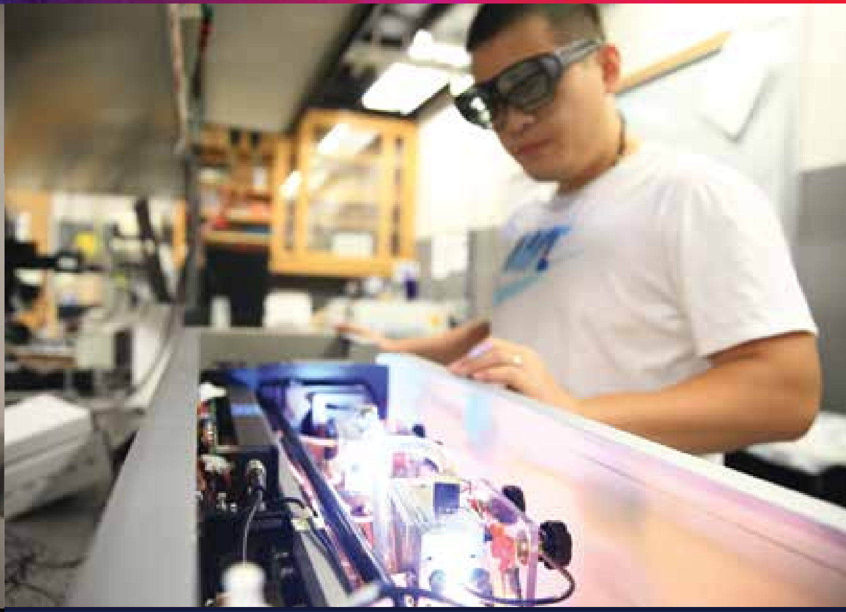
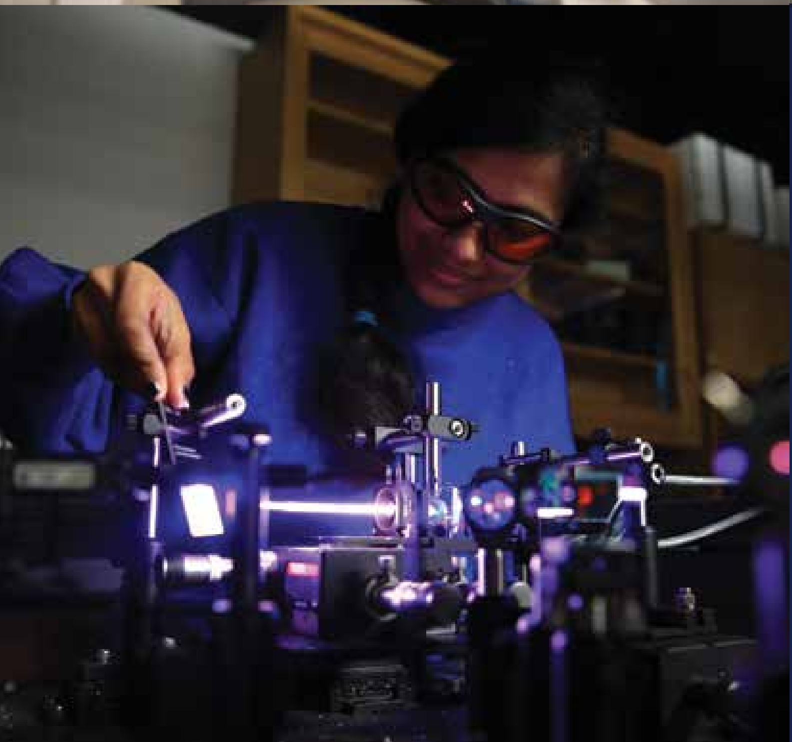
AGENDA

THIRD INTERNATIONAL WORKSHOP ON THIN FILMS FOR ELECTRONICS, ELECTRO-OPTICS, ENERGY AND SENSORS (TFE3S)





June 24-26, 2019

University of Iceland • Reykjavik, Iceland

University of Dayton

In collaboration with

PennState College of Engineering
ENGINEERING SCIENCE AND MECHANICS

HÁSKÓLI ÍSLANDS

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IEEE ICELAND SECTION

International Workshop on Thin Films for Electronics, Electro-Optics, Energy and Sensors

Reykjavik, Iceland
June 24-26, 2019

Organized by

University of Dayton, Pennsylvania State University and University of Iceland

Workshop Chairs

Partha Banerjee, University of Dayton
Karl Gudmundsson, University of Iceland
Akhlesh Lakhtakia, Pennsylvania State University
Guru Subramanyam, University of Dayton

International Advisory Committee

Sandwip Dey, Arizona State University
James G. Grote, Air Force Research Laboratory (Retired)
Ram Katiyar, University of Puerto Rico
Chung Kun Song, Dong-A University, South Korea

Local Organizing Committee

Karl Gudmundsson

Website

Karen Updyke, University of Dayton

Workshop Chairs

Partha Banerjee is chair and professor of the Department of Electro-Optics and Photonics at the University of Dayton, USA. He received his B. Tech from IIT Kharagpur, India, in 1979 and his M.S. and Ph.D. degrees from The University of Iowa in 1980 and 1983, respectively. He was faculty at Syracuse University from 1984-1991 and at the University of Alabama in Huntsville from 1991-2000 before moving to the University of Dayton as chair of the Department of Electrical and Computer Engineering. He is a fellow of OSA, SPIE and IoP, and received the NSF Presidential Young Investigator Award in 1986. He has published five books, over 140 journal papers and over 150 conference papers. His research interests are holography, metamaterials, nonlinear optics and photorefractives.

Karl S. Gudmundsson graduated from the Marine Engineering College of Iceland in 1984. He received his B.S. and M.S. degrees in computer engineering in 1996 and 1998 and his Ph.D in engineering with an electrical engineering concentration from Wright State University in 2004. He was project manager with the research and development company, Tern Systems, Inc., from 1998 until 2001. His research interests include theoretical and experimental, optical signal/image processing, classification and tracking, optical computing algorithms and architectures, intelligent sensor systems, digital systems design, and digital signal/image processing, classification and tracking.

Akhlesh Lakhtakia, a graduate of the Banarash Hindu University and the University of Utah, is currently the Evan Pugh University Professor and the Charles Godfrey Binder Professor of Engineering Science and Mechanics at the Pennsylvania State University. Elected a fellow of eight learned societies, he is currently interested in sculptured thin films, physicochemical deposition and characterization of mimumes, bioreplication, thin-film solar cells, and forensic science.

Guru Subramanyam graduated from PSG College of Technology, then affiliated to University of Madras in 1984 with a B.E. degree in electrical and electronics engineering with First Class and Distinction. He obtained his M.S. and Ph.D. degrees from the University of Cincinnati with a focus on microelectronics in 1988 and 1993, respectively. He is currently a professor in the Department of Electrical and Computer Engineering at the University of Dayton. He has published over 170 articles in the areas of thin films for electronics, electro-optics, energy and sensors. In 2013, the University of Dayton formally opened the Center of Excellence for Thin-Film Research and Surface Engineering (CETRASE) under his leadership.

Vision and Topics

University of Dayton's Center of Excellence for Thin-Film Research and Surface Engineering (CETRASE) is delighted to organize its third international workshop. This year's workshop will be at the University of Iceland, Reykjavik, Iceland, in collaboration with the Pennsylvania State University and the University of Iceland. The purpose of the workshop is to exchange technical knowledge and boost technical and educational collaboration activities within the thin film research community.

Topics include (but are not limited to):

1. Thin Films for Energy Harvesting and Energy Storage
2. Thin Film Microelectronics
3. Multifunctional Oxide Thin Films
4. Organic and Biological Thin Films
5. Flexible and Printable Electronics
6. Phase-Change Materials
7. Thin Films for Sensors
8. Optical Thin Films
9. Thin Film Metamaterials
10. Nanophotonics
11. Characterization of Thin Films

Instructions for Submission of Full Manuscripts

The workshop organizers invite all authors to submit a full-length manuscript for the *Proceedings of the Third TFE3S Workshop,* to be published by SPIE.

Submission Deadline: **July 31, 2019**

The manuscript must be 4-8 pages in length. Figures should be clear with legible axis markings and legends. Manuscripts will be reviewed by the workshop chairs, advisory committee and session chairs for technical merit. A sample manuscript will be made available for the participants.

Manuscript submission will be through the SPIE website http://spie.org/x14101.xml.

The Symposium Code is **TFE3S19** for the manuscript submission.

TFE3S19 Agenda

At-a-Glance

			Day 1 — Monday, June 24, 2019 Coffee Breaks: 10-10:20 a.m. and 3-3:20 p.m.	
8:40 a.m.	9 a.m.		**Welcome and Introductions (Room HT-104)**	
9 a.m.	10 a.m.		**Plenary I (Room HT-104) Robert Magnusson, University of Texas at Arlington, USA**	
10:20 a.m.	12:30 p.m.		**Nanophotonics I (Room HT-104)**	**Contemporary Thin Film Electronics I (Room HT-101)**
12:30 p.m.	2 p.m.		**Lunch**	
2 p.m.	3 p.m.		**Plenary II (Room HT-104) Mark W. Horn, Pennsylvania State University, USA**	
3:20 p.m.	5:30 p.m.		**Nanophotonics II (Room HT-104)**	**Contemporary Thin Film Electronics II (Room HT-101)**

			Day 2 — Tuesday, June 25, 2019 Coffee Breaks: 10-10:20 a.m. and 3-3:20 p.m.	
9 a.m.	10 a.m.		**Plenary III (Room HT-104) Tom G. Mackay, University of Edinburgh, Scotland**	
10:20 a.m.	12:30 p.m.		**Nanophotonics III (Room HT-104)**	**Phase-Change Materials (Room HT-101)**
12:30 p.m.	2 p.m.		**Lunch**	
2 p.m.	3 p.m.		**Plenary IV (Room HT-104) Augustine Urbas, Air Force Research Laboratory, USA**	
3:20 p.m.	5:30 p.m.		**Energy Harvesting (Room HT-104)**	**Optical Thin Films (Room HT-101)**

Workshop Banquet 7-9 p.m. @Skolabru

			Day 3 — Wednesday, June 26, 2019 Coffee Break: 10-10:20 a.m.	
9 a.m.	12 noon		**Multi-Ferroics (Room HT-101)**	
12 noon	12:10 p.m.		**Closing of the Workshop**	

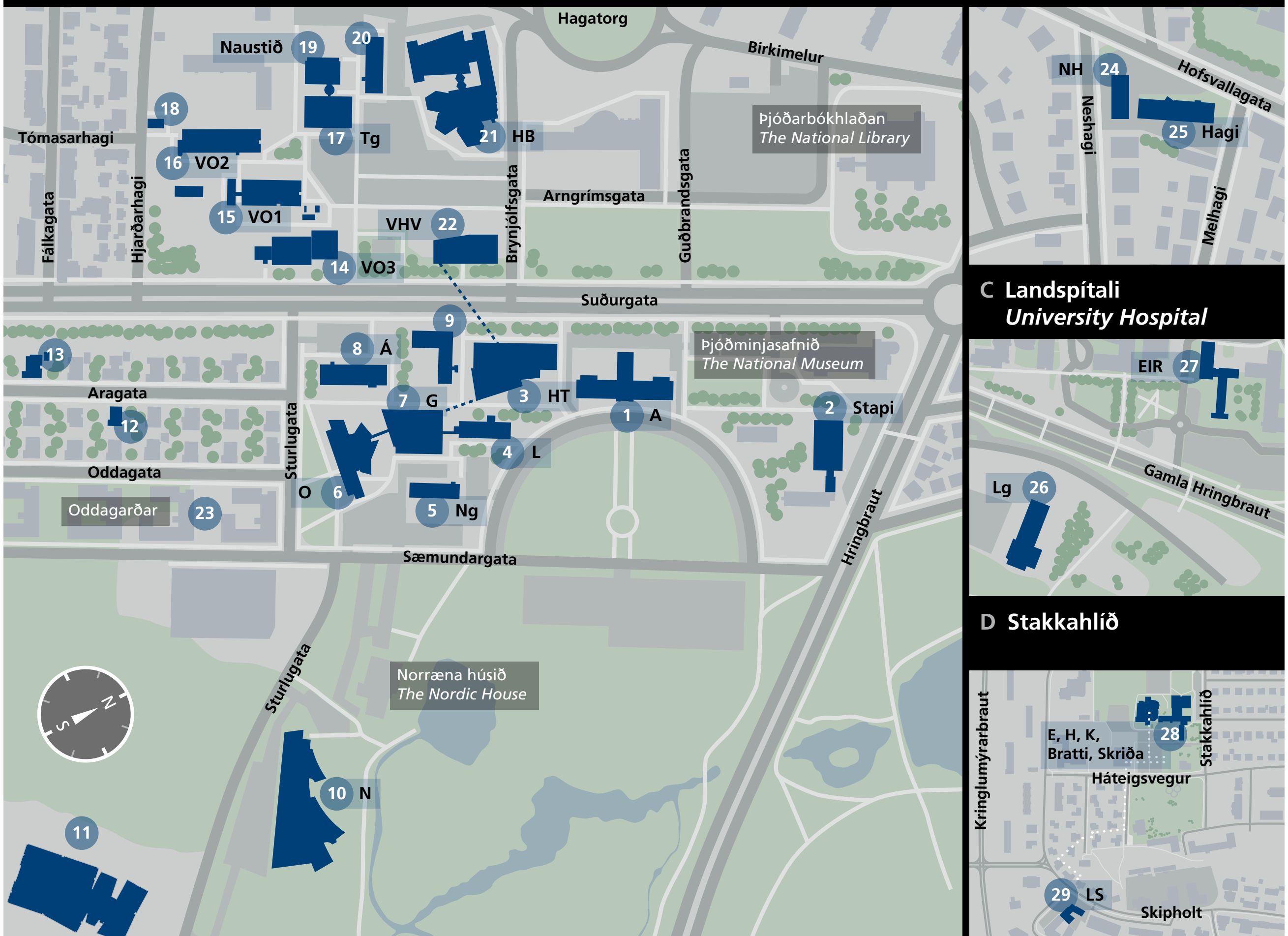
Map of University of Iceland

HÁSKÓLI ÍSLANDS

Háskóli Íslands er starfræktur á fimm svæðum
The University of Iceland operates in five locations

A Háskólasvæðið *Main University Campus*

B Neshagi · Hagi



1 **Aðalbygging *Main Building*** Miðlæg stjórnsýsla *Central Administration.* Hugvísindsvið *School of Humanities*

2 **Stapi** Heilbrigðisvísindasvið *School of Health Sciences*

3 **Háskólatorg *University Centre*** Þjónusta við nemendur *Student Services.* Fyrirlestrasalir *Lecture halls*

4 **Lögberg** Félagsvísindasvið *School of Social Sciences*

5 **Nýi-Garður** Hugvísindasvið *School of Humanities*

6 **Oddi** Félagsvísindasvið *School of Social Sciences* Heilbrigðisvísindasvið *School of Health Sciences*

7 **Gimli** Félagsvísindasvið *School of Social Sciences*

8 **Árnagarður** Hugvísindasvið *School of Humanities.* Stofnun Árna Magnússonar í íslenskum fræðum *The Árni Magnússon Institute for Icelandic Studies*

9 **Íþróttahús *University Sport Centre***

10 **Askja** Verkfræði- og náttúruvísindasvið *School of Engineering and Natural Sciences*

11 **Sturlugata 8** Verkfræði- og náttúruvísindasvið *School og Engineering and Natural Sciences.* Heilbrigðisvísindasvið *School of Health Sciences*

12 **Aragata 9** Kennslumiðstöð *Centre for teaching and learning*

13 **Aragata 14** Heilbrigðisvísindasvið *School og Health Sciences*

14 **VR-III** Verkfræði- og náttúruvísindasvið *School of Engineering and Natural Sciences*

15 **VR-I** Verkfræði- og náttúruvísindasvið *School of Engineering and Natural Sciences*

16 **VR-II** Verkfræði- og náttúruvísindasvið *School of Engineering and Natural Sciences*

17 **Tæknigarður** Verkfræði- og náttúruvísindasvið *School of Engineering and Natural Sciences*

18 **Smyrilsvegur** Verkfræði- og náttúruvísindasvið *School of Engineering and Natural Sciences*

19 **Endurmenntun** *Continuing Education*

20 **Raunvísindastofnun** *Science Institute*

21 **Háskólabíó** Fyrirlestrasalir *Lecture halls*

22 **Veröld - hús Vigdísar** *Hugvísindasvið School of Humanities*

23 **Oddagarðar** *Student Housing FS / Student Services*

24 **Neshagi 16** Stofnun Árna Magnússonar í íslenskum fræðum *The Árni Magnússon Institute for Icelandic Studies*

25 **Hagi** *School of Health Sciences*

26 **Læknagarður** *School of Health Sciences*

27 **Eirberg** *School of Health Sciences*

28 **Stakkahlíð** *School of Education*

29 **Skipholt 37** *School of Education*

Day 1 (Morning) — June 24, 2019

Time	Event	Location
8 a.m.-4 p.m.	Registration	Lobby Haskolatorg Building (HT)

Opening Ceremony and Plenary I

8:40-9 a.m. Opening Remarks, Chairs of TFE3S 2019 **Room HT-104**
Opening remarks by **Dr. Atli Benediktsson, Fellow of IEEE and SPIE, President of University of Iceland**

9-10 a.m. **Plenary Talk I** **Room HT-104**
Robert Magnusson, University of Texas at Arlington, USA
Title: "Principles and applications of guided-mode resonant photonic lattices" (Paper ID TFE19-33)

Abstract: We review principles of guided-mode resonant photonic lattices. We explain key properties enabling potential device applications. The one-dimensional periodic thin-film-type model is rich in properties and conceptually transparent encompassing all essential attributes applicable to two-dimensional metasurfaces and periodic photonic slabs. We address the operative physical mechanisms grounded in lateral leaky Bloch mode resonance emphasizing the significant influence imparted by the periodicity and the waveguide characteristics of the lattice. The effects discussed are not explainable in terms of local Fabry-Perot or Mie resonances. We summarize the band dynamics of the leaky stop band revealing principal Bragg diffraction processes responsible for band-gap size and band closure conditions. Application examples include wideband reflectors, nonfocusing spatial filters, ultra-sparse reflectors and polarizers, single-layer bandpass filters, and resonant sensors. In each case, representative fabricated example devices are described as well.

Bio: *Robert Magnusson is Texas Instruments Distinguished University Chair in Nanoelectronics and professor of electrical engineering at the University of Texas at Arlington. He directs the UT-Arlington Nanophotonics Device Group. Current theoretical and experimental research addresses periodic nanostructures, nanolithography, nanophotonics, nanoelectronics, nanoplasmonics, nanolasers, and optical bio- and chemical sensors. Magnusson has published 450 journal and conference papers and holds 35 patents. He is a fellow of the Optical Society of America and SPIE, a life fellow of IEEE, and a charter fellow of the National Academy of Inventors. He is co-founder and chief technical officer of Resonant Sensors, Incorporated, a company that provides next-generation optical sensor systems for pharmaceutical and biotech customers. He founded Tiwaz Technologies, LLC to provide consulting and prototyping in optical engineering, laser design, and nanophotonics technology.*

10-10:20 a.m. **COFFEE BREAK**

Notes:

Day 1 Morning Sessions 10:20 a.m.–12:30 p.m.

Session	Title	Location
Session 1A	**Nanophotonics I**	Room HT-104

Chair: *Akhlesh Lakhtakia*

10:20-10:50 a.m.
"Light-trapping sculptured thin films" (Paper ID TFE19-29)
Motofumi Suzuki, Kyoto University, Japan (Invited)

Abstract: Recently, various types of absorbers are investigated for applications to sensors, thermal emitters and thermoplasmonics. For example, we proposed thermoplasmonic nanoheaters, whose typical layered structure is composed of a mirror, dielectric spacer and nanoparticle absorbers. In the field of metamaterials, the so-called perfect absorbers are extensively studied. The typical perfect absorbers also consist of a mirror, dielectric spacer and nanostructured metals. The waveguide-mode sensors are similar to the well-known surface-plasmon-resonance sensors; however, they are composed of an analyte, dielectric waveguide layer and absorptive layer. As the interface of the analyte and waveguide layer is a perfect mirror owing to the total internal reflection, the waveguide-mode sensors also have the structure of a mirror, dielectric spacer, and absorbers. Therefore, these absorbers consist of optically common structures. As reported in our previous paper, the perfect absorption conditions for a high-reflectivity mirror can be achieved using bilayers fabricated with various combinations of different absorptive and dielectric materials. In this paper, we present several types of perfect absorbers including waveguide-mode sensors with a sculptured porous waveguide, low-reflectivity wire-grid polarizers, plasmonic nanoheaters for spatiotemporal control of heat generation and light-trapping photocatalyst.

***Bio:** Motofumi Suzuki is a professor at Kyoto University. He received his bachelor, master and doctor of engineering degrees from Kyoto University in 1986, 1988 and 1998, respectively. His current research interests include the optical properties of nanostructured thin films and the synthesis of novel nanostructures. He is a senior member of SPIE.*

10:50-11:20 a.m.
"Transition metal oxides thin films and chromogenics" (Paper ID TFE19-06)
Pandurang Ashrit, University of Moncton, Canada (Invited)

Abstract: Chromogenics is the field of study dedicated to materials showing, especially, the reversible optical property change under the influence of various external forces such as heat, electric field, light and more. Transition metal oxides (TMO) with their multiple oxidation states are one class of such materials showing very efficient chromogenic behavior. The basis of their reversible comportment is rooted in the rare electronic structure of the core transition metal, which is characterized by the partially filled d orbitals. Hence, like semiconductors, these materials can be switched between different states via a small activation provided by the various external forces. This switching between the various states entails large reversible changes in the optical, electrical, magnetic and structural properties. Based on the type of external stimulus applied to bring about the reversible change, the chromogenic materials can be classified under photochromic (light induced), thermochromic (heat induced), electrochromic (electric field induced) and more. Typical and well-known examples of transition metal oxides exhibiting the chromogenic behavior are the electrochromic tungsten trioxide (WO3), photochromic molybdenum trioxide (MoO3), thermochromic vanadium dioxide (VO2) and others. In this presentation, experimental and theoretical aspects of transition metal oxide (TMO) based chromogenic thin films will be discussed in detail. Results on the performance of the WO3 based electrochromic thin films and their devices will be presented. Various thin film nanostructuring techniques as well as the effect of nanostructuring on the WO3 electrochromic properties will be discussed. The fabrication method and electrochromic performance of a WO3 based inverse opal in tuning the PBG will be deliberated. Similarly, the effect of nanostructuring on the photochromic performance of MoO3 films and the potential to build an electro-photochromic device will be discussed. Various interactive chromogenic devices based on periodically and aperiodically nanostructured TMOs thin films such as smart windows, optical switches, sensors and more can be envisioned.

***Bio:** Pandurang Ashrit is currently the dean of the Faculty of Science at Université de Moncton in Canada and is affiliated with the Department of Physics and Astronomy at this university. He is also an adjunct professor at Université Laval in Canada. He is the invited author of the book published in 2017 by Elsevier titled, "Transition Metal Oxide Thin Film-Based Chromogenics and Devices." He has published more than 75 scientific articles on the optical and electrical properties of thin films and has authored several chapters in books dealing with these properties of thin films. He also holds a U.S. patent on chromogenically tunable photonic crystals. In 2012, he was granted an Innovation Award for Excellence in Applied Research by New Brunswick Innovation Foundation.*

11:20-11:50 a.m.
"Photoactive hybrid ZnO/N-Ag-TiO2 films for photocatalytic water purification: Nanofibers vs nanorods" (Paper ID TFE19-19)
Juan Martin Rodríguez, National University of Engineering, Peru (Invited)

Abstract: The light absorption of wide bandgap semiconductors in contaminated water, allows them to promote redox chemical reactions. The condition that ensures success is related to the spontaneous jump in the energy of the photo-generated charge carriers from their conduction/valence band energy positions to the oxidizing/reducing energy levels of those contaminants in the so-called heterogeneous photocatalytic water purification. In order to address drawbacks such as low absorption of the solar spectra, low active surface area, charge carrier's recombination, among others in this work, ZnO thin films composed of nanofibers and nanorods were compared and various coupling and doped materials were used to fabricate those on fluorine-doped tin oxide (FTO) glass substrate through electrospinning and hydrothermal techniques. The effect of doped with nitrogen, silver nanostructures and TiO2 nanoparticles on the properties of ZnO nanorods, in the order given, was investigated and discussed by using incident photon-to-current efficiency (IPCE), UV-VIS-IR spectroscopy, scanning electron microscopy (SEM), and X-ray diffraction (XRD). We found a significant enhancement of the photocatalytic degradation efficiency through degradation of methyl orange (MO), with ZnO:N-Ag nanorod films being more efficient than ZnO:N nanorod films and the latter better than the ZnO NRs film. Additionally, the obtained results evidenced that the coupling TiO2 with ZnO improves the photocatalytic activity of ZnO films. However, the ZnO films composed by nanofibers were more efficient than the ones composed by nanorods.

Bio: *Juan Martin Rodríguez Rodríguez, born in Lima in 1967, studied physics at the National University of Engineering in Peru and Uppsala University in Sweden. He is currently the director of the Center for the Development of Advanced Materials and Nanotechnology in Lima. His research is devoted to the development and characterization of advanced functional materials, vacuum and soft chemistry fabricated for photochemical applications. Dr. Rodriguez also conducts research pertaining to the construction of prototypes for the disinfection and removal of arsenic from water. He has more than 50 international publications, 10 book chapters, and three patents. He has advised two Ph.D., six M.Sc., and five licenciatura students and one engineering student. He is currently advising three Ph.D. students and one M.Sc. student. He is also a member of the board of the Peruvian Council for Science and Technology and the Latin American Center of Physics.*

11:50 a.m.-12:10 p.m.
"Optoelectronically optimized colored thin-film solar cells" (Paper ID TFE19-22)
Faiz Ahmad, Tom H. Anderson, Torben Lenau and **Akhlesh Lakhtakia**, Pennsylvania State University, USA; University of Delaware, USA; Technical University of Denmark

Abstract: Photovoltaic solar cells generally have a black or blue appearance that makes them aesthetically very different from traditional rooftops that either comprise burned-clay tiles or composite-material shingles. Rooftop solar cells may become more acceptable if they are colored, e.g., red or bluish green. This objective requires that a certain part of the incoming solar spectrum be reflected. The reflected part becomes unavailable for photovoltaic generation of electricity. We implemented and optimized an optoelectronic model for CZTSSe solar cells containing (i) a conventional 2200-nm-thick CZTSSe layer with a homogeneous bandgap, or (ii) an ultrathin CZTSSe layer with optoelectronically optimized sinusoidally nonhomogeneous bandgap, or (iii) a CZTSSe layer with optoelectronically optimized linearly nonhomogeneous bandgap. Either complete or partial rejection of either red or bluish green photons was incorporated in the model. Calculations show that on average, the efficiency of a typical solar cell will be reduced by 9 percent if 50 percent red photons are reflected or by 12 percent if 50 percent blue-green photons are reflected. The efficiency reduction increases to 20 percent if all red photons are reflected or 25 percent if all blue-green photons are reflected.

12:10-12:30 p.m.
"Optical wave and beam propagation through thin-film multilayered structures" (Paper ID TFE19-10)
Hammid Al-Ghezi, Rudra Gnawalli and **Partha Banerjee**, University of Dayton

Abstract: Multilayer structures have become important due to their potential applications as optical filters, sensors and coatings for invisibility, etc. In this talk, we show how multilayer structures composed of dissimilar isotropic materials can be approximated as an equivalent thin-film anisotropic bulk material using effective medium theory. We show that transmittance and reflectance for TE and TM polarizations can be found using the eigenvalues of the Berreman matrix, and the results for plane wave propagation can be readily extended to beam propagation using the angular plane wave spectral approach. This enables us to also derive the transfer function matrix for propagation in such anisotropic structures. The transfer function for TM polarization predicts focusing and negative refraction of Gaussian beams in hyperbolic metamaterials, which can be composed of metallo-dielectric stacks. Electro-optic materials sandwiched between multilayer structures can provide a convenient means for electronic tuning of active filters. Multilayers of anisotropic materials can also be modeled as an equivalent bulk medium, again using effective medium theory.

Session	Title	Location
Session 2A	**Contemporary Thin-Film Microelectronics I**	Room HT-101

Chair: *Eunsung Shin, University of Dayton*

10:20-10:50 a.m.
"Laser-scribed carbon films for flexible sensors and electronics" (Paper ID TFE19-30)
Savas Kaya, Ohio University, USA (Invited)

Abstract: Justifiably large interest on graphene as an extremely versatile and high-conductivity flexible electronic material led to an ongoing push for novel low-cost preparation techniques. Recently it has been demonstrated that polyimide (commercially available as Kapton®) films carbonizes in a surprisingly effective and simple fashion by illumination of medium power (~100mW) blue ns to ms range laser pulses in air. The resulting carbon layers have been shown to be of a random network of 3D and 2D graphitic structures that bestow the final layer sufficient conductivity (~1Ω-cm) that can be used in practical applications, especially for sensor and electrochemical applications. However, being a relatively immature process, neither a detailed account of process optimization and reliability of the conducting structures nor examples of passive RC-based sensors are available in the literature. In the present work, we address these deficiencies and methodically explore typical process parameter space to decouple the complex interplay between laser speed, pulse width, line spacing and laser power for the laser scribe process as well as investigating the longevity and statistical nature of device performance. In particular, we pay attention to humidity conditions and indicate how some of the potential weakness can be turned to strengths for sensor applications. Therefore, we will report on the optimal processing conditions, reliability of passive device performance and chemical stability of laser scribed PI structures, which can be applied to practical sensor development.

Bio: *Savas Kaya received his Ph.D. degree from Imperial College of Science, Technology and Medicine, London, in 1998, for his work on strained Si quantum wells on vicinal substrates, following the M.Phil. degree in 1994 from the University of Cambridge on polarization insensitive liquid crystal switches. He was a post-doctoral researcher at the University of Glasgow between 1998 and 2001, carrying out research in transport and scaling in Si/SiGe MOSFETs, and fluctuation phenomena in decanano MOSFETs. He is currently a professor with the Russ College of Engineering at Ohio University, Athens. His other interests include transport theory, device modeling and process integration, nanofabrication, nanostructures, and nanosensors for flexible electronics integration.*

10:50-11:20 a.m.
"Layer-by-layer magnetic switching in Fe/MgO(001) superlattices and islands" (Paper ID TFE19-07)
Fridrik Magnus, University of Iceland, Iceland (Invited)

Abstract: Magnetic tunnel junctions (MTJs), where two magnetic layers are separated by an insulating barrier, are the cornerstone of many current and proposed spintronic-device concepts such as MRAM, magnetic field sensors and spin logic devices. In particular, MgO-based magnetic tunnel junctions have been studied extensively due to their exceptionally high-tunneling magnetoresistance (TMR), and, as a result, they have become the industry standard for field sensors in hard drives. It is less well known that epitaxial Fe/MgO/Fe(001) MTJs can exhibit a magnetic interlayer exchange coupling (IEC) resulting in either a preferred ferromagnetic, antiferromagnetic or even a 90-degree in-plane alignment of the Fe layers, depending on the MgO thickness, temperature and growth conditions. The IEC is thought to be mediated by spin-polarized tunneling through the MgO, but the mechanism is not fully understood. Here, we show that such an IEC can be established throughout an Fe/MgO superlattice (the single-crystal counterpart of a multilayer) with at least nine back-to-back Fe/MgO/Fe MTJs. The superlattice is grown by a combination of DC and RF magnetron sputtering in a UHV system, resulting in epitaxial growth throughout the sample thickness. The interlayer exchange coupling in conjunction with the fourfold magneto-crystalline anisotropy of the epitaxial Fe layers results in a 180- or 90-degree periodic alignment of adjacent layers at remanence, depending on the MgO layer thickness. The thickness of the MgO layer can therefore be tuned to select a specific magnetic configuration. A discrete layer-by-layer magnetic switching is also observed, and the layers switch in sequence from the top downwards or bottom upwards, as shown by polarized neutron reflectivity measurements and magnetometry. This suggests that the interlayer exchange coupling extends beyond nearest neighbor layers. Such a structure could be used as a three-dimensional magnetic memory device, where magnetic bits are stacked on top of each other and read electronically or as a three-dimensional magnetic shift register, where a flipped magnetic bit can be propagated up or down the stack. Furthermore, we explore patterning of such superlattices into circular islands, from the nanoscale up to micrometer sizes. Patterning introduces a new interlayer magnetic coupling between the Fe layers through the stray magnetic field at the edges of the islands. We examine how the competition between these different interlayer coupling mechanisms affects the magnetic properties of the superlattices and how they are affected by the size of the islands. This is important for nanoscale device applications as well as for applications in magnetic metamaterials.

Bio: *Fridrik Magnus completed a Ph.D. in experimental solid-state physics at Imperial College, London, in 2008. He has worked as a researcher at the University of Iceland and at the Uppsala University in Sweden and is currently a research professor at the Science Institute of the University of Iceland. He has worked on the deposition of a range of metals, oxides and nitrides using PVD methods such as dc, rf and high-power impulse magnetron sputtering. His work focuses on magnetic heterostructures, both amorphous and single crystalline, and the tuning of magnetic properties through magnetic interlayer coupling and proximity effects. Dr. Magnus is also one of the founders of the startup company Grein Research, which uses state-of-the-art materials deposition, analysis and design methods to create new materials with tailored properties.*

11:20-11:50 a.m.
"Electronic and optical properties of metal oxides and doped diamond films" (Paper ID: TFE19-42)
M.S. Ramachandra Rao, Indian Institute of Technology, Chennai, India

Abstract: Oxide electronic materials provide a plethora of applications and offer ample opportunities for scientists to probe into some of the exciting and intriguing phenomena exhibited by oxide systems and oxide interfaces. Oxide electronic materials are becoming increasingly important in a wide range of applications including transparent electronics, optoelectronics, magnetoelectronics, photonics, spintronics, thermoelectrics, piezoelectrics, power harvesting, hydrogen storage and environmental waste management. Diamond is known as an 'ultimate engineering material' because it possesses extreme properties suitable for various applications including high thermal conductivity, high hardness, transparent over a wide range of frequencies, highly incompressible and highly resistant to chemical reactions. Doping of diamond further multiplies its area of research, for example, through nitrogen doping and boron doping, the bandgap of diamond can be engineered. Resistivity and grain size of diamond films can be tuned to suit various applications in the field of electronic devices. Quantum qubits can be generated in diamond where quantum information processing can be efficiently realized. In this talk, I will highlight our group's research activities on metal-oxide thin films and nanostructures: Light emission, whispering gallery modes in ZnO microspheres, large area ferroelectric thin films for applications to 2D-metal-oxide interfaces. I will also share our exciting results on boron and nitrogen doped diamond from the point of view of superconductivity and NV-centres for quantum computing.

Bio: *M.S. Ramachandra Rao did his M.Sc. and Ph.D. from IIT Kharagpur and then worked as a research scientist at CNRS, Bellevue, France, on high-Tc cuprates. Later at TIFR, Mumbai, he developed epitaxial high-Tc thin films for electrical transport and microwave devices. He was a Humboldt fellow at WMI, Munich, where he developed the first non-STO-type tunnel barrier using manganites. At IIT Madras, he established state-of-the art thin film growth facilities and established two centres: Nano-centre and Solar-Hub. His research work focuses on oxide-electronics, doping effects in oxides, oxide hetero- and nano-structures for light emission, spin injection in 2D layers and superconductivity in doped diamond. He is a visiting professor in the Erasmus Mundus European Master's Program since 2007 and serves as an editorial board member and INTERMAT section editor of J.Phys.D. Appl. Phys (IOPP, UK). His inventive work on diamond coatings led to incubating a company in IIT Madras Research Park.*

11:50 a.m.-12:10 p.m.
"Growth of SiGe nanocrystals in SiO2 matrix by applying HiPIMS: On the way to crystallization bypassing the need of annealing" (Paper ID TFE19-03)
Muhammad Taha Sultan, Jon Tomas Gudmundsson, Andrei Manolescu, Magdalena Lida Ciurea and **Halldór Guðfinnur Svavarsson**, University of Iceland.

Abstract: Nanoscale SiGe heterostructures exhibit high quantum light emission efficiency, a property that has heightened the applications of monolithic Si-based devices. A former stumbling block in fabricating such structures, the lattice misfit (4.2%) between Si and Ge, has turned-out to materialize the advantage of such system in electronic and optoelectronic devices, by tailoring the band gap of the system which has been especially useful in quantum-optical devices. The first fabrication step in such nanostructure is typically a deposition of thin films with a sputtering. Most often, the as-grown film is amorphous rather than crystalline. A common approach to achieve nanocrystals within dielectric matrix is via thermal annealing process. A consistent drawback of such annealing procedure is accumulation of strain induced dislocations and point defects which alter the structures interface integrity, causing degradation of its optical properties. Any method that could bypass such treatment procedure would be of great interest. Several methods to lower the temperature of crystallization has been proposed, and have found new ways to obtain better control over the structural morphology and optoelectronic characteristics. The detrimental effect of thermal treatment on structures, however, remain an issue. In this study, we provide a model of how to obtain SiGe nanocrystals in as-grow structures without any thermal treatment. For this motive, co-sputtering of Ge and Si was carried out via combination of a modern technique of high impulse power magnetron sputtering (HiPIMS) and direct current magnetron sputtering (dc-MS), respectively. The structures were prepared by depositing alternate layers of SiO2 and SiGe films. A wide spectral response with a threshold up to 1300 nm was obtained. The size of nanocrystals were found to be 2.1 ± 0.8 nm and can be varied by varying deposition parameter (i.e. repetition frequency). In addition, a brief study of varying matrix thickness over interface affect in light of obtained photo-spectra was carried out.

NOTES:

12:30-2 p.m. **LUNCH BREAK (Litla Torg Room, 2nd Floor HT)**

2-3 p.m. **Plenary Talk II** **Room HT-104**

Mark Horn, Pennsylvania State University, USA

Title: "How do you engineer a vapor-deposited thin film?" (Paper ID TFE19-34)

Abstract: The ability to make or deposit a thin film has enabled a myriad of modern applications from integrated circuits and flat panel displays to wear-resistant coatings on cutting tools to energy-efficient and decorative plate glass windows, just to name a few. Advancements in the technology of thin film deposition and the ability to characterize thin films at the monolayer level have opened up vistas for new materials and new applications. In this talk, the engineering of vapor deposited thin films will be addressed, specifically reviewing process/property/application interdependency. The role of temperature, chemistry and bombardment during deposition will be examined as well as the importance of interfaces, surfaces and post-deposition treatments. A review of current research and manufacturing techniques for vapor deposition will be presented. Physical vapor deposition (PVD), such as thermal and electron beam evaporation, sputtering and ion beam deposition, will be discussed. Chemical vapor deposition (CVD) will also be examined including low pressure CVD, metal organic CVD, plasma enhanced CVD, atomic layer deposition (ALD), plasma enhanced ALD and molecular beam epitaxy (MBE). A brief review of characterization techniques will also be conducted with a specific emphasis on structure, composition and property analysis of thin films. In this overview, special attention will be given to the importance of sample preparation and sample condition during analysis. The bulk of the talk will focus on three different case studies, which will serve to illustrate the synergy of the final application, the deposition technique and the characterization methods. Case study #1 will deconvolve the deposition of sculptured thin films (STFs) using evaporation and the role that surface morphology and deposition technique play in the final properties. STFs of TiOx for use as optical sensors or electrode materials in dye-sensitized solar cells will serve as examples. Polymer STFs will also be briefly reviewed. Case #2 will focus on the fabrication of microbolometers for use in uncooled infrared focal plane arrays. The use of PECVD for a low thermal conductivity membrane material and ion beam deposition and sputtering for a high temperature coefficient of resistance (TCR) imaging layer will be presented, specifically addressing electrical, mechanical, optical and thermal performance criteria. Case #3 will highlight the fabrication of ultra-thin NiTi shape memory alloy films using biased target ion beam deposition (BTIBD). This technique is a combination of sputtering and ion beam technology and presents a unique set of challenges as well as opportunities. The remainder of the talk will briefly describe future challenges in two emerging thin-film technologies. The physics community has discovered a number of unique properties in topological insulators primarily fabricated using MBE. What is required to enable practical applications for these unique films? Fabrication and modification of two dimensional (2D) materials, particularly transition metal dichalcogenides (TMDG), is growing exponentially. What are the current fabrication techniques for 2D materials, and will they enable the technology necessary for the internet of things?

Bio: *Professor Horn obtained his B.S., M.S. and Ph.D. degrees from the Department of Engineering Science and Mechanics at the Pennsylvania State University. He worked as a member of technical staff at MIT Lincoln Laboratory from 1988 to 1998 in the submicron technology group. From 1998 to 2001, he was the associate director of the PSU nanofabrication facility. After that, he became an associate professor of engineering science and became a full professor in 2011. He teaches mechanics and nanotechnology at Penn State and continues to pursue a wide variety of thin-film research.*

3-3:20 p.m. **COFFEE BREAK**

Notes:

Day 1 Afternoon Sessions 3:20–5:20 p.m.

Session	**Title**	**Location**
Session 1B	**Nanophotonics II**	Room HT-104

Chair: *Partha Banerjee, University of Dayton*

3:20-3:50 p.m.
"Electromagnetic response properties on nanocarbon films and structures" (Paper ID TFE17-09)
Sergey Maksimenko, Belarus State University, Belarus (Invited)

Abstract: We consider electromagnetic response of nano-structured carbon films in giga- and terahertz frequency range. Thin films comprising graphene and graphene/polymer structures, carbon nanotubes and carbon nanotube/WS2 nanotube hybrids, pyrolitic carbon, etc. are discussed as actual or potential materials for diverse electromagnetic applications: for instance to fabricate emitters, detectors, absorbers, antennas and interconnects. We investigate the main phenomena to be controlled in view of the above applications: conductivity, plasmon resonances, screening and absorption properties, etc. and demonstrate their essential peculiarities as compared to traditional electromagnetic materials.

Bio: *Professor Sergey Maksimenko (M.S. – 1976, Ph.D. – 1988, Dr. Sci. – 1996) is director of the Institute for Nuclear Problems, Belarusian State University, since 2013. In 1992-2012, he worked at the Institute as a head of laboratory of nanoelectromagnetics. He is SPIE fellow (2009) and associate editor of the Journal of Nanophotonics. He chaired the Intern. Conf. Fundamental and Applied Nanoelectromagnetics, Minsk, May 2012, and NATO ARWs with the same title in May 2015 and June 2018. He participates in a number of international projects, including EU Graphene Flagship, and coordinated the EU FP7 project BY-NANOERA. He is expert of Horizon 2020, the Skolkovo Foundation and Italian Ministry of Education, University and Research. He co-authored more than 200 publications indexed in Scopus and WoS. His research interest is nanoelectromagnetics - a multidisciplinary approach combining electrodynamics of inhomogeneous media and quantum theory of electronic ensembles.*

Notes:

3:50-4:10 p.m.
"Bi-modal resonance and spectral characteristics of a thin chiral slab resonator on an achiral substrate using Fresnel coefficients" (Paper ID TFE19-05)
Rajab Y. Ataai and **Monish Chatterjee**, University of Dayton, USA

Abstract: Recently, some work involving investigation of polarization states and Fresnel coefficients (FCs) at an achiral/chiral (ACC) interface was carried out and presented whereby it was found that depending on specific chiral bands and also the density (or phase index) of the two dielectrics, certain anomalous behavior would result. These anomalous types of behavior included Brewster effects for s-polarized incident light and total internal reflection even for propagation from lower to higher phase index. The characteristics were examined via graphical plots, analog time signals and 2-dimensional stationary images were propagated across the ACC boundary to determine the effect of chirality and other electromagnetic parameters (such as permittivity and permeability) under first-order dispersion. To ascertain the transmitted amplitudes, frequency-dependent FCs were used in the computation on the basis of the first-order dispersion model. It was found that dispersion and chirality noticeably change the transmitted signal and image (in the latter case, the chirality and dispersion together lead to noise-like snowflaking in the transmitted image). In a follow up, extensions to the case of two interfaces whereby the front end will be ACC and the back end chiral/achiral (CAC) are considered, potentially leading to entirely different optical characteristics. As mentioned, initial work for ACC included the discovery of specific chiral bands within which the Brewster effect anomalously manifests itself even for s-polarized light; likewise, total internal reflection (TIR) phenomena occur even under rarer-to-denser (R/D) or lower to higher phase index propagation. The snow-flake like distortions caused by propagation across an ACC with dispersive material parameters vary with incident angle and the dc value of the chirality parameter κ (and also the dispersion in permittivity and permeability). In the present work, we will specifically examine the FCs for ACC and CAC boundaries and explore the corresponding changes in the polarization states of the reflected and transmitted light waves. MATLAB simulations of the physical problem are carried out by incorporating appropriate boundary conditions and deriving the effective transmitted and reflected fields relative to the slab. The results are examined specifically for the case of a thin chiral slab with thickness d (placed between an achiral surface and an achiral substrate) in the range 10-100 nm. The transmission characteristics (which are usually examined to study the resonance behavior of a Fabry-Perot etalon) are investigated as a function of wavelength for both thick and thin film limits and the results are compared from resonance, resolution and polarization perspectives.

4:10-4:30 p.m.
"Artificial neural network to predict the refractive index of a liquid infiltrating a chiral sculptured thin film: Theory and experiment" (Paper ID: TFE19-02)
Patrick McAtee, Satish Bukkapatnam and **Akhlesh Lakhtakia**, Pennsylvania State University, USA

Abstract: We expanded the capabilities of surface multiplasmonic resonance sensing via a prism-coupled configuration by devising a new scheme to analyze data obtained from simulations and/or experiments. An index-matched substrate with a metal thin film and a chiral sculptured thin film (CSTF) deposited successively on it is affixed to the base of a prism with an isosceles triangle as its cross section. When a fluid is brought in contact with the exposed face of the CSTF, the latter is infiltrated. As a result of infiltration, the traversal of light entering one slanted face of the prism and exiting the other slanted face of the prism is affected. We trained an artificial neural network (ANN) using reflectance data generated from simulations to predict the refractive index of the infiltrated fluid. ANN performance for various incidence conditions was studied. The scheme is quite robust. Corresponding experiments for a metal thin film deposited onto an index-matched substrate are ongoing.

4:30-4:50 p.m.
"Twisted light by a Kerr-like TiO2 thin film with Au-Pt nanoparticles" (Paper ID: TFE19-43)
Carlos Torres, National Polytechnic Institute, Mexico

Abstract: Third-order nonlinear optical effects exhibited by gold-platinum nanoparticles in a titanium dioxide thin solid film were induced by a two-wave mixing configuration with digitally-modulated irradiance profiles. A round continuously variable nonlinear refractive index induced in the samples was able to generate twisted light by nanosecond pulses. Bimetallic nanoparticles integrated by gold and platinum were prepared by a standard sol-gel method. The system was designed in a flexible thin film form integrated by randomly distributed nanoparticles. Spectroscopy studies of the nanoparticles were conducted by an UV-vis spectrometer. Two peaks related to the absorption exhibited by the surface plasmon resonance of the Au and Pt metals were observed in transmittance spectrum of the sample. transmission electron microscopy observations were undertaken and spherical structure of the bimetallic nanoparticles was identified. The bimetallic nature of the nanostructures was revealed by energy-dispersive x-ray spectroscopy. The optical Kerr effect exhibited by the nanoparticles was explored by a standard two-wave mixing experiment. A Nd:YAG laser system featuring 4 ns pulses at a 532 nm wavelength was employed to conduct polarization-resolved measurements. Within this work is reported the potential use of Kerr nonlinearities for developing dynamic wave plates using randomly distributed bimetallic Au-Pt nanoparticles in dielectric thin solid films. Surface plasmon resonance phenomena in the multimetallic nanoparticles may take a key role in the enhancement of third-order optical nonlinearities.

Session	Title	Location
Session 2B	**Contemporary Thin-Film Microelectronics II**	Room HT-101

Chair: *Guru Subramanyam, University of Dayton*

3:20-3:50 p.m.
"Nanoparticle and 2D material inks for additive manufacturing of flexible hybrid sensors" (Paper ID: TFE19-36)
David Estrada, Boise State University, USA (Invited)

Abstract: Recent advances in the synthesis of 2-dimensional (2D) materials-based inks has increased the design space for additive manufacturing of flexible hybrid electronics (FHE) and sensors. Such systems stand to benefit from high performance flexible silicon IC's for signal processing and amplification, while also leveraging the high surface area and unique physical properties of 2D materials as sensors. For example, previous work has elucidated the fundamental role of crystal defects in the sensing mechanisms of graphene chemiresistors; however, such sensors are yet to find widespread commercial application. Integration of graphene with flexible silicon ICs could help expedite the adoption of such sensors in industry, as sensor response to target analytes could be isolated from other environmental factors through rapid signal processing techniques. Furthermore, advances in additive manufacturing of such systems could further enable widespread adoption of FHE's for applications requiring on-demand manufacturing and repair of sensors and systems. Towards this end, the Advanced Nanomaterials and Manufacturing Laboratory at Boise State University has undertaken several projects to help overcome obstacles facing the integration of 2D materials with FHE systems and sensors. This talk will highlight results of several ongoing studies on the integration of 2D materials with flexible silicon ICs including limiting factors of power dissipation in printed graphene electrodes, the electrochemical response of fully printed graphene electrochemical sensors, the reliability of flexible silicon die attach strategies for FHE system integration, and recent progress in aerosol jet printing of MXenes.

Bio: *Dr. David Estrada served in the United States Navy as an electronics warfare technician/ cryptologic technician – technical from 1998 to 2004. He achieved the rank of petty officer first class in 2003 before receiving an honorable discharge and returning to Idaho to pursue his undergraduate education at Boise State University (BSU) where he was a Ronald E. McNair scholar. After completing his Bachelor of Science in electrical engineering from BSU in May of 2007, he began graduate studies at the University of Illinois at Urbana-Champaign (UIUC) under the direction of Professor Eric Pop; earning his Doctor of Philosophy in electrical engineering in 2013. He then returned to Boise State University where he is an assistant professor in the Micron School of Materials Science and Engineering. David is the recipient of the Society of Hispanic Professional Engineers 2015 Innovator of the Year Award, two AFOSR Summer Faculty Fellowships, and an NSF CAREER award.*

3:50-4:20 p.m.
"Why orthotropic friction is important on graphene and graphene fluoride thin films" (Paper ID TFE19-04)
Sergei Lyuksyutov, University of Akron, USA (Invited)

Abstract: Physics of nanoscale friction in thin films of graphene, graphene fluoride is of great interest to nano-photonics, tribology, nanotechnology and surface science. Focus of this work is on experimental and theoretical studies of the orthotropic friction of graphene and graphene fluoride thin films at the edges of the thin films. Friction in graphene is highly anisotropic and dependent on scanning direction of an atomic force microscope tip. Computational study of the friction forces on graphene suggests that the contact area between the probe and a surface is substantially smaller than it appears and the quality of the contact area may influence how the friction force is applied across the contact area. In this work, we experimentally demonstrate that graphene and graphene fluoride thin films manifest different coefficients of sliding friction at the edges (graphene fluoride from 5.8×10-3 to 4.9×10-1; graphene from 8.2×10-3 to 3.3×10-1) of a sheet sample versus the interior(graphene fluoride from 5.1×10-3 to 1.5×10-1; graphene from 2.5×10-2 to 2.3×10-1) under ambient humidity conditions (RH ~ 40-60 percent). The friction coefficients show distinct directional dependence between graphene and graphene fluoride. To compare friction at the interior and edges of graphene as well as provide insights into the motion of atoms at the edge of a graphene nanoribbon during sliding friction, atomistic simulations have been performed. Our simulations show that bending deformation of the tip and downwards deformation of graphene edge has resulted in changes in friction forces (~0.6 nN) and energy dissipation (~ 1 eV difference) for an AFM tip moving from SiO2 over the graphene edge.

Bio: *Sergei Lyuksyutov earned degrees from Moscow Institute of Physics and Technology: M.S. in 1984, and Ph.D. in physics and mathematics in 1991. He was awarded George Soros Fellowship at Oxford University, Hertford College, UK, (1989-1990), and continued at Institute of Physics in Kiev, Ukraine, (1990-1994), starting a company making holograms of artefacts. He was postdoctoral at the Technical University of Denmark and University of Louisville, Kentucky. He is currently a professor of physics and chemistry at Akron University, Ohio, since 2000. He was awarded NRC Fellowship at Wright-Patterson AFB, (2002-2004), Japan Society Promotion Science in Japan (2004-2005), Fulbright Senior Specialist in Kiev, Ukraine, (2008), NASA Fellowship (2010-2011, 2014, 2016) and Senior Fellowship at Naval Research Laboratory, Washington, D.C., (2012-2013). He published 50+ papers, and delivered 100+ talks at international meetings. His research interests in areas of photonics of thin films and nanolithography using atomic force microscopy.*

4:20-4:50 p.m.
"Catalyzed growth of hydrogen Rydberg matter on surfaces, detection and properties (Paper ID TFE19-12)
Sveinn Olafsson, University of Iceland, Iceland (Invited)

Abstract: Among the atoms of the periodic system, hydrogen and deuteron have the lowest number of electrons and thus the simplest electronic structure and are generally only found in the simplest state as chemical binding of two atoms forming H2 and D2 molecules. No other forms of molecular structure with higher number of atoms of H or D has been observed or predicted using simple quantum mechanical models. In the beginning of the twenties, this picture started to change and be questioned with the work of Leif Holmlid at Gothenburg University, Sweden. He was able first to form new cluster state K7 and K19 of K atoms who found stable state when the K atoms were assembled in an excited Rydberg state with high n excitation number. Later, he was able to find methods to do the same thing for H and D and form Rydberg matter of H7 and H19. In this talk, experimental setup for growth of such phases on surfaces will be described along with some characterization work to detect the phases using short 1064nm laser pulses and time of flight measurements.

***Bio:** Professor Olafsson is a research professor of physics in the Science Institute of the University of Iceland, conducting research on growth of thin films by sputtering in general and hydrogen interactions in thin films and superlattices, instrument development, growth of nano-structured materials with STM and MBE growth of semiconductors. Surface science work at MaxLab Laboratory, Lund, Sweden, and defects studies of semiconductors at ISOLDE, CERN, Switzerland, using nuclear solid state techniques. He served as the chair of the Icelandic physical society, 2008-2013.*

4:50-5:20 p.m.
"Soft and wireless bio-integrated electronics for the human" (Paper ID: TFE19-41)
Kyun-In Jang, Daegu Gyeongbuk Institute of Science and Technology (DGIST), Korea (Invited)

Abstract: Conventional technologies hold many promises to advance disease diagnosis and therapeutic research by enabling precise sensing and actuation in a small scale, leading to implantable, portable or wearable biomedical systems. These modern medical devices interfaced with our body are rigid, bulky and remain permanently. However, biological organs and systems are soft and curvilinear, time-dynamic and the pathways to internal organs are small and narrow. Technologies that bridge this gap should be investigated for advanced healthcare by creating devices that provide intimate, minimally invasive and bio-resolvable interface with the human body, so that people cannot feel the existence of the device. To address this issue, based on modern MEMS and advanced material integration technologies, I will present our efforts, which are designed to be conformal, strain-limiting and stretchable forms of biomedical devices with multiple modalities and wireless capabilities.

***Bio:** Professsor Kyung-In Jang is with the Department of Robotics Engineering Department of Information and Communication Engineering. He is a member of the Brain Engineering Convergence Center at the Daegu Gyeongbuk Institute of Science and Technology (DGIST). He obtained his Ph.D. in mechanical engineering from Yonsei University, Seoul, Korea, in 2011. He has published over 40 journal papers in bio-integrated electronics.*

Notes:

Day 2 (Morning) — June 25, 2019

Time	Event	Location
8 a.m.-4 p.m.	Registration	Lobby Haskolatorg Building (HT)

9-10 a.m. **Plenary Talk III** **Room HT-104**

Tom MacKay, University of Edinburgh, Scotland

Title: "Free lunches: Extending material properties by homogenization" (Paper ID TFE19-20)

Abstract: The phrase "the whole is greater than the sum of its parts," or something close to that in spirit, is attributed to Aristotle, writing over 2300 years ago. This phrase could be applied to the extension of electromagnetic material properties that can be achieved through combining constituent materials to form a composite material. Provided that the granularity of the composite material is much smaller than the electromagnetic wavelengths involved, the composite material may be regarded as a homogenized composite material (HCM). There are many ways in which the material properties of HCMs can extend beyond those of the constituent materials; indeed, there even are many ways in which HCMs can exhibit materials properties that are not at all exhibited by its constituent materials. In this talk, a survey is presented of some recent results, and some not so recent results, on the manifestation of these extended properties of HCMs. The topic of electromagnetic homogenization is a venerable one that predates even the formulation of the Maxwell postulates. However, homogenization formalisms that can accommodate the most general types of linear materials – namely, bianisotropic materials – were established only within the past 20 years or so. We now have at our disposal versions of the Maxwell Garnett formalism, the Bruggeman formalism and the strong-property-fluctuation theory that can be used to estimate the constitutive parameters of the most general linear and weakly nonlinear HCMs, including extended versions that make allowance for the nonzero (but still small) size of the constituent material particles. While these formalisms are generally applicable to a vast range of HCMs, there are certain constitutive-parameter regimes that are out of bounds because in such instances unphysical estimates of the HCMs constitutive parameters can emerge. Anyhow, through the application of these formalisms, a wide variety of means of extending material properties may be established.

Bio: *Tom G. Mackay is a graduate of the Universities of Edinburgh, Glasgow, and Strathclyde. He is a reader in the School of Mathematics at the University of Edinburgh, and also an adjunct professor in the Department of Engineering Science and Mechanics at the Pennsylvania State University. He has been working on the electromagnetic theory of complex mediums, including homogenization and surface waves, for the past twenty years; and he has co-authored three textbooks on these topics.*

10-10:20 a.m. **COFFEE BREAK**

Notes:

Day 2 Morning Sessions 10:20 a.m.–12:30 p.m.

Session	Title	Location
Session 1C	**Thin-film Nanophotonics III**	Room HT-104

Chair: *Partha Banerjee, University of Dayton*

10:20-10:50 a.m.
"High-efficiency metasurfaces: Physics and applications" (Paper ID TFE19-08)
Qiong He, Fudan University, PRC (Invited)

Abstract: Metasurfaces are planar metamaterials exhibiting certain inhomogeneous phase distributions for transmitted or reflected waves, which can efficiently reshape the wave-fronts of incident beams in desired manners based on the Huygens principle. Due to their exotic abilities to freely manipulate electromagnetic (EM) waves on a flat and ultrathin platform, metasurfaces have attracted intensive attention recently, resulting in numerous new concepts and effects that could possibly find applications in many different aspects. In this presentation, we will brief introduce the working principles of metasurfaces and present our recent works on high-efficiency, multifunctional and tunable EM manipulation based on metasurfaces. By focusing on the efficiency issue of metasurfaces, we will describe different mechanisms and realizations of high-efficiency metasurfaces for manipulating linearly or circularly polarized EM wave, with several real applications.

Bio: *Qiong He received his Ph.D. degree in physics from Paris Institute of Optics in Paris-Sud University, Orsay, France, in 2008. From 2009 to 2013, he was postdoctoral fellow in the Physics Department of Fudan University. He is currently an associate professor at the Physics Department of Fudan University, Shanghai, China. His research interests focus on metamaterials and plasmonics. He has coauthored more than 50 publications in scientific journals, including Nature Materials, PRL, PRX, LSA,etc.*

10:50-11:20 a.m.
"Spectral response of GaAlAs/GaAs photocathode of vacuum photodiode based on external electric field" (Paper ID TFE19-39)
Rongguo Fu, Nanjing University of Science and Technology, PRC (Invited)

Abstract: In this paper, the influence of external electric field on cathode current emission density is analyzed. The theoretical model of external electric field and cathode current emission density is constructed by the basic theoretical model of photoelectric emission. Spectral response test experiments were performed using GaAlAs/GaAs vacuum photodiodes at different bias voltages. It is found that as the applied bias voltage increases, the corresponding current emission density also increases, and the influence of the empty point charge limiting region is suppressed to a certain extent, achieving a higher emission current density. A vacuum photodiode is used to make experiment, the energy band of GaAs photocathode is also given. According to emission theory of photocathode, the cathode emission current density expression of photon-enhanced thermal electron emission is given. This photodiode is based on GaAlAs/GaAs as the photocathode and nickel-aluminum alloy as the anode. Due to the different work function of the cathode anode, a blocking field is formed on the surface of the cathode. The electrons emitted from the cathode must reach the anode to overcome the blocking field. The spectral response sensitivity test was performed using GaAlAs/GaAs vacuum photodiodes at different bias voltages. Under the action of the external electric field, the original stable state is broken. The external electric field transmits electron energy to obtain sufficient energy to quickly transit from the cathode to the anode, while avoiding the influence of space charge, a higher emission current density is achieved. NEA GaAlAs/GaAs vacuum photodiode has an increased response sensitivity in low external electric field. It reaches saturation at about 100V in this structure. It shows that external electric field cannot modify the energy band of photocathode.

Bio: *Rongguo Fu is currently an associate professor in the School of Electronic Engineering and Optoelectronic Technology, Nanjing University of Science and Technology. He specializes in GaAs photocathode and solar energy conversion technology. He has been a visiting scholar at Stanford's SLAC in the last four years.*

Notes:

Session	Title	Location
Session 2C	**Contemporary Thin-film Microelectronics III**	Room HT-104

Chair: *Qiong He, Fudan University*

11:20-11:50 a.m.
"Fabrication of ZnS thin film using water bath method" (Paper ID TFE17-2)
Wenhua Gu, Nanjing University of Science and Technology, PRC (Invited)

Abstract: Zinc sulfide (ZnS) has excellent optical and electrical properties and can be widely used in many optical and optoelectronic applications, including optical coating, photocatalysis, solar cell, LED, etc. One of its outstanding merits is that it has high optical transmittance in both visible-light and infrared wavelength regions. Also the ZnS thin film is regarded as a good candidate to replace the toxic CdS buffer layer in the copper-indium-galium-selenium (CIGS) solar cells. The water bath method was used in this report to fabricate uniform and dense ZnS thin film. The impacts of different pH, different concentration, different water bath temperature, and different annealing temperature and time were studied to find the optimal condition. The reaction and annealing conditions were optimized. The optimal results were as follows: the mixture of 0.056mol/L thiourea and 0.0532mol/L ZnSO4.7H2O in water was titrated to pH=10.7 by ammonia, followed by water bath reaction at 85℃, then annealed in Ar at 300℃ for 1.5h. Thus fabricated ZnS thin film has the best surface flatness and film uniformity, with high optical transmittance.

Bio: *Wenhua Gu, is currently a professor at the School of Electronic and Optical Engineering, Nanjing University of Science and Technology; Deputy Director of the Institute of Micro and Nano Optoelectronic Devices and Applications. He obtained his Bachelor of Engineering degree from Tsinghua University and Master of Science and Ph.D. degrees from the University of Illinois at Urbana-Champaign. His research interests include printed electronics, micro and nano electronic devices, and optical communication. He has published over 40 SCI & EI indexed academic papers, and filed seven patents.*

Contributed Papers:

11:50 a.m.-12:10 p.m.
"Tailoring interface mixing and magnetic properties of Permalloy/Pt multilayers" (Paper ID: TFE19-25)
Movaffaq Kateb, University of Iceland

Abstract: We present deposition of multilayers consisting of 20 repetitions of 15 Å permalloy Ni80Fe20 at.% (Py) and 5 Å Pt. We studied the effect of substrate roughness and sputtering power on the in-plane magnetic uniaxial anisotropy of the film. We also used different methods of dc magnetron sputtering (dcMS) and high power impulse magnetron sputtering (HiPIMS) for deposition of Py. The multilayers were characterized by x-ray reflectivity and diffraction as well as magneto-optical Kerr effect (MOKE). It is shown that HiPIMS presents multilayers with unique surface and interface roughness which is more pronounced for the substrate with higher surface roughness. Multilayers prepared by both dcMS and HiPIMS present strong (111) texture normal to the film plane. The results show that utilizing HiPIMS leads to a minimum interface mixing between individual layers compared to dcMS at different powers. This is associated with high temporal deposition rate of HiPIMS (during the pulse on stage of the growth) that suppresses adatom mobility and interdiffusion of layers. However, this sharp interface results in higher coercivity and an opening in the hard axis while multilayers with intermixing present well defined in-plane uniaxial anisotropy i.e. a linear hard axis magnetization. In a comparison with Py/Cu and Py/CuPt multilayers prepared by identical condition using HiPIMS, it is shown that poor in-plane uniaxial anisotropy in Py/Pt case is attributed to the magnetostriction arising from large lattice mismatch between Py and Pt. While Py/Pt with interface mixing has a more relaxed interface and negligible magnetostriction.

12:10-12:30 p.m.
"TiO2 films on CoFe2O4 nanoparticles for the photocatalytic oxidation of rhodamine B: Influence of the alcoholic solutions" (Paper ID: TFE19-28)
Elmer Gastello and **Juan Martin Rodriguez**, National University of Engineering, Peru

Abstract: TiO2 and cobalt ferrites have a 3,2 eV and 1,3 eV optical bandgaps, respectively. TiO2 is more recommended for the photocatalytic degradation of contaminants in water, whereas the CoFe2O4 exhibits mainly, but not, exclusively, a magnetic response. If it is in a water solution, it can settle down from the solution using a magnet. In this work, TiO2/ CoFe2O4 core-shell films were fabricated having the TiO2 nanoparticles film deposited on the CoFe2O4 nanoparticles. Different chemicals were used in order to optimize the film deposition and a possible enhancement of the photocatalytic activity due to the synergic absorption of light in the visible zone and UV-A zone of the TiO2 and CoFe2O4, respectively. Cobalt ferrite nanoparticles were obtained by coprecipitation/ oxidation process using Fe+2 and Co+2 salts. Results show that the crystalline structure corresponds to cobalt ferrite inverse spinel, and these particles have spheroidal shape with 36 ± 20 nm diameter. TiO2 films deposited on the cobalt ferrite nanoparticles using ethanol or 2-propanol solutions have sizes between 57-96 nm or 122-124 nm, respectively. According to the high-resolution transmission electron microscopy analysis, TiO2 films prepared from ethanol solutions covering better the cobalt ferrite surface. Photocatalytic studies show that all TiO2 /CoFe2O4 materials can oxidize 5 ppm rhodamine aqueous solutions, and it was found that the best cobalt ferrite to TiO2 ratio to oxidize rhodamine is 4 to 8 percent.

Session	Title	Location
Session 6A	**Thin Films of Phase Change Materials and Sensors**	Room HT-101

Chair: *Andrew Sarangan, University of Dayton*

10:20-10:50 a.m.
"Phase changing oxide semiconductors" (Paper ID TFE19-13)
Shriram Ramanathan, Purdue University, USA (Invited)

Abstract: Adaptive matter that can modulate their electronic phase under external stimuli represent an emerging class of functional materials. Examples include perovskite oxides and chalcogenides whose properties can be programmed through several metastable pathways. The orders of magnitude change in carrier density accompanying the insulator-metal phase transition create opportunities for new classes of solid state devices in photonics, meta-surfaces, neuromorphic electronics and sensing. We will describe the principles governing phase change mechanisms in oxides considering structural-electronic coupling and orbital occupancy. We will discuss a few examples of their use in reconfigurable photonics and computing that we have been pursuing in a collaborative setting.

Bio: *S. Ramanathan received his Ph.D. in materials science and engineering from Stanford University. He served on the research staff at Components Research, Intel, for over three years. Subsequently, he served on the applied physics faculty at Harvard University for nearly a decade. Presently, he is a faculty member in materials and electrical engineering at Purdue University.*

10:50-11:20 a.m.
"Metal-insulator transition (MIT) actuators for microswitching applications" (Paper ID TFE19-23)
Ron Coutu, Marquette University, USA (Invited)

Abstract: Microswitches and actuators, fabricated using metal-insulator transition (MIT) materials, can be potentially used in applications ranging from wireless communication systems (e.g., cell phones, radar and satellite) to automatic test equipment. This is primarily due to their unique property of being transitioned from insulator to metallic or vice versa at room temperature due to a high ON/OFF resistivity ratio [1]. High contact force (~10 μN-1 mN), low actuation voltage (~2-5 V), and low contact resistance (~1Ω) are key parameters for commercial performance benchmarks (e.g., insertion loss: ~ 0.2 dB, isolation 30-35 dB) for direct current (DC) and radio frequency (RF) applications [2-5]. VO2 (Vanadium dioxide)/CNT (Carbon nanotube) bimorph cantilever -based microswitch actuators shows potential to meet these requirements [6]. This transitional metal oxide-based structure shows a structural phase transition when exposed to an external stimulus (e.g., light, joule heating, etc.). VO2 changes its monoclinic crystal structure to rutile tetragonal structure at temperature 68 °C. Past studies show that a VO2 cantilever coated with CNT shows 670 μm deflection and response time about 13 ms [6]. The high electrical conductivity and large optical absorption coefficient associated with CNT makes this structure highly responsive to external stimuli (e.g. light, electric current/field, and heat). Moreover, this device has been shown to reliably operate for more than 1M cycles with low actuation voltages (i.e., 2.7 V) [7-10].

Bio: *Ronald A. Coutu, Jr., is a professor and the V. Clayton Lafferty Endowed Chair in Electrical Engineering at Marquette University, Milwaukee, WI. He received his B.S. in electrical engineering from the University of Massachusetts at Amherst in 1993, his M.S. in electrical engineering from the California Polytechnic State University (CalPoly) in San Luis Obispo in 1995, and his Ph.D. in electrical engineering from the Air Force Institute of Technology in 2004. He is a California professional engineer and senior member of the IEEE and SPIE. His research interests include microelectromechanical systems (MEMS), advanced microsystems, sensors and actuators, biosensors, device fabrication, micro-electrical contacts, and phase-change materials.*

NOTES:

11:20-11:50 a.m.
"Novel synthesis and design methods of optical thin film structures using vanadium dioxide phase change material" (Paper ID TFE19-37)
Andrew Sarangan, University of Dayton, USA (Invited)

Abstract: Recent developments in phase change materials have led to a new generation of electronic and photonic memory devices and thermally tunable devices. Vanadium dioxide (VO2) and germanium antimoy telluride (GST) are two of the most developed phase change materials. The focus of this work is on vanadium dioxide. Current methods of growing vanadium dioxide rely on reactive physical vapor deposition on heated and lattice-matched substrates. This is often a difficult deposition process with a very narrow process window. The high process temperatures, patterning and etching challenges, and the lattice-matching requirement severely limit the number of materials it can co-exist with. As a result, compared to other types of inorganic optical thin film materials, the development of practical devices exploiting VO2 has been modest. In this paper, novel and simplified approaches to producing VO2 thin films is discussed, especially in regards to creating multilayer optical structures, tunable optical filters, switchable wiregrid polarizers, and tunable Bragg reflectors. The growth and characterization of nanostructured VO2 films is also discussed.

***Bio:** A. Sarangan is a professor in the Department of Electro-Optics and Photonics at the University of Dayton. He received his B.ASc. and Ph.D. from University of Waterloo in 1991 and 1997, respectively. His current work includes novel concepts in photodetection, image sensors, optical thin films and nanolithography. At UD, he founded the nanofabrication laboratory for optical thin films, interference lithography and semiconductor processing. He has developed optical computational tools including BPM, FDTD and integrated optical waveguide simulation. He is a senior member of IEEE and SPIE.*

11:50 a.m.-12:20 p.m.
"Design and fabrication of tunable inductors based on vanadium dioxide thin films" (Paper ID TFE3-46)
Eunsung Shin, CETRASE, University of Dayton, USA (Invited)

Abstract: Since vanadium dioxide (VO_2) is a well-known phase change material, that shows an insulator to metal transition at temperatures near 68°C, it has many potential applications in science and engineering. In this study, VO_2 thin film based planar spiral tunable inductors were designed and fabricated on a sapphire substrate. This approach can be a potential solution for reconfigurable RF/microwave wireless communication systems. According to the experimental results, fabricated inductors show a 72.8 percent (from 3.02 nH to 0.82 nH) tuning range when the VO_2 thin film layer undergoes the insulator-to-metal transition from room temperature to the temperatures above the transition temperature. This result confirms that the proposed inductor structure was fully functional with the successful inductance tuning capability.

***Bio:** Eunsung Shin received the B.S. degree in physics and the M.S. degree in optics from the Hallym University, Chunchon, South Korea, in 1990 and 1997, respectively, and the Ph.D. degree in electro-optics from the University of Dayton, Dayton, Ohio, USA, in 2004. He is currently a senior research physicist at the University of Dayton. His current research interests include phase change materials, thin film devices, thin film batteries, integrated photonics and nanomaterial synthesis.*

12:30-2 p.m.	LUNCH BREAK (Litla Torg Room)

NOTES:

2-3 p.m. **Plenary Session IV** **Room HT-104**

Augustine Urbas, Air Force Research Laboratory, USA

Title: "Materials for nonlinear optical metasurfaces" (Paper ID: TFE19-38)

Abstract: Plasmonic and metasurface systems have allowed for the exploration of unprecedented optical properties and phenomena using widely available materials such as noble metals. As the field advances, researchers have begun to explore dynamic, tunable and nonlinear phenomena in metamaterials and plasmonics with the aim of developing technologically relevant responses. These studies drive research to increase performance and functionality within the metasurface system based on optimized design and better material performance. In this presentation, we will explore efforts to create nonlinear metasurfaces with engineered properties and ongoing efforts to develop materials capabilities that will support their further development. Nonlinear metasurfaces have a broad range of application, and we explore how nonlinear properties of metasurfaces can be engineered for quantum information applications as a specific avenue. We show that nonlinear multipole interference allows both non-reciprocal and unidirectional nonlinear generation from nanoelements or their periodic arrangement in a metasurface, with the direction of nonlinear generation preserved with respect to a fixed laboratory coordinate system when reversing the direction of the fundamental field. Alternatively, balanced multipolar generation can ensure a directionally selective inhibition of the nonlinear response for certain respective directions of the fundamental beams. To support the development and demonstration of nonlinear metasurfaces, we are exploring novel materials systems that can achieve the dimensions and properties required to control nonlinear response. In general, the thicknesses and uniformity required from nonlinear metasurfaces, specifically of the type we propose, which have complex dimer or cut wire pair type substructure, are challenging to achieve. To advance the palette of materials available and thereby advance the functionality of metasurfaces, we are exploring systems that support epitaxial growth of high precision layered structured. Investigation of both transition metal nitride and arsenide based systems is ongoing. In each case, the control of linear and nonlinear properties, deposition of ordered hetero-structures and the structural control of these materials provides novel engineering control for metasurface applications. We will review current progress in these efforts and discuss future device capabilities that are enabled by the work.

Bio: *Dr. Augustine Urbas is a senior research physicist at the Materials and Manufacturing Directorate of the Air Force Research Lab. He has served as a research team leader in a variety of technical areas, most recently for the Integrated Opto-Electronics Research Team. Research in this team encompasses: structured materials, self-assembled optical composites, nanophotonics, adaptable/responsive materials, nonlinear materials properties and enhancements, EM properties of composite and structured media, integrated photonics, detector materials and structures, and the design and characterization of structured electromagnetic materials. Prior to that Augustine served as the technical lead for an AFRL level initiative to develop applications of metamaterials. His expertise includes laser spectroscopy, nano-optics, photonic materials, self-assembly, holography and morphological characterization.*

3-3:20 p.m. **COFFEE BREAK**

Notes:

Day 2 Afternoon Sessions 3:20–5:20 p.m.

Session	Title	Location
Session 6	**Thin Films for Energy Harvesting and Storage**	Room HT-104

Chair: *Guru Subramanyam, University of Dayton*

3:20-3:50 p.m.
"Nonlinearity, noise and dynamic range in two-dimensional nanoelectromechanical resonators" (Paper ID TFE19-47)
Max Zenghui Wang, University of Electronic Science & Technology of China (Invited)

Abstract: The advent of low-dimensional nanostructures has enabled a plethora of new devices and systems. Among them, nanoelectromechanical systems (NEMS) offers the unique capability of coupling the exquisite material properties found in these atomically-defined nanostructures with their mechanical degree of freedom, opening new opportunities for exploring exotic phenomena at the nanoscale. In this talk, I will discuss the theoretical and experimental study of nonlinearity, noise and dynamic range in two-dimensional nanoelectromechanical resonators and demonstrate that broad dynamic range can be achieved in such atomically-thin nanomechanical structures.

References:

1. Jaesung Lee and Zenghui Wang et al., Science Advances 4, eaao6653 (2018).
2. Zenghui Wang and Philip X.-L. Feng, Applied Physics Letters 104, 103109 (2014).
3. Jaesung Lee and Zenghui Wang et al., ACS Nano 7, 6086–6091 (2013).

Bio: *Max Zenghui Wang is currently a professor in the Institute of Frontier and Fundamental Sciences (IFFS) at the University of Electronic Science and Technology of China (UESTC) and a visiting professor in the Electrical Engineering and Computer Science Department (EECS) at Case Western Reserve University (CWRU), where he had worked as a research associate (2012-2014) and senior research associate and investigator (2014-2016). His research interests and expertise primarily focus on nanoscale devices and systems, particularly nanoscale resonators and high-frequency resonant sensors and transducers. Prior to joining Case, during 2010-2012, he worked at Cornell University as a postdoc researcher. He earned a Ph.D. degree (2010) from the University of Washington, Seattle, for building an ultra-high frequency NEMS resonant sensor with an individual single-walled carbon nanotube and used it to detect and study the low-dimensional phase transitions of the atomic layer adsorbed on the nanotube surface. He is an expert on studies of emerging nanoscale devices and sensors based on new materials such as carbon nanotubes, graphene and other low-dimensional nanomaterials, and has published research articles in peer-reviewed journals, including Science, Nature Nanotechnology, Nature Communications, Science Advances, Nano Letters, ACS Nano, Physical Review Letters, 2D Materials, etc. He is an ssociate editor for Micro and Nano Letters, and has been serving on the Technical Program Committees for IEEE IFCS, IEEE Nano, and the MEMS/NEMS Technical Group at the American Vacuum Society (AVS) International Symposium and Exhibition.*

3:50-4:20 p.m.
"Fabrication, processing and advance applications of carbon nanotube sheets and fibers" (Paper ID TFE19-35)
Vesselin Shanov, University of Cincinnati, USA (Invited)

Abstract: Carbon nanotubes (CNTs) have attracted great interest due to their unique properties like good thermal and electrical conductivity, high strength and surface area, chemical inertness and lightweight. A challenge remains how to translate the extraordinary properties of the individual CNTs into macro-assemblages, such as sheets and fibers. In this talk will be presented improved electrical and mechanical properties of CNT sheets and fibers, as well as their advanced applications for sensors, antennas, energy storage devices, heatable filters for water purification, etc.

Bio: *Vesselin Shanov is a professor with the chemical engineering program at the Department of Chemical and Environmental Engineering and the co-founder and co-director of the teaching and research facility NANOWORLD Lab at the University of Cincinnati. His recent research focuses on synthesis, characterization, processing and application of nanostructured materials with emphasis on carbon nanotubes, graphene, as well as on biodegradable Mg for medical implants. Applications of Dr. Shavon's research are in the areas of energy storage, electronics, aerospace and nanomedicine. He has more than 300 scientific publications, including 18 issued patents, 25 provisional patents & patent applications and six books, cited in about 3,500 different references. Dr. Shanov has received several prestigious awards, including Fulbright Scholar, German Academic Foundation (DAAD) and College of Fellows at the American Institute for Medical and Biomedical Engineers.*

4:20-4:50 p.m.
"Effect of H2/Ar plasma exposure on photoconductivity of SiGe nanoparticles: Influence of short and protracted intervals" (Paper ID TFE19-35)
Halldor Svavarsson, University of Iceland (Invited)

Abstract: Optical properties of structures based on functional SiGe nanoparticles may be enhanced by, for example, incorporating barrier layers above and below the intermediate layer containing nanoparticles, doping, incorporation of super-lattices, heat treatments and varying the Si/Ge ratio. Still another and versatile approach is to use hydrogen plasma treatment. It is known that atomic hydrogen passivates shallow and deep-level traps and defects in virtually all semiconductors. Here we studied the effect of hydrogenation time (short and long intervals) on the photoconductivity of a thicker (~200 nm) SiGe films, sandwiched between SiO2 layers. The samples were fabricated by applying radio-frequency magnetron sputtering (rfMS) and short term annealing. Similar structure was analyzed by us recently, where its fabrication was shown to result in formation of planar defects due to relaxation of stress field inside structure and that the SiGe nanocrystals had lens-like morphology due to the formation of shearing lattice defects and micro twins. Here, we demonstrate that hydrogenation does greatly improve the photoconductivity of such structure. It is also shown that several short intervals of hydrogen exposure, rather than the same total time in a single interval, causes less surface damage and trapping of molecular hydrogen, which would otherwise degrade the optical properties of the structure.

***Bio:** Halldor G. Svavarsson is a professor at The School of Science and Engineering (SSE) at Reykjavik University. He holds a B.Sc. degree in chemistry from the University of Iceland and a M.Sc. degree in materials science engineering from Tampere University of Technology in Finland. In 2003, he received a Ph.D. degree in physics from the University of Iceland. Halldor was a chair of the Mechanical and Electrical Engineering Department at SSE in 2008-2010 and a chair of the Research Council of the SSE in 2013-2018. His current research interests include photonic nanostructures, functionalized thin films, and silicon nanowires for energy conversion and sensors application.*

4:50- 5:20 p.m.
"Maximal equilibrium temperatures of wideband perfect light absorbers under solar light radiation" (Paper ID TFE19-40)
Junpeng Guo, University of Alabama, USA (Invited)

Abstract: A new thermal emission model is developed and used to predict the maximal equilibrium temperatures of multilayer metal-dielectric thin film wideband solar light absorbers. It was found that the single dielectric coating layer structure gives the highest equilibrium temperature of around 979 K.

***Bio:** Junpeng Guo is a professor of electrical engineering and optics at the University of Alabama in Huntsville. He is a fellow of SPIE-The International Society for Optics and Photonics. He currently serves as an associate editor of the SPIE Journal of Nanophotonics and an associate editor of Photonics Research.*

Notes:

Session	Title	Location
Session 7	**Optical Thin Films**	Room HT-101

Chair: *Eunsung Shin, CETRASE, University of Dayton*

3:20-3:50 p.m.
"Metal-insulator and optical transitions in reactive magnetron sputtered single crystal V2O3 thin films" (Paper ID: TFE19-21)
Unnar Arnalds, University of Iceland (Invited)

Abstract: V2O3 is a transition metal oxide, which undergoes a first order structural phase transition from a high temperature metallic state to a low temperature insulating state affecting also the optical properties of the material. For bulk V2O3 the transition occurs at a temperature of around 155 K. When fabricated in thin film form the temperature and magnitude of the transition and change in electrical properties are strongly dependent on the choice of substrate material, strain in the film and sensitive to the amount of vanadium and oxygen deficiencies and defects. This tunability aspect of the material is vital as it can be utilized to control the temperature at which the transition occurs. We present recent results, which have shown how the transition temperature and scale of the metal-insulator transition and optical properties are directly correlated with the stoichiometry and local strain in the film with both directly controllable by the deposition parameters.

3:50-4:20 p.m.
"Analysis of structure characteristics and internal electron diffusion characteristics of GaAs" (Paper ID TFE19-44)
YaFeng Qiu, Nanjing University of Science and Technology, PRC (Invited)

Abstract: GaAs material has excellent photoelectric properties and is the most sensitive vacuum semiconductor material in the visible light band. It has been widely used in the field of low-light-level night vision. GaAs photocathode has become the core component of the low-light-level night vision device. We systematically analyzed the structural characteristics of the low-light image intensifier and defined the boundary conditions of GaAs material's electron emission. It provided calculation basis to better analyze the photoelectric effect of GaAs photocathode. We established GaAs crystal model on first principles, calculate the energy band structure, analyzed the surface of the electronic escape mechanism, after setting the photon energy and transfer to the electronic, excited electrons went out of its orbit, as free electrons, free electrons gain kinetic energy at the beginning, according to the experience assumes that the free electron diffusion process after the collision energy loss rate, calculated number of electrons in a crystal model collision and mobile distance, moving linear distance for electronic diffusion length. The initial kinetic energy of electrons excited by GaAs material depends on the energy of incident photons, as well as on the cathode's own temperature. We analyzed the relationship between the electron diffusion length of the material and the temperature. The electron emission characteristics of GaAs material were summarized, which provided technical support for the subsequent process research of this cathode material. The low light image intensifier made of the GaAs material consist of the following parts: photocathode MCP screen and high voltage power. Using the elastic collision model, calculated the energy of the photon to the electron transfer, set up electronic diffusion in the process of collision energy loss rate of 20 percent every time, until the free electron collision is the photon energy losses, the collision frequency and the moving distance of GaAs material properties. The diffusion length of electrons in the material is a non-linear relation to temperature. Because when the temperature of the material rises to a certain rating, the thermal energy can generate free electrons, the number of free electrons in the crystal increases, the number of collisions between electrons increases greatly, and the free electron diffusion length decreased sharply instead.

***Bio:** Dr. Yafeng Qiu specializes in photoelectronic device and photoelectronic system, infrared imaging technology, and multi-spectrum images fusion. He has taken part in SPIE several times. Now he is researching On SNR parameter test system of MCP in vacuum system, improving the photo spectral response and quantum efficiency.*

4:20-4:50 p.m.
"Research on photoelectric properties of n-GaN (0001) surface with point defects via first-principles" (Paper ID TFE19-45)
Lei Liu, Nanjing University of Science and Technology, PRC (Invited)

Abstract: In order to reveal the influence of n-type doping and point defects on the electronic and optical properties of GaN (0001) surface, the pristine and defective n-GaN (0001) surface models are established. The formation energy, work function, atomic structure, electronic and optical properties of these surfaces are discussed by first-principles calculations. The results show that the defects have the strong tendency to be close to the surface position, and the N interstitial defect (Ni) and the Ga vacancy (VGa) are easily formed. The work function of the surface with VGa drops the greatest, and the conductivity of n-type increases. In addition, the absorption coefficient of the surface with various defects is smaller than that of the pristine n-type surface. The appropriate amount of Ga vacancies can increase the probability of electron emission, but it is not conducive to the absorption of photons.

***Bio:** Lei Liu, received the doctoral degree in optical engineering in 2005 from Nanjing University of Science and Technology. She is currently a professor at this university. Her research interests include physical electronics and photo electronics materials, devices and systems.*

7-9 p.m. **WORKSHOP BANQUET @SKOLABRU**
http://skolabru.is/index.html

Day 3 (Morning) — June 26, 2019

Morning Sessions 9 a.m.–12 noon

Session	Title	Location
Session 8	**Thin-film Multiferroics**	Room HT-101

Chair: *Nian Sun, Northeastern University*

9-9:30 a.m.
"Finding new oxide materials coexisted with multiple quantum parameters" (Paper ID TFE19-15)
Yalin Lu, University of Science and Technology of China (USTC), PRC (Invited)

Abstract: Layered perovskite oxides with the manipulable degrees of freedom in lattice, charge and spin, possess intriguing quantum phenomena, and have been recently found great potentials in next generation quantum devices. In this talk, I will briefly introduce our recent works toward this direction: 1. realization of room temperature single-phase multiferroics on layer-structured perovskite-oxides via atom-layer-inserting route; 2. growth of single crystalline layer-structured perovskite-oxides films via the interface engineering and their fascinating properties in exchange biases; 3. discovering of new strain-determined ferromagnetism insulation material above the liquid nitrogen temperature; 4. engineering lattice defects in perovskite oxides such as Sr2IrO4 and SrRuO3. Characterization methods using new advanced light sources for such properties also will be briefly introduced.

Bio: *Yalin Lu, received his Ph.D. from Nanjing University in 1991, and is now a full professor in the University of Science and Technology of China (USTC). Before joining USTC, he was a professor in AFA, Tufts University and Lawrence Berkeley National Laboratory. Dr. Lu was the recipient of China National Award for Natural Science (first class) in 2006. He currently serves as the director of National Synchrotron Radiation Laboratory of China and deputy director of the Hefei Science Center of CAS. His research focuses on quantum functional materials, nanophotonics, new energy materials and THz technologies. He is highly noted for the past inventions on transparent electro-optical PMN-PT ceramics, quasi-phase matched PPLN crystal, nonlinear microwave scanning tip microscope, quantum functional complex oxides, and terahertz compact FEL. Dr. Lu has ~ 320 publications, ~ 80 U.S. and Chinese patents and applications, and five books/ chapters.*

9:30-10 a.m.
"Band gap lowering, higher temperature operation and high Q resonances with thin film ferroelectrics" (Paper ID TFE19-16)
James Raju, University of Hyderabad, India (Invited)

Abstract: Ferroelectric thin films can be manipulated to yield desired results with different processes, compositions and device structures. One of each would be presented in this paper. BaTiO3 was prepared by a sol gel process to yield different sizes of particles. One interesting aspect of the process, when it was done with ultrasonic energy, was observed with TEM data that mesocrystals were formed. Depending on their crystallite size, it was found that the band gap energy can be tailored. It is an important aspect for energy harvesting because lowering of the band gap of BaTiO3 is important to make them absorb solar energy, so that their built-in electric field can be exploited to facilitate separation of generated charges. Thin films of Bi based Aurivillius phase composition CaBi4Ti4O15 (CBTi) were prepared in pulsed laser deposition method to achieve electromechanical resonators that can be used as resonant perturbation sensors, which works at higher temperatures up to 350oC. Using these CBTi and BST ((Ba,Sr)TiO3) thin films, high-overtone bulk acoustic resonators (HBAR) were fabricated, which gave resonances with peaks as high as 22,850. The multiple resonances generated by HBARs pose a problem in communication applications, but these high Q resonances can be used in resonance perturbation sensors. In this application, it was observed that not only the Q value of the resonances and their perturbation, which is useful, but also the peak distribution profile variation of SPRF (spacing of parallel resonant frequencies) is quite sensitive to the presence of a perturbing agent, which can be a new route for achieving sensing functionality at higher frequencies with piezoelectric thin film based electromechanical resonators.

Bio: *Professor James Raju obtained his Ph.D. from Indian Institute of Technology, Madras, India. He is a professor at the University of Hyderabad, India, working in the field of ferroelectric thin films, high temperature piezoelectrics and low loss dielectrics. These materials are being studied particularly at microwave frequencies. Using such materials, devices for application in the microwave frequencies are being fabricated. Recent interests are with magneto electric nano laminates, electro acoustic high Q resonators, resonators for sensor applications, high temperature piezoelectric thin films, band gap narrowing mechanisms and microwave range measurement techniques for thin films and multilayers.*

10-10:20 a.m.	**COFFEE BREAK**

10:20-10:50 a.m.
"Magneto-electric magnetic field sensors" (Paper ID TFE19-35)
Eckhard Quandt, University of Kiehl, Germany (Invited)

Abstract: Magnetoelectric (ME) composites have high potential for applications, e.g., as very sensitive ac magnetic field sensors. Special features are their passive nature, their high sensitivity and their large dynamic range with linear response. Especially at the mechanical resonances these sensors show limit of detections (LOD) in the fT/Hz1/2-range but suffer from their small bandwidth and from difficulties to cover the low frequency range (1 to 100 Hz) that is attractive for biomedical applications. To overcome these limitations electrical modulated ME sensors are an attractive alternative. In my talk, I will address surface acoustic wave sensors (1), and sensors using a passive readout method by a pickup coil, which is applied to thin film magnetoelectric composites under active piezoelectric excitation at high quality factor high frequency resonances (2). These two approaches will be discussed in terms of their potential use as very sensitive magnetic field sensors in the pT range at biomagnetic relevant frequencies. (1) Kittmann, A.; Durdaut, P.; Zabel, S.; Reermann, J.;, Schmalz, J.; Spetzler, B.; Meyners, D.; Sun, N.X.; McCord, J.; Gerken, M.; Schmidt, G.; Höft, M.; Knöchel, R.; Faupel, F.; Quandt, E.: Wide Band Low Noise Love Wave Magnetic Field Sensor System, Scientific Reports 8 (2018), 278. (2) Hayes, P.; Schell, V.; Salzer, S.; Burdin, D.; Yarar, E.; Piorra, A.; Knöchel, R.; Fetisov, Y.K. and Quandt, E.: Electrically modulated magnetoelectric AlN/FeCoSiB film composites for DC magnetic field sensing, *J. Phys. D: Appl. Phys. 51* (2018), 354002. Funding by the DFG via the Collaborative Research Center CRC 1261 is gratefully acknowledged.

Bio: *Eckhard Quandt received his Diploma and Dr.-Ing. degrees in physics from the Technische Universität Berlin, Germany, in 1986 and 1990, respectively. He is currently a professor with Kiel University, Kiel, Germany, where he is the director at the Institute for Materials Science. He is the spokesperson for the DFG CRC 1261 Magnetoelectric Sensors: From Composite Materials to Biomagnetic Diagnostics, and is a member of Acatech, National Academy of Science and Engineering. His scientific focus is material research on smart materials and multiferroics and the development of sensors and actuators for microelectromechanical systems and nanoelectromechanical systems using such materials.*

10:50-11:20 a.m.
"RF NEMS magnetoelectric sensors for picoTesla magnetic sensing" (Paper ID: TFE19-17)
Nian Sun, Northeastern University, USA (Invited)

Abstract: Prior studies have shown the effectiveness of micro-scale, piezoelectric/magnetostrictive resonators that can be used as DC magnetic field detectors by exploiting the ΔE effect. A sensitivity of a few Hz/nT has been achieved in unshielded lab environments by monitoring changes in resonance frequency as a function of magnetic field. With lateral dimensions on the order of a hundred microns, and hundreds of nanometers thick, these nano-plate resonator devices offer the advantages of small scale: Portability, low power consumption and the potential for high spatial resolution in sensor arrays. However, the effects of various physical parameters on magnetic properties in these magnetometers has not been fully elucidated, likely leading to less than optimum sensors. In this study, we demonstrate the critical effect of resonator plate curvature on sensor performance. We found that the resonance frequency response to magnetic fields dropped off exponentially with increasing curvature, which can be attributed to residual stresses accumulated during microfabrication. Up to two orders of magnitude separated the highest and lowest observed frequency shift in otherwise identical sensors. Good agreement was found with prior studies revealing influence of stress on the ΔE effect. By fabricating a magnetoelectric nano-plate resonator with low curvature, a record-high magnetic field sensitivity of 4.98 Hz/nT was achieved. A high degree of resonator stability was also observed, quantified by an Allan deviation minimum of 0.0245 Hz at 100 ms averaging time. This yields an estimated detectivity of 1.56 pT/Hz^1/2 at 10 Hz, giving the best low field sensing capability of micro/nanoscale magnetometers to date.

Bio: *Nian Sun is professor of electrical engineering, director of the W.M. Keck Laboratory for Integrated Ferroics, Northeastern University, and founder and chief technical advisor of Winchester Technologies, LLC. He received his Ph.D. degree from Stanford University. Before joining Northeastern University, he was a Scientist at IBM and Hitachi Global Storage Technologies. Dr. Sun was the recipient of the NSF CAREER Award, ONR Young Investigator Award, the Søren Buus Outstanding Research Award, etc. His research interests include novel magnetic, ferroelectric and multiferroic materials, devices and subsystems. He has over 250 publications and over 20 patents and patent applications. One of his papers was selected as the "ten most outstanding full papers in the past decade (2001~2010) in Advanced Functional Materials." Dr. Sun has given over 150 plenary/keynote/invited presentations and seminars. He is an editor of Sensors, and IEEE Transactions on Magnetics, and a fellow of IoP and of IET.*

Notes:

11:20-11:50 a.m.
"Extensions of the van der Pauw method applied to magnetoresistance measurements in ferromagnetic films" (Paper ID TFE19-27)
Snorri Ingvarsson, University of Iceland (Invited)

Abstract: Due to its high permeability, high anisotropic magnetoresistance, low magnetostriction and low coercivity, the alloy permalloy, Ni80Fe20 (Py), has pervaded magnetoelectronic devices through decades. From the telecommunication industry, bubble memory, anisotropic- and giant magnetoresistive devices to magnetic tunnel junction devices. In today's heterostructure devices, Py is usually thermally evaporated or sputter deposited, resulting in polycrystalline films, while with careful choice of substrate material and deposition conditions it can also be made single crystal. Electrical resistivity is quite sensitive to geometrical shape and microstructure of materials, film thickness and grain size for example. Numerical results show that electrical resistivity of Py is extremely sensitive to its electronic and magnetic structure and to the lattice constant, or strain [2]. Our previous results from resistivity and magnetization damping measurements (ferromagnetic resonance) support this, both in free standing Py films and bilayers of Py/Cu and Py/Pt [3], as well as in layers of Py alloyed with e.g. Pt [4]. The Pt introduces strong spin-orbit coupling that contributes to increase in spin-flip scattering and magnetization damping. The abovementioned results [2] were obtained by a regular van der Pauw (vdP) resistivity measurement, ignoring anisotropy. It is a very sensitive measurement technique where it is easy to avoid unwanted sample shape effects. However, in its original form it assumes isotropic resistivity in the material. We present measurements of magnetoresistivity using two different extensions of the vdP method, that account for anisotropy in resistivity, in ferromagnetic Ni80Fe20 (Py) films [5,6]. This allows us to determine accurately the full 2x2 in-plane resistivity tensor of the films. We apply these to measure anisotropic magnetoresistance (AMR) in Py films and compare the results of the vdP method with the more conventional Hall-bar method along the hard and easy axis of the film and show that the vdP method gives a more reliable AMR result [7]. For instance, the AMR result along the hard and easy axis of the film are in close agreement, the result depending only on the relative orientation of magnetization with respect to electrical current. We have also observed differences in resistivity in single crystal Py-films with different levels of disorder in atomic arrangement. Different order was obtained by different deposition techniques. Samples with atomic disorder (but the same perfect crystal structure as the ordered samples) have substantially higher resistivity [1]. Further, we applied the vdP method to study AMR in a series of Py films with thicknesses ranging between 10–250 nm. The films were grown by sputter deposition at an angle with respect to the substrate normal and with an in situ magnetic field, both conditions assisting in the definition of in-plane uniaxial anisotropy. The microstructure of Py films was characterized using x-ray reflectivity, diffraction and polar mapping of (1 1 1) planes. We detected no off-normal texture and negligible surface roughness, which indicates that self-shadowing can be of no significance in our growth. Yet the films have well defined uniaxial anisotropy. Abrupt changes in the average resistivity versus film thickness were observed, which cannot be explained by resistivity models accounting for the thickness and grain size but strongly correlate with the changes in (1 1 1) texture in the films. We compared our results with the literature and show that independent of growth method, substrate, and deposition temperature, the AMR value presents a saturation behavior with thickness at about 100 nm [7]. [1] Movaffaq Kateb, Jon Tomas Gudmundsson, and Snorri Ingvarsson, *AIP Advances, 9,* 035308 (2019) [2] D. M. C. Nicholson, W. H. Butler, W. A. Shelton, Yang Wang, X.-G. Zhang, G. M. Stocks, and J. M. MacLaren, *J. Appl. Phys., 81,* 4023 (1997) [3] S. Ingvarsson, L. Ritchie, X. Y. Liu, Gang Xiao, J. C. Slonczewski, P. L. Trouilloud, and R. H. Koch, *Phys. Rev. B, 66,* 214416 (2002) [4] S. Ingvarsson, Gang Xiao, S. S. P. Parkin, and R. H. Koch, *Appl. Phys. Lett., 85,* 4995 (2004) [5] W. L. V. Price, *Solid-State Electronics, 16*, 753 (1973) [6] S. Asmontas, J. Kleiza, and V. Kleiza, *Acta Physica Polonica A, 113*, 1559 (2008) [7] Movaffaq Kateb, Egill Jacobsen, and Snorri Ingvarsson, *J. Phys. D: Appl. Phys., 52,* 075002 (2019).

Bio: *Professor Snorri Ingvarsson obtained his Ph.D. degree from Brown University, Rhode Island, in 2001. He has worked on ferromagnetic materials and devices, in particular magnetic tunnel junction memory and sensors. He has been involved in low frequency noise measurements on tunnel junctions and characterization of magnetization damping in ferromagnetic thin films and heterostructures. He has also worked on infrared emission from Joule heated nano-and micro-wires. He has been with the University of Iceland since 2004.*

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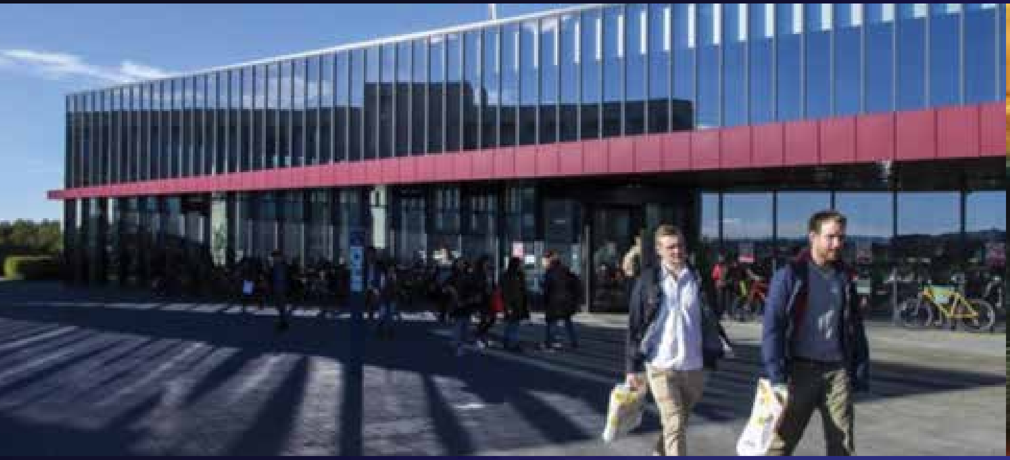

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