative KI/I2 solution. Although the surface of SnS after the Au-mediated exfoliation reveals several-nm oxide layer of SnOx, the surface morphology retains the flatness unlike the case of GeS.

Distribution Statement: 1-Approved for public release; distribution is unlimited.
Technical Report

Grant Number: W911NF-18-1-0154

Amount: $5,000

Reporting Period: 3 April 2018 to 2 September 2018


Objectives:

In the past several years, halide perovskite materials have been shown to exhibit extraordinary performance as photovoltaic materials. It has been revealed that novel material physics is behind the success of these materials. For example, ultra-long carrier lifetime has rarely been observed in other semiconductor materials. Considering that these materials are prepared by low-cost solution-based methods, the finding is even more surprising. Understanding such a highly desired property is not only essential to the further development of these materials for applications, but also enriches our knowledge base generally applicable to other semiconductor materials. Achieving this goal requires synergetic efforts from synthesis of high-quality materials, delicate characterization of their properties, as well as understanding of the physical processes from theory and computation. This symposium was dedicated to understanding perovskite semiconductors from their fundamental physics and materials science aspects.

Presentations

Symposium EN15 received about 110 submissions, of which 94 were accepted. Among the accepted presentations, 22 were invited, 54 were contributed oral presentations, and 18 were posters. The titles of the invited presentations are:

Mercouri Kanatzidis, 3D and 2D Halide Perovskites - Poor Man’s High Performance Semiconductors

Jian Shi, Low Dimensional Soft Perovskite Crystals

Wanyi Nie, The Interplay of Structure, Light and Electric Field in 3D and 2D Perovskite Photovoltaic Devices

Nam-Gyu Park, Non-Heating, Large-Area Coating Technology for High Efficiency Perovskite Solar Cells

Henry Snaith, Understanding Instability and Enhancing the Stability of Metal Halide Perovskite Solar Cells

Osman Bakr, Understanding the Origins of Ultra-long Radiative States in Metal Halide Perovskite Crystals

Annamaria Petrozza, Understanding Defect Physics in Metal Halide Perovskite Semiconductors

Hemamala Karunadasa, Capturing the Properties of Lead Halide Perovskites with New Materials

David Mitzi, Structural Diversity and Engineering within Layered Halide Perovskite Semiconductors

Yabing Qi, Perovskite Material and Solar Cell Research by Surface Science and Advanced Characterization
Leeor Kronik, Structural Dynamics in Lead Halide Perovskites from First Principles
Xiaoyang Zhu, Solving the Lead Halide Perovskite Puzzle
Prashant Kamat, Charging Effects in TiO2 and Its Influence on the Carrier Recombination in CsPbBr3 Perovskite Films
Oleg Prezhdo, Excited State Dynamics of Photo-excited Charge Carriers in Halide Perovskites - Time Domain Ab Initio Studies
Yanfa Yan, Oxide Double Perovskites for Efficient Photoelectrochemical Water Oxidation
Felix Deschler, Probing the Origin of Strong Radiative Band Edge Emission in Hybrid Perovskites with Ultrafast Spectroscopy
Lijun Zhang, Computational Design of Lead-free Halide Perovskites for Solar Application
Mao-Hua Du, Low-Dimensional Hybrid Organic-Inorganic Metal Halides as Efficient Luminescent Materials
Yoshihiko Kanemitsu, Exciton Dynamics in Lead Halide Perovskite Nanocrystals
Filippo De Angelis, Dielectric Screening and Exciton Binding Energy in Metal Halide Perovskites
Daniel Niesner, Giant Rashba Splitting in Lead Halide Perovskite
Peijun Guo, Ultrafast and First Principles Investigations of Carrier and Phonon Dynamics in Perovskite Halides

Highlights

Some unique physical properties of the hybrid halide perovskites that contribute to the high power conversion efficiency have been revealed theoretically and experimentally over the past several years. Among others, these materials exhibit high defect tolerance so that defect-mediated recombination could be weaker than radiative recombination [Talk by Annamaria Petrozza]. Even the radiative recombination could be significantly reduced by screening effect, which forms the so-called large polarons. It was originally perceived that the polarons are formed by the nearly freely rotating dipolar cations. However, the “soft” nature of such materials [Talk by Leeor Kronik] actually leads to the understanding that the polarons are most probably a result of the Pb-I framework [Talk by Xiaoyang Zhu]. Making high-PCE solar cells is a battle with recombination. With these highly desired properties which reduce recombination, there is reason to be enthusiastic to further push the limit towards higher efficiency, ideally reaching the Shockley-Queisser limit, and eventually industrial application.

Contributions to discipline

Defect tolerant semiconductors have long been searched for various applications, especially for photovoltaics, where low cost is a critical criterion to satisfy if aiming at large-scale applications. The organic-inorganic hybrid halide perovskites have appeared to be the first material that fulfills the criterion. This is a significant contribution to the theory and application of semiconductor materials. The understandings on the halide perovskites may lead to discovery of new semiconductor materials for broader applications.

Formation of polarons typically leads to low carrier mobility, which is usually undesired. Ionic semiconductors are therefore overlooked for mainstream semiconductor applications. However, in halide
materials, the large polarons prevent the recombination of electrons and holes and, therefore, significantly increase the carrier lifetime, which compensates the relatively low mobilities and eventually yields ultra-long carrier diffusion length. These findings open a new venue for the future design of novel semiconductor materials for various applications.

**Future direction of this symposium topic**

This symposium is the first time when the physics part on perovskite photovoltaics is spinned off from the device part in an MRS meeting. The idea was to summarize the unique material physics that we have learned from the hybrid halide perovskites with a hope to transplant such understanding to the development of other semiconductor materials. This symposium topic has been carried on in the forthcoming 2018 MRS Fall Meeting in Boston.

**List of supported speakers, symposium chairs and session chairs**

Zhu, Xiaoyang (Invited speaker)
Park, Nam-Gyu (Invited speaker)
Zhang, Lijun (Invited speaker)
Mitzi, David (Invited speaker)
Shi, Jian (Invited speaker)
Prezhdo, Oleg (Invited speaker)
Karunadasa, Hemamala (Invited speaker)
Zeng, Hao (Invited speaker)
Guo, Peijun (Invited speaker)
Du, Maohua (Invited speaker)
Deschler, Felix (Invited speaker)
Kronik, Leeor (Invited speaker)
Neisner, Daniel (Invited speaker)
Qi, Yabing (Invited speaker)
Xiao, Zewen (Session chair)
Zhou, Yuanyuan (Session chair)
Petrozza, Annamaria (Invited speaker)
Saparov, Bayrammurad (Symposium chair)
Sun, Yiyang (Symposium chair)
SESSION EN15
Novel Materials Physics of Perovskite Semiconductors
April 2 - April 6, 2018

Symposium Organizers
Mingzhen Liu, University of Electronic Science and Technology
Bayrammurad Saparov, University of Oklahoma
Aron Walsh, Imperial College London
Sun Yi-Yang, Shanghai Institute of Ceramics, Chinese Academy of Sciences

MRS Invitation to Publish
All authors are invited to submit articles based on their 2018 MRS Spring Meeting presentations to journals in the MRS portfolio. (www.mrs.org/publications-news) Papers submitted and accepted for publication in MRS Advances (www.mrs.org/mrs-advances) will be available as symposium collections. Visit the MRS/Cambridge University Press Publications Booth #100 in the Exhibit Hall to learn more, including MRS Advances print options available at special rates during the meeting week only.

* Invited Paper

SESSION EN15.01: Low-Dimensional Perovskites
Session Chairs: Yi-Yang Sun and Aron Walsh
Monday Afternoon, April 2, 2018
PCC North, 100 Level, Room 122 C

1:30 PM *EN15.01.01
3D and 2D Halide Perovskites—Poor Man’s High Performance Semiconductors
Mercouri G. Kanatzidis; Northwestern University, United States.

2:00 PM *EN15.01.02
Low-Dimensional Soft Perovskite Crystals
Jian Shi; Rensselaer Polytechnic Institute, United States.

2:30 PM EN15.01.03
Structures and Properties of New 2D Lead Halide Perovskites with a Conjugated Diammonium
Matthew P. Hautzinger; University of Wisconsin Madison, United States.

2:45 PM EN15.01.04
Identifying the Bandgap of Two-Dimensional Perovskite CsPbBr3
Juming Bao1, 2; 1University of Houston, United States; 2University of Electronic Science and Technology of China, China.

3:00 PM BREAK

3:30 PM *EN15.01.05
The Interplay of Structure, Light and Electric-Field in 3D and 2D Perovskite Photovoltaic Devices
Wanyi Nie; Los Alamos National Laboratory, United States.

4:00 PM EN15.01.06
Electron–Phonon Coupling and Slow Vibrational Relaxation in 2D Organic–Inorganic Hybrid Perovskites
Daniel B. Straus; University of Pennsylvania, United States.

4:15 PM EN15.01.07
Improving the Stability of the Hybrid Perovskites—A New Structural Motif
Arun Kumar Mannodi Kanakkithodi; Argonne National Laboratory, United States.

4:30 PM EN15.01.08
Novel Hybrid Organic-Inorganic Electron Extraction Layers for Polymer Solar Cells with Improved Processing Robustness
Donia Fredj1, 2; 1Faculté des sciences de Sfax, France; 2Faculté des sciences de Sfax, Tunisia.

4:45 PM EN15.01.09
Band Tail States in FAPbI3—Characterization and Simulation
Adam D. Wright; Department of Physics, University of Oxford, United Kingdom.

SESSION EN15.02: Device Physics
Session Chair: Mingzhen Liu
Tuesday Morning, April 3, 2018
PCC North, 100 Level, Room 122 C

10:30 AM *EN15.02.01
Non-Heating, Large-Area Coating Technology for High Efficiency Perovskite Solar Cells
Nam-Gyu Park; Sungkyunkwan University, Korea (the Republic of).

11:00 AM *EN15.02.02
Cubic Perovskite Semiconductors with Enhanced Photovoltaic Properties
Peng Qin; Shanghai Institute of Ceramics, Chinese Academy of Sciences, China.

11:30 AM *EN15.02.03
Understanding Instability and Enhancing the Stability of Metal Halide Perovskite Solar Cells
Henry Snaith; University of Oxford, United Kingdom.

SESSION EN15.03: Defect Properties
Session Chairs: Bayrammurad Saparov and Zewen Xiao
Tuesday Afternoon, April 3, 2018
PCC North, 100 Level, Room 122 C

1:30 PM EN15.03.01
Defect Properties of Halide Double Perovskite Semiconductors
Zewen Xiao; Tokyo Institute of Technology, Japan.

1:45 PM EN15.03.02
The Unusual Character of Point Defects in Organic-Inorganic Perovskite Solar Cells
Olivia D. Hentz; Massachusetts Institute of Technology, United States.

2:00 PM *EN15.03.03
Understanding the Origins of Ultralow Radiative States in Metal Halide Perovskite Crystals
Oman M. Bakr; KAUST, Saudi Arabia.

2:30 PM BREAK

3:30 PM EN15.03.04
Effects of A-Site Symmetry-Breaking and Dynamically Correlated Disorder on Phase Transition and Thermal Properties of Hybrid Organic-Inorganic Perovskites
Taishan Zhu; Univ of Illinois-Urbana Champ, United States.

3:45 PM EN15.03.05
Role of Lead Vacancies for Optoelectronic Properties of Lead-Halide Perovskites
Dmitri Kilin1, 2; 1University of South Dakota, United States; 2North Dakota State University, United States.

4:00 PM *EN15.03.06
Understanding Defect Physics in Metal-Halide Perovskite Semiconductors
Annamaria Petrozza; Istituto Italiano di Tecnologia, Italy.

4:30 PM EN15.03.07
Defect Physics of Lead-Based Mixed Halide Hybrid Perovskites from First Principles Computations
Arun Kumar Mannodi Kanakkithodi; Argonne National Laboratory, United States.

4:45 PM EN15.03.08
Charge-Carrier Traps in Hybrid Perovskites and the Consequences for Solar Cells
Moritz H. Futschik; AMOLF, Netherlands.

SESSION EN15.04: Novel Perovskites
Session Chairs: Bayrammurad Saparov and Yi-Yang Sun
Wednesday Morning, April 4, 2018
PCC North, 100 Level, Room 122 C

8:00 AM EN15.04.01
Design Lead-Free Organic-Inorganic Double Perovskites for Optoelectronics—A High-Throughput Approach
Kesong Yang; University of California, San Diego, United States.

8:15 AM EN15.04.02
Materials Discovery—From Bi-Based to Rare-Earth Hybrid Double Perovskites
Zewen Xiao; Tokyo Institute of Technology, Japan.

8:30 AM *EN15.04.03
Capturing the Properties of Lead-Halide Perovskites with New Materials
Hemamala Karunadasa; Stanford University, United States.
SESSION EN15.05: Advanced Characterization
Session Chair: Lijun Zhang
Wednesday Afternoon, April 4, 2018
PCC North, 100 Level, Room 122 C

1:30 PM EN15.05.01
Time-Resolved X-Ray Absorption Near Edge Structure (TR-XANES)
Spectroscopy of Lead-Free Perovskite Nanocrystals Cuming Liu; Argonne National Laboratory, United States.

2:00 PM *EN15.05.03
Perovskite Material and Solar Cell Research by Surface Science and Advanced Characterization Yabing Qi; Okinawa Institute of Science and Technology, Japan.

2:30 PM EN15.05.04
Probing Electron-Phonon Interactions in Single Crystalline van der Waals Ruddlesdon-Popper Perovskite (C\textsubscript{2}H\textsubscript{3}NH\textsubscript{3})\textsubscript{3}PbI\textsubscript{5} Prepared by Vapor Deposition Zhizhong Chen; Rensselaer Polytechnic Institute, United States.

4:00 PM *EN15.05.06
Structural Dynamics in Lead-Halide Perovskites from First-Principles Leeor Kronik; Weizmann Institute of Science, Israel.

4:30 PM EN15.05.07
Slow Thermal Equilibration in Hybrid Organic-Inorganic Perovskites Revealed by Transient Infrared Absorption Spectroscopy Peijun Guo; Argonne National Laboratory, United States.

5:00 PM *EN15.05.08
Development of Low-Energy Ultraviolet and Inverse Photoelectron Spectroscopies and Their Application To Determining Energy Levels in Organometal Halide Perovskites Kenneth R. Graham; University of Kentucky, United States.
10:15 AM EN15.07.06
Carrier Dynamics in Methylammonium Lead Iodide Studied Using Low Optical Power Density, Steady-State Microwave Conductivity
John G. Labram; Oregon State University, United States.

10:30 AM *EN15.07.07
Excited State Dynamics of Photoexcited Charge Carriers in Halide Perovskites—Time-Domain Ab Initio Studies
Oleg Przhdo; University of Southern California, United States.

11:00 AM EN15.07.08
Ultrafast Excited-State Dynamics in Shape- and Composition-Controlled CsPbX3 Nanocrystals
Naray Soetan; Vanderbilt University, United States.

11:15 AM EN15.07.09
The Influence of Cation Dipole Moment on the Indirect Bandgap in Lead Halide Perovskites
Benjamin Daliber; AMOLF, Netherlands.

11:30 AM EN15.07.10
Exploring the Way to Approach the Efficiency Limit of Perovskite Solar Cells by Drift-Diffusion Model
Wallace C. Chow; University of Hong Kong, China.

11:45 AM EN15.07.11
The Novel Dopant for Hole-Transporting Material Opens a New Processing Route to Efficiently Reduce Hysteresis and Improve Stability of Planar Perovskite Solar Cells
Junheng Lao; University of Electronic Science and Technology of China, China.

SESSION EN15.08: Novel Applications
Session Chairs: Mingzhen Liu and Bayrammurad Saparov
Thursday Afternoon, April 5, 2018
PCC North, 100 Level, Room 122 C

1:30 PM EN15.08.01
Environmental Studies of Perovskite Solar Cells for Space Applications
Pilar Espinet Gonzalez; California Institute of Technology, United States.

1:45 PM *EN15.08.02
Oxide Double Perovskites for Efficient Photoelectrochemical Water Oxidation
Yanfa Yan; University of Toledo, United States.

2:15 PM EN15.08.03
PEDOT/NiO Composite Hole Transportation Layer for Perovskite Solar Cells
Joseph Asare; Baze University, Nigeria; Arizona State University, United States; African University of Science and Technology (AUST), Nigeria.

2:30 PM BREAK

3:30 PM EN15.08.04
Multiphoton Absorption Order of CsPbBr3, as Determined by Wavelength-Dependent Nonlinear Optical Spectroscopy
Joon Jang; Sogang University, Korea (the Republic of).

3:45 PM EN15.08.05
Thomas J. MacDonald; Brown University, United States.

4:00 PM *EN15.08.06
Probing the Origin of Strong Radiative Band Edge Emission in Hybrid Perovskites with Ultrafast Spectroscopy
Felix Deschler; Univ of Cambridge, United Kingdom.

4:30 PM EN15.08.07
A Novel Non-Halide Lead Source for High Efficiency Perovskite Solar Cells
Fuming Li; University of Electronic Science and Technology of China, China.

4:45 PM EN15.08.08
 Ferroelectric Domains in Methylammonium Lead Iodide Thin-Film Solar Cells
Alexander Colsman; Karlsruhe Institute of Technology, Germany.

SESSION EN15.09: Poster Session II
Thursday Afternoon, April 5, 2018
5:00 PM - 7:00 PM
PCC North, 300 Level, Exhibit Hall C-E

EN15.09.01
Surface-Guided CsPbBr3 Perovskite Nanowires with Size-Dependent Photoluminescence Well Beyond the Quantum Confinement Regime
Eiran Oksenberg; Weizmann Institute of Science, Israel.

EN15.09.02
Ambipolar Alpha Particle Detection in the A3M2I9 Defect Perovskites
Kyle M. McCall; Northwestern University, United States; Northwestern University, United States.

EN15.09.03
Lead-Free, Stable and Sensitive X-Ray Detectors Based on Cs2AgBiBr6 Single Crystal and Wafer
Junme Tang; Wuhan National Laboratory for Optoelectronics, China.

EN15.09.05
Vis-Near Infrared Photodetectors Based on Methyl Ammonium Lead Iodide Thin Films by Pulsed Laser Deposition
Nagabhushan Patel; Indian Institute of Science, India.

EN15.09.06
Lead-Free Perovskites Thin Films Obtained by Pulsed Laser Deposition and Their Functional Properties
Andreja Carmen Andrej; NILPRP, Romania.

EN15.09.07
Halide Migration and Phase Stability in Mixed-Halide Organic-Inorganic Perovskite Heterostructures
Rhiannon (Rhys) M. Kennard; University of California, Santa Barbara, United States.

EN15.09.08
Prediction of Crystal Structure of Hybrid Organic-Inorganic Perovskite by First-Principles Evolutionary Technique
Omotayo A. Salawu; Korea Institute of Energy Research, Korea (the Republic of).

EN15.09.09
Seamless Stitching Between Single All-Inorganic Perovskite Nanocrystals
Lyle Gonger; Institute of Physics, Netherlands.

EN15.09.10
Thermal Evaporated Bismuth Triiodide (BiI3) Thin Films for Photovoltaic Applications
Natalia d. Coutinho; UNICAMP, Brazil.

EN15.09.11
Bandgap Tuning of Organometal Halide Perovskite in Ternary Phase Diagram
St. Hong Lee; Kyungpook National University, Korea (the Republic of).

SESSION EN15.10: Structure and Growth
Session Chairs: Xujie Lu and Yuanjun Zhou
Friday Morning, April 6, 2018
PCC North, 100 Level, Room 122 C

8:00 AM EN15.10.01
Microstructural/Compositional Tailoring of Cesium Tin Iodide Perovskites for Solar Cells with Improved Efficiency and Stability
Yuanyun Zhou; Brown University, United States.

8:15 AM *EN15.10.02
Computational Design of Lead-free Halide Perovskites for Solar Application
Lijun Zhang; Center for High Pressure Science and Technology Advanced Research, China.

8:45 AM *EN15.10.03
Pressure-Induced Dramatic Changes in Structures and Properties of Halide Perovskites
Xujie Lu; National University of Singapore, Singapore.

9:15 AM EN15.10.04
Methylammonium Iodide Effect on the Supersaturation Concentration and Interfacial Energy of the Crystalization of Methylammonium Lead Triiodide Single Crystals
Binchen Li; National University of Singapore, Singapore.

9:30 AM BREAK

10:00 AM EN15.10.05
Effect of Excessive Lead on the Stability and Performance of Lead Halide Perovskite Solar Cells Against Photo-Induced Degradation
Aditya S. Yerramilli; Arizona State University, United States.

10:15 AM EN15.10.06
Impact of Organic Cation Dynamics on Solar Cell Performance of Metal Halide Perovskites
Joshua Choi; University of Virginia, United States.

10:30 AM EN15.10.07
Elucidating the Photoinstability and Degradation Kinetics of Organic-Inorganic Halide Perovskites
Phoong Song; University of Toledo, United States.
10:45 AM *EN15.10.08 Low-Dimensional Hybrid Organic-Inorganic Metal Halides as Efficient Luminescent Materials Mao-hua Du; Oak Ridge National Laboratory, United States.

11:15 AM EN15.10.09 Toward Capillary-Fed Solution Growth of Thin, Monocrystalline Perovskite Films Geneveze Hall; Arizona State University, United States.

11:30 AM EN15.10.10 Investigation of Post Deposition Annealing Temperature Effect on the Performance of Dehydrated Lead Acetate Precursor in an Inverted Planar CH₃NH₃PbI₃ Perovskite Solar Cells Aditya S. Yerramilli; Arizona State University, United States.

11:45 AM EN15.10.11 The Presence and Impact of Ferroelectricity in Methylammonium Lead Iodide Lauren Garten; NREL, United States.

SESSION EN15.11: Exciton and Many-Body Effect
Session Chair: Yi-Yang Sun
Friday Afternoon, April 6, 2018
PCC North, 100 Level, Room 122 C

1:30 PM *EN15.11.01 Exciton Dynamics in Lead Halide Perovskite Nanocrystals Yoshihiko Kanemitsu; Kyoto University, Japan.

2:00 PM *EN15.11.02 Dielectric Screening and Exciton Binding Energy in Metal-Halide Perovskites Filippo De Angelis; 1,2 CNR-ISTM, Italy; 3Istituto Italiano di Tecnologia, Italy.

2:30 PM BREAK

3:00 PM EN15.11.03 Band Tailing and Deep Defect States in CH₃NH₃PbI₃, CH₃NH₃PbBr₃ Perovskites Carolin M. Sutter-Fella; Lawrence Berkeley National Laboratory, United States.

3:15 PM EN15.11.04 Dephasing and Quantum Beating of Excitons in Methylammonium Lead Iodide Perovskite Nanoplatelets Bernhard J. Bohn; Ludwig-Maximilians-Universität München, Germany.

3:30 PM *EN15.11.05 Giant Rashba Splitting in Lead Halide Perovskite Daniel Niesner; Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Germany.

4:00 PM EN15.11.06 Origin of Abnormal Bandgap Shift and Second Emission Peak in Organic-Inorganic Lead Halide Perovskites M. Ibrahim Dar; Ecole Polytechnique Federale de Lausanne, Switzerland.

4:15 PM *EN15.11.07 First Principles Modeling of Phonon Transport and Equilibration in Perovskite Halides Maria K. Chan; Argonne National Laboratory, United States.

4:45 PM EN15.11.08 Dresselhaus-Rashba Semiconductors in Photovoltaics Combine Benefits of Direct and Indirect Semiconductors Oleg Rubel; McMaster University, Canada.

SYMPOSIUM EN16
Combining Materials, Technologies and Societal Awareness to Harvest Natural and Human-Made Energy Sources
April 3 - April 5, 2018

Symposium Organizers
Tito Busani, University of New Mexico
Sergej Filonovich, Total Gas
Olga Lavrova, Sandia National Laboratories
Robert Opila, University of Delaware

MRS Invitation to Publish
All authors are invited to submit articles based on their 2018 MRS Spring Meeting presentations to journals in the MRS portfolio. (www.mrs.org/publications-news) Papers submitted and accepted for publication in MRS Advances (www.mrs.org/mrs-advances) will be available as symposium collections. Visit the MRS/Cambridge University Press Publications Booth #100 in the Exhibit Hall to learn more, including MRS Advances print options available at special rates during the meeting week only.

* Invited Paper

SESSION EN16.01: Role of Solar Energy for Renewable Systems I
Session Chairs: Tito Busani and Matthew Doty
Tuesday Morning, April 3, 2018
PCC North, 100 Level, Room 128 A

10:30 AM *EN16.01.01 Scalable and Sustainable Tandem Solar Devices—Low-Cost Tandem Photovoltaics and Tandem Photoelectrodes for Solar Fuel Generation Harry A. Atwater; California Institute of Technology, United States.

11:00 AM *EN16.01.02 Bridging Scientific Research and Industry—Research Progress on Industrial Crystalline Silicon Solar Cells at SJTU Wenzhong Shen; Shanghai Jiao Tong University, China.

11:30 AM EN16.01.03 Aluminium Zinc Oxide (Azo) Optimization Process for Use in Optically Transparent Antennas Maria E. Zamudio; The University of New Mexico, United States.

11:45 AM EN16.01.04 Polymer-Dopant Synergies for Thermoelectric Performance in Sustainable Materials Howard E. Katz; Johns Hopkins University, United States.

SESSION EN16.02: Role of Solar Energy for Renewable Systems II
Session Chairs: Robert Opila and Elizabeth Zamudio
Tuesday Afternoon, April 3, 2018
PCC North, 100 Level, Room 128 A

1:30 PM *EN16.02.01 High Efficiency Photovoltaics as the Basis for a Modern Energy System Christiana Honsberg; Arizona State University, United States.

2:00 PM *EN16.02.02 A New Type of Heat Engine—Using LED's as Refrigerators Eli Yablonovitch; University of California, Berkeley, United States.

2:30 PM BREAK

3:30 PM *EN16.02.03 Addressing the Challenges of Harvesting and Locally Using Solar Energy Alison Lennon; UNSW Sydney, Australia.

4:00 PM *EN16.02.04 Photon Recycling—Upconversion of Low-Energy Photons in Semiconductor Nanostructures Matthew Doty; University of Delaware, United States.

4:30 PM *EN16.02.05 Energy Loss Due to Soiling of Photovoltaic Systems Bruce King; Sandia National Labs, United States.
With a paradigm shift in the nature of computational workloads for most applications today, there are significant efforts in devising new information processing engines inspired by the brain that tap into the unique nanoscale and quantum nature of materials. The goal of this symposium was to provide an overview of current active topics of research in materials science targeted at developing new materials for analytics and neuromorphic computing. The symposium featured invited talks from researchers that provided a high-level view of machine learning trends, and requirements from systems development perspective, as well as cutting-edge developments in new materials systems such as memristors, chalcogenides, polymers and organice materials.

**Keynote speakers:** The symposium had the following keynote talks, covering basic materials and device optimization for deep learning applications, system optimization perspective as well as algorithmic aspects for learning systems beyond deep learning:

1. Dr. Geoff Burr, IBM Almaden, *Neuromorphic Computation for Hardware Acceleration of Deep Neural Networks - Challenges and Perspectives*
2. Dr. Dileep George, CEO of Vicarious Inc, *What is Beyond Deep and Narrow for AI?*
3. Prof. Subhasish Mitra, Stanford University, *Transforming Nanodevices into NanoSystems - The N3XT 1,000X*

**Invited speakers:** The symposium also featured invited talks from the following speakers, covering a wide spectrum of topics ranging from basic materials optimization to system level implementation:

1. Prof. Subu Iyer, UCLA, *Technologies for Massively Scaled-Out Neuromorphic Systems (MaSoNs)*
2. Prof. Hyunsang Hwang, Pohang University of Science and Technology, *ReRAM Based Synapse Devices and IMT Oscillator Neuron for Neuromorphic System*
3. Dr. Xavier Obradors, Institute of Materials Science of Barcelona, *Resistive Switching Mechanism in Metallic Perovskite Thin Film Oxides Displaying Metal Insulator Transitions*
4. Dr. Fabien Alibart, French National Centre for Scientific Research, *Neuromorphic Computing—Toward Dynamical Data Processing*
5. Prof. Udayan Ganguly, IIT Bombay, *Dynamics,Design and Application of a Silicon on Insulator Technology Based Neuron*
6. Dr. Alice Mizrahi, NIST, *Neural-Like Computing with Populations of Superparamagnetic Basis Functions*
7. Dr. Suhas Kumar, HP Labs, *Memristor Based Analog Computations - Devices, Systems and Experimental Demonstrations*
8. Dr. Alex Serb, University of Southampton, *Processing Big Data with Metal Oxide Memristors*
9. Dr. Angel Yanguas Gil, Argonne National Laboratory, *Neuromorphic Architectures for Smart Sensing Applications - Lessons from the Insect Brain*
10. Robert Legenstein, TU Graz, *Rewiring in Deep Neural Networks with Noisy Parameter Updates*
12. Blanka Magyari Kope, Stanford, *Non-Volatile Memory Device Optimization Trends from Ab Initio Simulations*
13. Sabina Spiga, Institute for microelectronics and microsystems, Italy, Analog HfO$_2$-Based Memristive Devices for Spiking Neural Networks

14. Han Wang, USC, Emerging 2D Material Devices for Neuromorphic Computing

Regular talks: The symposium also featured regular talks from the following speakers, covering various fundamental advances in nanoscale device phenomena for neuro-inspired and machine learning-inspired Computing as well as the theory and modeling of material systems for these applications:

1. Elliot Fuller, Floating Gate Memory Based on Ion Insertion Electrodes for Low Voltage Analog Computing
2. Sanjoy Nandi, Evolution of Switching Behaviour in Ag:HfO$_2$ Based Conductive Bridge RAM Devices
3. Yuhan Shi, Modeling Resistive Synaptic Devices for Implementation of Unsupervised Learning with Spiking Neural Networks
4. Scott Tan, Epitaxial Silicon-Germanium Artificial Synapses for Neuromorphic Computing Systems
5. Zheng Wang, Ferroelectric Coupled Oscillator Network for Neuromorphic Computing
6. Rohit John, Flexible IonicElectronic Hybrid Oxide Synaptic TFTs with Programmable Dynamic Plasticity for BrainInspired Neuromorphic Computing
7. Yan Fang, Increasing Information Storage Capacity in Computing Devices Formed from Self-Oscillating Gels
8. Jun Tao, Scalable Neuromorphic Computing Platform Based on Indium Phosphide Synaptic Device on Silicon
9. Sayani Majumdar, Organic Ferroelectric Memristors for Neuromorphic Computing
11. Mohammad Sharbati, Low Power, Electrochemically Tunable Graphene Synapses for Neuromorphic Computing
13. Amitesh Kumar, Synaptic Learning and Memory Functions in Amorphous Yttria-Based Memristive Systems
14. Rohit John, Hybrid Synaptic Elements for OptoNeuromorphic Computing
15. Sung Pyo Park, Investigation of Resistive Switching Behavior for GlucoseBased Biomaterials
16. Brajendra Sengar, Synaptic Functions Revealed in Dual Ion Beam Sputtered Zinc Oxide Based Memristive Devices for Neuromorphic Computing

Posters: A poster session was also part of the symposium, with the following 9 posters:

1. Paul Yang, Single and Double Gate Synaptic Transistors with a Reversible and Analog Drain Current Modulation Using a Pt/HfOx/nIGZO Memcapacitor
2. Jennifer Gerasimov, Long and Short Term Potentiation and Depression in an Organic Electronic Synapse
3. Sung Il Kim, Artificial Synapse Based on PolymerBlended Perovskite
4. Steven McGarry, Drift-Diffusion Simulation of Coupled Ionic-Electronic Devices
Contributions to discipline: The keynote talks provided a high level view of the requirements and specifications from nanoscale materials for accelerating future machine learning and neuromorphic algorithms, and for their adaptation at the system level. Talks from senior researchers from IBM and HP clearly laid out some of the requirements as well as approaches to be avoided to engineer nanoscale materials for these applications.

Recent breakthroughs such as the demonstration of using superparamagnetic basis functions for neural like computations (Nature Communications, 2018) and epitaxial SiGe synapses with engineered dislocations (Nature Materials, 2018) were also presented and discussed in detail by the authors at this meeting.

Future direction: The symposium was very well received, and most sessions drew between 30-50 participants. In this highly dynamic and emerging field, it is also crucial that researchers working at materials and device engineering aspects have opportunities to interact and learn from experts in system design and software, so that their research efforts are steered in the right direction. Given that the research into the development of materials and devices for Machine Learning and Neuromorphic Computing is expected to grow in the coming years, the organizers feel that similar symposia should be held in the coming years at MRS meetings as well as other premier conferences.

Award recipients: The following speakers were selected for receiving a financial support of $600 from the ARO award, based on the evaluation of their CV and a brief statement of interest:

1. Alice Mizrahi, Postdoctoral researcher at the National Institute of Standards and Technology
2. Scott Tan, PhD student at MIT
3. Sayani Majumdar, Academy Research Fellow, Department of Applied Physics, Aalto University school of Science
4. Rohit John, PhD Student at Nanyang Technological University (NTU), Singapore
5. Paddy Chan, Associate Professor in the Department of Mechanical Engineering, The University of Hong Kong
6. Sanjoy Nandi, Postdoctoral Fellow, Research School of Physics and Engineering, Australian National University.
7. Sung Pyo Park, Ph.D candidate in the School of Electrical and Electronic Engineering, Yonsei University
8. Alexander Serb, Post-doctoral research fellow University of Southampton

The symposium organizers: The symposium was organized by Dr. Bipin Rajendran (NJIT), Dr. Duygu Kuzum (UCSD), Dr. Manan Suri (IIT Delhi) and Dr. Abu Sebastian (IBM Research - Zurich).
Highly Luminescent Cubic CH$_3$NH$_3$PbI$_3$ Nanocrystals for Efficient Light-Emitting Diodes

Characterization of Yb Doped Cesium Lead Halide Perovskite Nanocrystals

Highly Thickness Tolerant Organometal Halide Perovskite-Polymer Composite Thin Films for Efficient Light-Emitting Diodes

Temperature-Dependent Photoluminescence of CH$_3$NH$_3$PbBr$_3$ Perovskite

Organic Light Emitting Diodes

Quantum Technologies

InP/InGaAs Multi-Quantum Well Nanowires Grown by MOCVD for Tunable Near IR Emission

First-Principles Engineering of Charged Defects for Two-Dimensional Alloyed Colloidal Quantum Wells

Donor and Acceptor Codoping in Silicon Quantum Dots for Efficient and Stable and Bright Perovskite Light-Emitting Diodes with High Energy Conversion Efficiency

SESSION EP05.10: New Types of Nanoscale Emitters—Perovskites and Non-Perovskites

Characterization of Yb Doped Cesium Lead Halide Perovskite Nanocrystals

Highly Luminescent Cubic CH$_3$NH$_3$PbI$_3$ Nanocrystals for Efficient Light Emitting Devices

Transport and GHz Phototransport Reaching Recombination Limited Dynamics in CsPbX$_3$ Nanocrystal Arrays

Donor and Acceptor Codoping in Silicon Quantum Dots for Efficient and Stable and Bright Perovskite Light-Emitting Diodes

SESSION EP06.01: Neuromorphic Devices I

*EP06.01.01
Technologies for Massively Scaled-Out Neuromorphic Systems (MaSoNs)

*EP06.01.02
Floating Gate Memory-Based on Ion Insertion Electrodes for Low-Voltage Analog Computing

*EP06.01.03
Observation of Conductance Plateaus in a Molecular Film via Nanometer Control of Phase Boundary

EP06.01.03
ReRAM-Based Synapse Devices and IMT Oscillator Neuron for Neuromorphic System

EP06.02.02
InP/InGaAs Multi-Quantum Well Nanowires Grown by MOCVD for Light Emitting Device Applications

EP06.02.03
Polar-Electrode-Bridged Electroluminescent Devices Based on a Novel Isoplanar Structure

EP06.02.04
Development of Flexible Mechanoluminescent Polymeric Based Systems

EP06.02.05
High-Efficiency Optical Gain in Type-II Semiconductor Nanocrystals of Donor and Acceptor Codoping in Silicon Quantum Dots for Efficient and Stable and Bright Perovskite Light-Emitting Diodes with High Energy Conversion Efficiency

EP06.02.06
Resistive Switching Mechanism in Metallic Perovskite Thin-Film Oxides Displaying Metal-Insulator Transitions

EP06.02.07
Evolution of Switching Behaviour in Ag:HO, Based Conductive-Bridge RAM Devices

EP06.02.08
Modeling Resistive Synaptic Devices for Implementation of Unsupervised Learning with Spiking Neural Networks

EP06.02.09
An Add-On Organic Green-to-Blue Photon-Upconversion Layer for Organic Light Emitting Diodes

EP06.02.10
InP/InGaAs Multi-Quantum Well Nanowires Grown by MOCVD for Light Emitting Device Applications

EP06.02.11
Polar-Electrode-Bridged Electroluminescent Devices Based on a Novel Isoplanar Structure

EP06.02.12
Development of Flexible Mechanoluminescent Polymeric Based Systems

EP06.03.01
First-Principles Engineering of Charged Defects for Two-Dimensional Quantum Technologies

EP06.03.02
An Add-On Organic Green-to-Blue Photon-Upconversion Layer for Organic Light Emitting Diodes

EP06.03.03
InP/InGaAs Multi-Quantum Well Nanowires Grown by MOCVD for Light Emitting Device Applications

EP06.03.04
Polar-Electrode-Bridged Electroluminescent Devices Based on a Novel Isoplanar Structure

EP06.03.05
Development of Flexible Mechanoluminescent Polymeric Based Systems

* Invited Paper
SESSION EP06.03: Neuromorphic Devices II
Session Chairs: Xavier Obradors and Abu Sebastian
Tuesday Afternoon, April 3, 2018
PCC North, 200 Level, Room 221 C

3:30 PM *EP06.03.01
Neuromorphic Computing—Toward Dynamical Data Processing
Fabien Alibart1, 2; 1IEMN-CNRS, France; 2LN2-CNRS, Canada.

4:00 PM EP06.03.02
Epitaxial Silicon-Germanium Artificial Synapses for Neuromorphic Computing Systems Scott H. Tan; Massachusetts Institute of Technology, United States.

4:15 PM EP06.03.03
Ferroelectric Coupled Oscillator Network for Neuromorphic Computing Zheng Wang; Georgia Institute of Technology, United States.

4:30 PM *EP06.03.04
Dynamics, Design and Application of a Silicon-on-Insulator Technology Based Neuron Udayan Ganguly; IIT Bombay, India.

SESSION EP06.04: Poster Session
Tuesday Afternoon, April 3, 2018
5:00 PM - 7:00 PM
PCC North, 300 Level, Exhibit Hall C-E

EP06.04.01
Single- and Double-Gate Synaptic Transistors with a Reversible and Analog Drain Current Modulation Using a Pt/HfOx/n-IGZO Memcapacitor Paul Yang; Myongji University, Korea (the Republic of).

EP06.04.02
Long- and Short-Term Potentiation and Depression in an Organic Electronic Synapse Jennifer Gerasimov; Linköping University, Sweden.

EP06.04.03
Artificial Synapse Based on Polymer-Blended Perovskite Sung Il Kim; Seoul National University, Korea (the Republic of).

EP06.04.04
Drift-Diffusion Simulation of Coupled Ionic-Electronic Devices Steven McGarry; Carleton University, Canada.

EP06.04.05
Keystroke Dynamics Enabled Authentication and Identification Using Triboelectric Nanogenerator Array Changsheng Wu; Georgia Institute of Technology, United States.

EP06.04.06
Analog Memcapacitance Characteristics in Al/SiOx/TaOx/n-IGZO Capacitor Structure for Synaptic Transistor Geon Won Beem; Myongji University, Korea (the Republic of).

EP06.04.07
Scaling Behaviour and Anatomy of Filamentary Threshold Switching in NbOx Sanjoy K. Nandi; Australian National University, Australia.

EP06.04.08
A Synaptic Transistor Based on Two-Dimensional Molybdenum Oxide Dashan Shang; Institute of Physics, Chinese Academy of Sciences, China.

EP06.04.09
Polymer-Based Non-Volatile Analog Synapses for Low-Power Neuromorphic Computing Armanitas Melianas; Stanford University, United States.

SESSION EP06.05: In-Memory Computing
Session Chairs: Bipin Rajendran and Abu Sebastian
Wednesday Morning, April 4, 2018
PCC North, 200 Level, Room 221 C

8:30 AM *EP06.05.01
Neuromorphic Computation for Hardware Acceleration of Deep Neural Networks—Challenges and Perspectives Geoffrey W. Burr; IBM Almaden Research Center, United States.

9:15 AM *EP06.05.02
Keynote: What is Beyond Deep and Narrow for AI? Dileep George; Vicarious AI, United States.

SESSION EP06.06: Poster Session
Tuesday Afternoon, April 3, 2018
5:00 PM - 7:00 PM
PCC North, 300 Level, Exhibit Hall C-E

EP06.06.01
Single- and Double-Gate Synaptic Transistors with a Reversible and Analog Drain Current Modulation Using a Pt/HfOx/n-IGZO Memcapacitor Paul Yang; Myongji University, Korea (the Republic of).

EP06.06.02
Long- and Short-Term Potentiation and Depression in an Organic Electronic Synapse Jennifer Gerasimov; Linköping University, Sweden.

EP06.06.03
Artificial Synapse Based on Polymer-Blended Perovskite Sung Il Kim; Seoul National University, Korea (the Republic of).

EP06.06.04
Drift-Diffusion Simulation of Coupled Ionic-Electronic Devices Steven McGarry; Carleton University, Canada.

EP06.06.05
Keystroke Dynamics Enabled Authentication and Identification Using Triboelectric Nanogenerator Array Changsheng Wu; Georgia Institute of Technology, United States.

EP06.06.06
Analog Memcapacitance Characteristics in Al/SiOx/TaOx/n-IGZO Capacitor Structure for Synaptic Transistor Geon Won Beem; Myongji University, Korea (the Republic of).

EP06.06.07
Scaling Behaviour and Anatomy of Filamentary Threshold Switching in NbOx Sanjoy K. Nandi; Australian National University, Australia.

EP06.06.08
A Synaptic Transistor Based on Two-Dimensional Molybdenum Oxide Dashan Shang; Institute of Physics, Chinese Academy of Sciences, China.

EP06.06.09
Polymer-Based Non-Volatile Analog Synapses for Low-Power Neuromorphic Computing Armanitas Melianas; Stanford University, United States.

SESSION EP06.07: Computing Architectures Enabled by New Materials and Devices
Session Chairs: Suhas Kumar and Themis Prodromakis
Wednesday Afternoon, April 4, 2018
PCC North, 200 Level, Room 221 C

3:30 PM *EP06.07.01
Neuromorphic Architectures for Smart Sensing Applications—Lessons from the Insect Brain Angel Yanguas-Gil; Argonne National Laboratory, United States.

4:00 PM *EP06.07.02
Rewiring in Deep Neural Networks with Noisy Parameter Updates Robert Legenstein; Graz University of Technology, Austria.

4:30 PM *EP06.07.03
Organic Ferroelectric Memristors for Neuromorphic Computing Sayani Majumdar; Aalto University, Finland.

4:45 PM *EP06.07.04
Neuromorphic Computing by Organic Transistor Circuits Paddy K. L. Chan; University of Hong Kong, Hong Kong.

SESSION EP06.08: Design and Modeling for Neuromorphic Computing
Session Chairs: Duygu Burr and Manan Suri
Thursday Morning, April 5, 2018
PCC North, 200 Level, Room 221 C

9:00 AM *EP06.08.01
Keynote: Transforming Nanodevices into NanoSystems—The N3XT 1,000X Subhasish Mitra; Stanford University, United States.

10:00 AM BREAK
**SYMPOSIUM EP07**

Phase-Change Materials and Their Applications—Memories, Photonics, Displays and Non-von Neumann Computing  
April 3 - April 5, 2018

**Symposium Organizers**  
Harish Bhaskaran, University of Oxford  
Kotaro Makino, National Institute of Advanced Industrial Science and Technology  
Stefania Privitera, CNR  
Veronique Sousa, CEA LETI MINATEC

MRS Invitation to Publish  
All authors are invited to submit articles based on their 2018 MRS Spring Meeting presentations to journals in the MRS portfolio.  
([www.mrs.org/publications-news](http://www.mrs.org/publications-news)) Papers submitted and accepted for publication in MRS Advances ([www.mrs.org/mrs-advances](http://www.mrs.org/mrs-advances)) will be available as symposium collections. Visit the MRS/Cambridge University Press Publications Booth #100 in the Exhibit Hall to learn more, including MRS Advances print options available at special rates during the meeting week only.

*Invited Paper*

**TUTORIAL**  
Phase-Change Materials—Basic Research to Industrial Applications  
Monday Morning, April 2, 2018  
PCC North, 200 Level, Room 222 A

**Part I:**  
Geoffrey W. Burr  
Memory Applications  
Memory technology is rapidly evolving, as new nonvolatile memories (NVM) such as Phase Change Memory (PCM) and Resistive RAM (RRAM) emerge. Such memories have begun to enable Storage-Class Memory (SCM), by combining the high performance and robustness of solid-state memory with the long-term retention and low cost of conventional storage. Simultaneously, as we seek to continue to improve computing systems, attention is turning to Non-Von Neumann algorithms, including computing architectures motivated by the human brain. The same large NVM arrays that have enabled initial SCM products can also be used in non-Von Neumann neuromorphic computational schemes, with device conductance serving as synaptic “weight.” This allows the all-important multiply-accumulate operation within these algorithms to be performed efficiently AT the weight data. I will discuss these two broad classes of applications, and their various sub-classes. The sub-classes of SCM will include Memory-class SCM and Storage-class SCM applications; the sub-classes for Deep Learning Accelerators include Forward Inference-only applications (e.g., ex-situ training) and in-situ/on-chip Training. I will describe how the various application needs drive the target device specifications for the ideal PCM devices that would be needed to enable each of these applications.

**Part II:**  
Hidekazu Tanaka  
Basics and Applications of Electronic Phase Change Oxides  
Monday Morning, April 2, 2018  
PCC North, 200 Level, Room 222 A

**Session Chairs:**  
Bipin Rajendran and Han Wang

**Thursday Afternoon, April 5, 2018**  
PCC North, 200 Level, Room 221 C

**SESSION EP06.09: Neuromorphic Devices III**  
Session Chairs: Bipin Rajendran and Han Wang

**1:30 PM *EP06.09.01**  
Analog HfO2-Based Memristive Devices for Spiking Neural Networks  
Sabina Spiga; CNR-IMM, Italy.

**2:00 PM EP06.09.02**  
Low-Power, Electrochemically-Tunable Graphene Synapses for Neuromorphic Computing  
Mohammad T. Sharbati; University of Pittsburgh, United States.

**2:15 PM EP06.09.03**  
Demonstrative Operation of Four-Terminal Memristive Devices by Controlling Oxygen Vacancy Distribution in TiO₂ Single Crystals  
Akira Saka; Osaka University, Japan.

**2:30 PM BREAK**

**SESSION EP06.10: Materials and Devices for Large Scale Computing Systems**  
Session Chairs: Yusuf Leblebici and Sabina Spiga

**3:30 PM *EP06.10.01**  
Emerging 2D Material Devices for Neuromorphic Computing  
Han Wang; University of Southern California, United States.

**4:00 PM EP06.10.02**  
Synaptic Learning and Memory Functions in Amorphous Yttria-Based Memristive Systems  
Mangal Das; Indian Institute of Technology, India.

**4:15 PM EP06.10.03**  
Hybrid Synaptic Elements for Opto-Neuromorphic Computing  
Rohit A. John; 1, 2 Nanyang Technological University, Singapore; 2 Nanyang Technological University, Singapore.

**4:30 PM EP06.10.04**  
Investigation of Resistive Switching Behavior for Glucose-Based Biomaterials  
Sung Pyo Park; Yonsei University, Korea (the Republic of).

**4:45 PM EP06.10.05**  
Synaptic Functions Revealed in Dual Ion Beam Sputtered Zinc Oxide Based Memristive Devices for Neuromorphic Computing  
Brajendra S. Sengar; IIT Indore, India.

* Invited Paper
Executive Summary:
Our NM11 symposium on Deformable Atomically-thin Materials – Mechanics, Materials and Devices was successfully held on April 2-6, 2018. Our symposium focused on disseminating and discussing research progress centered on how mechanical deformation of atomically-thin materials can be used to create functional morphologies for new materials properties and advanced device functions. Both invited and contributing speakers presented and discussed how surface morphologies and straining from deformable 2D materials systems can lead to unique and emerging physical and chemical functionalities. Our symposium attracted a sizable audience, averaging 60 attendees per presentation. With the support of ARO, we implemented NM11 Best Presentation Awards for students/postdocs (6 Gold Awards and 13 Silver Awards), with more than 20% of the recipients being women/minority students. We believe our symposium has led to the nucleation of new research direction/field of mechanically-coupled properties of 2D materials, and we expect that a similar symposium will be organized in future MRS Spring and Fall 2019 MRS Meetings.

Objectives:
Our NM11 symposium on April 2-6, 2018, entitled ‘Deformable Atomically-thin Materials – Mechanics, Materials and Devices,’ brought together researchers from academia, industry and government laboratories to engage in discussion on emerging areas of deformable atomically-thin materials. In particular, our symposium focused on how mechanical deformation of atomically-thin materials can be used to create functional morphologies for new materials properties and advanced device functions. Invited speakers from materials/chemistry, solid mechanics and device physics provided their expertise in their respective areas and initiated discussions on how we could further enhance/tailor materials properties by mechanical designs.

Presentations:
Our symposium had a total of 72 presentations with 22 invited speakers in the areas of synthesis, processing, mechanics, emerging physical/chemical properties, and device applications of deformable 2D materials. Our final talk schedule and abstracts are posted here:
Highlights:
Invited presentations given by Professors Rodney Ruoff (UNIST) and Jiwoong Park (University of Chicago) (see photos below) on the synthesis of deformable atomically-thin materials on April 2, 2018 drew a peak number of attendees (>110 attendees).

Contributions to Discipline:
We believe our symposium has led to a nucleation of new research direction/field of mechanically-coupled properties of 2D materials, and we expect that similar symposiums will be organized in upcoming MRS Spring and Fall 2019 Meetings.

Future Direction of this Symposium Topic:
We expect that this area of research will continue to grow as there are emerging interests in Quantum Materials, Materials by Design and Soft Matter. The deformable electromechanical properties of atomically-thin materials will provide unique opportunities and promise in these emerging research areas. The lead organizer, Dr. SungWoo Nam, plans to be involved in several similar MRS symposiums in upcoming MRS Spring and Fall 2019 Meetings to build and strengthen the research community in this topic area.
A list of Those Supported with Grant Funds:

With the support of ARO, we were able to implement NM11 Best Presentation Awards for students/postdocs with 6 Gold Awards and 13 Silver Awards (>20% of the awards given to women/minority students). A list of awardees is included below. We are grateful for the generous grant support provided by ARO.

<table>
<thead>
<tr>
<th>2018 MRS Spring Meeting NM11 Best Presentation Awards</th>
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<tr>
<td><strong>Gold ($400)</strong></td>
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<tr>
<td><strong>Name</strong></td>
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<tr>
<td>Michelle Chen</td>
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<tr>
<td>Sabine M. Neumayer</td>
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<tr>
<td>Matthew R. Rosenberger</td>
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<td>Michael Cai Wang</td>
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<td>Saien Xie</td>
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<td>Keong Yong</td>
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<td><strong>Silver ($200)</strong></td>
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<td><strong>Name</strong></td>
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<tr>
<td>Emil J. Annevelink</td>
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<tr>
<td>Chullhee Cho</td>
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<td>Md Farhadul Haque</td>
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<td>Kyoung-Ho Kim</td>
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<td>Anirudh Krishna</td>
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<td>Shuai Lou</td>
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<td>Julian Ramirez</td>
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<td>Wei Wu</td>
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<tr>
<td>Yiping Wang</td>
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<tr>
<td>Yuzhou Zhao</td>
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</tbody>
</table>
3:30 PM *NM10.12.01
Exploring the Plasticity and Hall-Petch Limit of Nanotwinned Silver by Microattributing
Frederic Sansoz; University of Vermont, United States.

4:00 PM NM10.12.02
Transition from Source- to Stress-Controlled Plasticity in Nanotwinned Materials Below a Softening Temperature Sevedeh Mohadeseh Taheri; Monash; Massachusetts Institute of Technology, United States.

4:15 PM *NM10.12.03
Deformation Mechanisms in Mg/Nb Based Nanolaminates Irene J. Beverlein; University of California, Santa Barbara, United States.

4:45 PM NM10.12.04
In Situ SEM and TEM Tensile Testing of Nanoporous Gold Joshua Stueckler; Virginia Polytechnic Institute and State University, United States.

SESSION NM10.13: Poster Session II
Thursday, April 5, 2018
5:00 PM - 7:00 PM
PCC North, 300 Level, Exhibit Hall C-E

NM10.13.02
Accelerated Nano Super Bainite in Ductile Iron Eric J. Zhao; Beijing New Oriental Foreign Language School at Yangzhou, China.

NM10.13.03
Tensile Behavior of Multilayer, Solid Solution and Phase Separated Cu-Co Films Rohit Berlia; Arizona State University, United States.

NM10.13.04
The Processing-Structure-Property Relationship in High Strength, High Electrical Conductivity Al Matrix Calcium or Carbon Nanotube Reinforced Nanocomposites Liang Tian; Iowa State University, United States; 1University of Central Florida, United States.

NM10.13.05
Fabrication of Multilayered Metal Sheet by Accumulative Roll Bonding Process Jiwoong Park; University of Illinois at Urbana-Champaign.

NM10.13.06
Site-Selective Growth of Ag Nanocubes for Sharpening Their Corners and Edges, Followed by Elongation into Nanobars Through Symmetry Reduction Shan Zhao; Georgia Institute of Technology, United States.

NM10.13.07
Effect of Sputter Pressure on Phase Formation, Texture and Stresses in Beta Ta Thin Films Shefford P. Baker; Cornell University, United States.

NM10.13.08
Synthesis and Mechanical Behavior of a Freestanding, Nanocrystalline NiTi Film Under Cyclic Tensile Deformation Paul Rasmussen; Arizona State University, United States.

NM10.13.09
Dealloyed Platinum-Bismuth Nanoparticles as High Activity Electrocatalysts for Dimethyl Ether Oxidation Anastasios Angelopoulos; University of Cincinnati, United States.
11:15 AM NM11.02.03
Simulation Guided Growth of 2D Materials—A Generalized Multiscale Framework Kasra Momeni1; 2; 1Louisiana Tech University, United States; 2The Pennsylvania State University, United States.

11:30 AM NM11.02.04
Solution Based, Graphite Oxide Template Assisted Growth and Characterization of Large Scale, High-Temperature Stable Ultrathin Graphitic ZnO Kyle B. Tom1; 2; 1University of California, Berkeley, United States; 2Lawrence Berkeley National Laboratory, United States.

11:45 AM NM11.02.05
Wrinkling of Graphene on Copper Doguskan Senvildiz; TOBB University of Economics and Technology, Turkey.

 SESSION NM11.03: Synthesis of Deformable 2D Materials III
Session Chair: Baoxing Xu
Tuesday Afternoon, April 3, 2018
PCC North, 200 Level, Room 226 C

1:30 PM *NM11.03.01
Structure-Properties Relationship of Ultrathin Graphene Particles with Paper Ball-Like Shape Jiaxing Huang; Northwestern University, United States.

2:00 PM NM11.03.02
Facile Fabrication of Large-Area Atomically Thin Membranes by Bottom-Up Synthesis of Nanoporous Monolayer Graphene Piran Ravichandran, Kidambi; Vanderbilt University, United States.

2:15 PM NM11.03.03
Novel Surface Molecular Functionalization Route to Enhance Environmental Stability of Tellurium Containing 2D Layers SiJie Yang; Arizona State University, United States.

2:30 PM BREAK

 SESSION NM11.04: Mechanics of Deformable 2D Materials I
Session Chair: Baoxing Xu
Tuesday Afternoon, April 3, 2018
PCC North, 200 Level, Room 226 C

3:30 PM *NM11.04.01
Tuning Interlayer Coupling of van der Waals Materials with High Pressure Junqiao Wu; University of California, Berkeley, United States.

4:00 PM *NM11.04.02
Interface Mechanics and Its Effect on Morphology and Functions of 2D Nanomaterials Yong Zhu; North Carolina State University, United States.

4:30 PM *NM11.04.03
1D van der Waals Nano-Materials—Selenium and Tellurium Peide P. Yu; Purdue University, United States.

 SESSION NM11.05: Mechanics of Deformable 2D Materials II
Session Chairs: SungWoo Nam and Baoxing Xu
Wednesday Morning, April 4, 2018
PCC North, 200 Level, Room 226 C

8:30 AM NM11.05.01
Universal Deformation Pathways and Flexural Hardening of Nanoscale 2D-Material Standing Folds Bernardo R. Neves; University Federal-Minas Gerais, Brazil.

8:45 AM NM11.05.02
Liquid Evaporation-Driven Deformation and Assembly Mechanics—From 2D Graphene to 3D Architected Structures Baoxing Xu; University of Virginia, United States.

9:00 AM *NM11.05.03
Mechanical Interactions at Interfaces of Atomically Thin Materials Rui Huang; The University of Texas at Austin, United States.

9:30 AM NM11.05.04
Strain and Edge/Interface Tailoring to Control 2H/1T’ Phase Transition Senwuso Zhang; University of Pennsylvania, United States.

9:45 AM NM11.05.05
Mechanical Properties of TiC_{x}T MXene Alexey Lipatov; University of Nebraska – Lincoln, United States.

5:00 PM - 7:00 PM 

 SESSION NM11.06: Deformable 2D Materials III
Session Chair: Baoxing Xu
Wednesday Afternoon, April 4, 2018
PCC North, 200 Level, Room 226 C

1:30 PM *NM11.06.01
Chemically Derived Kirigami of Transition Metal Dichalcogenides Liang Cai1; 2; 1University of Wisconsin-Madison, United States; 2University of Science and Technology of China, China.

1:45 PM *NM11.06.02
Mechanically Robust Flexible Metal Electrodes by the Integration of Multi-Layer Graphene Chunhee Cho; University of Illinois at Urbana-Champaign, United States.

2:00 PM NM11.06.03
Strain Transfer Analysis of Encapsulated Atomically Thin Materials in Four-Point Bending Experiments Wei Wu; University of Connecticut, United States.

2:15 PM NM11.06.04
Negative Poisson's Ratio in Two-Dimensional Honeycomb Structures Guangzhao Qin; RWTH Aachen University, Germany.

2:30 PM BREAK

 SESSION NM11.07: Mechanically Driven Processing of 2D Materials I
Session Chair: Chi Hwan Lee
Wednesday Afternoon, April 4, 2018
PCC North, 200 Level, Room 226 C

3:30 PM *NM11.07.01
Ultrathin, Transparent Silicon Nanomembranes—Properties and Applications Jong-Hyun Ahn; Yonsei University, Korea (the Republic of).

4:00 PM NM11.07.02
AFM “Squeezeee” for the Creation of Clean 2D Material Interfaces Matthew R. Rosenberger; U.S. Naval Research Laboratory, United States.

4:15 PM NM11.07.03
Fabrication and Surface Engineering of Two-Dimensional SnS Toward Piezoelectric Nanogenerator Application Naoki Higashitarumizu; The University of Tokyo, Japan.

 SESSION NM11.08: Poster Session: Deformable 2D Materials I
Session Chair: SungWoo Nam
Wednesday Afternoon, April 4, 2018
PCC North, 300 Level, Exhibit Hall C-E

 NM11.08.01
3D Architecture Based on 2D Lateral Heterojunction Shani Long; University of California, Berkeley, United States.

 NM11.08.02
Insights on Mechanical Properties of WS_{x}/MoS_{x} Heterostructures Ygor M. Inoue; University of Campinas, Brazil.

 NM11.08.03
A Self-Sacrificing Camphor-Assisted Clean Transfer of Graphene Nianduo Cai; Southern University of Science and Technology, China.
SESSION NM11.08: Empowering 2D Materials to Solve the Challenges of the 21st Century

NM11.08.04
Large Area Photonic Crystallization of 2D MoS2 for Flexible Electronics
Richard H. Kim; Wright-Patterson Air Force Research Laboratory, United States.

NM11.08.05
Optimization of Graphene Mesh and Silicon Schottky-Junction by External Field-Effect for High Efficiency Solar Cells Su Han King; Hanyang University, Korea (the Republic of).

NM11.08.06
Non-Contact Flow and Particle Measurements via Elastohydrodynamic Deformation with Graphene Nano-Island Sensors Charles Dhong; University of California, San Diego, United States.

8:00 AM NM11.09.01
Quantifying Disorder in CVD Graphene Induced by Ripples from Thermal Expansion Mismatch Qun Su; University of Minnesota, United States.

8:15 AM NM11.09.02
0D/1D/2D Meta-Materials—Large-Scale, Highly-Ordered Self-Assembly of 0D/1D Plasmonic Nanoparticle Arrays on Deterministically Deformed Monolayer 2D Materials Templates Michael Cai Wang; University of Illinois-Urbana-Champaign, United States.

8:30 AM *NM11.09.03
Multi-Scale Patterning of Conformable Deformable Thin Materials Teri W. Odom; Northwestern University, United States.

9:00 AM *NM11.09.04
Active Origami with 2D Materials Paul McEuen; Cornell University, United States.

9:30 AM NM11.09.05
Experimental Exploration of High Mobility Metal Phosphides—Vapor Phase Deposition of Two-Dimensional SIP Ying Wang; Rensselaer Polytechnic Institute, United States.

9:45 AM BREAK

10:15 AM *NM11.09.06
Strain Engineering of 2D Materials Teng Li; University of Maryland, College Park, United States.

10:45 AM *NM11.09.07
Continuously Tunable Uniaxial Strain Engineering in Graphene via Self-Rolled-Up Membrane Technology Xueling Li; University of Illinois at Urbana-Champaign, United States.

11:15 AM NM11.09.08
Surface Acoustic Wave Exfoliation of Piezoelectric Stratified MoS2 Md. Mohiuddin; RMIT University, Australia.

11:30 AM NM11.09.09
Kirigami-Inspired Strain-Independent Functional Graphene Devices Keong Yong; University of Illinois Urbana-Champaign, United States.

SESSION NM11.10: Emerging and Novel Properties of 2D Materials

1:30 PM *NM11.10.01
Ballistic Thermal Transport in Two-Dimensional MoSe2 Lattices Adrian Bachtold; ICFO, Spain.

2:00 PM *NM11.10.02
MoS2-Based Nanoelectromechanics Andras Kis; Ecole Polytechnique Federale de Lausanne, Switzerland.

2:30 PM BREAK

3:30 PM *NM11.10.03
Novel Nanophotonic Devices—Graphene-Based Nanolasers and Photon-Triggered Nanowire Transistors Hong-Gyu Park; Korea University, Korea (the Republic of).

4:00 PM *NM11.10.04
Nanomaterial-Based Strain Sensors for Space Applications Mahmooda Sultana; NASA Goddard Space Flight Center, United States.

4:30 PM NM11.10.05
Giant Negative Electrostriction and Dielectric Tunability in a van der Waals Layered Ferroelectric Sabine M. Neumayer; University College Dublin, Ireland.

SESSION NM11.11: Poster Session: Deformable 2D Materials II

SESSION NM11.11.02
Size and Strain-Induced Tuning of Properties of MoS2 Nanostructures Shubham Bhagat; Guru Nanak Dev University, India.

SESSION NM11.11.03
Friction for Polycrystalline Graphene on Flexible Substrates as Transparent Flexible Sensors Qing Yi; Sinosteel Corporation Wuhan Safety & Environmental Protection Research Institute, China.

SESSION NM11.11.04
Investigated NTC Semiconductor Nano-Particles and Graphene Flexible Hybrid Material as Multiple-Role Sensor Lihong Su; Northwest Polytech University, China.

SESSION NM11.11.05
Topography Induced Tunable Flexoelectricity in Mono-Layer MoS2, Md. Farhadul Haque; University of Illinois at Urbana-Champaign, United States.

SESSION NM11.11.06
The Internal Buckling Behavior Induced by Growth Self-Restriciton in Vertical Multi-Walled Carbon Nanotube Arrays Guoan Cheng; Beijing Normal University, China.

SESSION NM11.12: Emergent Properties of Deformable 2D Materials II and Deformable 2D Electronics I

SESSION NM11.12.01
Vertical Field-Effect Transistor Using ZnO Nanotubes Grown on Graphene Films for Flexible Inorganic Electronics Hongsook Oh1, 2, 3; 1Seoul National University, Korea (the Republic of); 2Seoul National University, Korea (the Republic of); 3Seoul National University, Korea (the Republic of).

SESSION NM11.12.02
Electrostatic Cycling of Suspended Graphene Thermal Switches Michelle Chen; Stanford University, United States.

SESSION NM11.12.03
Soft Curved Image Sensor Array Using MoS2, and Graphene Dae-Hyeong Kim1, 2; 1Seoul National University, Korea (the Republic of); 2Institute for Basic Science, Korea (the Republic of).

8:30 AM NM11.12.04
Role of Surface Induced Defect States on Thermoelectric Power Factor in MoS2, Manjunath C. Rajagopal; University of Illinois at Urbana-Champaign, United States.

9:30 AM NM11.12.05
Defect Mediated Molecular Interaction and Charge Transfer in Graphene-Based Electrolyte-Gated FET Sensors Sun Sang Kwon; Hanyang University, Korea (the Republic of).

10:00 AM BREAK
SESSION NM11.13: Deformable 2D Electronics II
Session Chair: Won Il Park
Friday Morning, April 6, 2018
PCC North, 200 Level, Room 226 C

10:30 AM *NM11.13.01
Mechanics and Functionalities of Graphene Electronic Tattoos (GETs)
Nanshu Lu; University of Texas at Austin, United States.

11:00 AM NM11.13.02
Excitation of Plasmonic Waves in Curved Graphene Nanostructures by Subwavelength Periodic Modulation
Kyoung-Ho Kim; University of North Carolina at Chapel Hill, United States.

11:15 AM NM11.13.03
Fabrication of Graphene Oxide/Graphene Vertical Heterostructure Film and Its Use in Flexible Organic Light Emitting Diodes
Jinhong Du; Institute of Metal Research, Chinese Academy of Sciences, China.

11:30 AM NM11.13.04
Crumple Nanostructuring of Atomically Thin Materials for High Performance Devices
Pileyu Kang; George Mason University, United States.

11:45 AM NM11.13.05
Ultratransparent and Stretchable Graphene Electrodes
Nan Liu1; 2 Beijing Normal University, China; 3Stanford University, United States.

SESSION NM11.14: Deformable 2D Electronics III
Session Chair: Won Il Park
Friday Afternoon, April 6, 2018
PCC North, 200 Level, Room 226 C

1:30 PM NM11.14.01
Thin, Needle-Based Piezoelectric Systems for Guided Tissue Targeting by Mechanical Sensing
Xinge Yu1; 2 Northwestern University, United States;
University of Illinois at Urbana-Champaign, United States.

1:45 PM NM11.14.02
Metallic Nanoislands on Graphene and Machine Learning for Monitoring Swallowing Activity in Head and Neck Cancer Patients
Julian Ramirez; University of California San Diego, United States.

2:00 PM NM11.14.03
Mechanically Crumpled Two-Dimensional Semiconductor for Enhanced Photosensitivity
Juyoung Leem; University of Illinois at Urbana Champaign, United States.

2:15 PM NM11.14.04
Bio-Inspired Radiative Cooling and Reconfigurable Surface Emissivity of Crumpled Graphene
Anirudh Krishna; University of California, Irvine, United States.

SYMPOSIUM NM12

Transitioning Quantum Dots from Benchtop to Industry
April 3 - April 5, 2018

Symposium Organizers
Wan Ki Bae, Korea Institute of Science and Technology
Brian Korgel, University of Texas at Austin
Hunter McDaniel, UbiQD, LLC
Lazaro Padilha, Universidade Estadual de Campinas

Symposium Support
UbiQD, Inc.

MRS Invitation to Publish
All authors are invited to submit articles based on their 2018 MRS Spring Meeting presentations to journals in the MRS portfolio. (www.mrs.org/publications-news) Papers submitted and accepted for publication in MRS Advances (www.mrs.org/mrs-advances) will be available as symposium collections. Visit the MRS/Cambridge University Press Publications Booth #100 in the Exhibit Hall to learn more, including MRS Advances print options available at special rates during the meeting week only.

* Invited Paper

SESSIONNM12.01: QD Photodetectors
Session Chairs: Hunter McDaniel and Lazaro Padilha
Tuesday Morning, April 3, 2018
PCC North, 200 Level, Room 228 A

10:30 AM *NM12.01.01
Colloidal Quantum Dots for Mid-Infrared Applications
Philippe Guyot-Sionnest; University of Chicago, United States.

11:00 AM NM12.01.02
Near-Infrared Optoelectronics Using HgTe Colloidal Quantum Wells
Clement Livache1; 2 ESPCI, France; 3Université Pierre et Marie Curie, France.

11:15 AM *NM12.01.03
Direct Casting of Conductive Lead Chalcogenide Nanocrystal Films—Turning Ligands from Foe to Friend
Jeffrey M. Pietryga; Los Alamos National Laboratory, United States.

11:45 AM NM12.01.04
Probing the Energy Landscape of PbS QDs via Capacitance Spectroscopy
Eric Wong; University of Pennsylvania, United States.

SESSION NM12.02: QD Products and Manufacturing
Session Chairs: Doh Lee and Jeffrey Pietryga
Tuesday Afternoon, April 3, 2018
PCC North, 200 Level, Room 228 A

1:30 PM *NM12.02.01
Development of Heavy Metal-Free Quantum Dots—From Lab Bench to Commercial Applications
Nigel L. Pickett; Nanoco Technologies Limited, United Kingdom.

2:00 PM NM12.02.02
Upscaling Colloidal Nanocrystal Hot-Injection Syntheses via Reactor Underpressure
Makevyn Yarema; ETH Zurich, Switzerland.

2:15 PM NM12.02.03
Toward a Thermodynamic Profile for Cadmium-Based Quantum Dot Surface Chemistry via Isothermal Titration Calorimetry
Megan Y. Gee; University of South Carolina, United States.

2:30 PM BREAK

3:30 PM *NM12.02.04
From Quantum Dots to Holography
Seth Coe-Sullivan; Luminit, LLC, United States.

4:00 PM NM12.02.05
Correlated Atomic Structure and Single Nanocrystal Photophysics for Directed Colloidal Quantum Dot Synthesis
James R. McBride; Vanderbilt University, United States.