NORTHWESTERN UNIVERSITY/ TEL AVIV UNIVERSITY WORKSHOP

Recent Advances in Materials Science and Engineering

Northwestern University
July 16-18, 2018

mccormick.northwestern.edu/nu-tau-workshop
mccormick.northwestern.edu/materials-science/
en-materials.tau.ac.il/

Northwestern | McCORMICK SCHOOL OF ENGINEERING

אוניברסיטת תל-אביב
TEL AVIV UNIVERSITY

WELCOME

July 16, 2018

Dear Friends and Colleagues,

We are delighted to welcome you to the third Northwestern University–Tel Aviv University Workshop, 16th to 18th July 2018. This year the workshop is being held on the Evanston campus of Northwestern University, on the broad theme of *Recent Advances in Materials Science and Engineering*.

Our first joint workshop was held at Tel Aviv University, 22nd to 25th February 2015, on the themes *Semiconductors, Electronic Materials, Thin Films and Photonic Materials*. Our second joint workshop was held at Northwestern University, 20th to 22nd September 2016, on the themes *Energy, Sustainability and Biomaterials*, and a sub-theme on *Water and Materials*.

In a joint white paper dated July 19, 2013, the departments of materials science and engineering at Northwestern University and Tel Aviv University proposed to collaborate on multiple levels. Their mutual interests are built on successful on-going research collaborations between professors and their research groups at both institutions. Dedicated funding is, however, necessary to develop this international relationship to its absolute fullest. The first component of this collaboration is the organization of joint research workshops on focused themes, alternating between Tel Aviv and Northwestern Universities. We are indebted to Dean Julio Ottino for nucleating these workshops through much encouragement and wherewithal.

For each workshop, we are trying to bring new speakers to potentially broaden and foster long-term collaborations among our respective faculty members. We are extremely happy to see how the previous two workshops have resulted in new funded projects, including two US-Israel Binational Science Foundation grants, as well as joint publications. Additionally, a new NU-TAU program for postdoctoral fellowships was established, and two postdoctoral students from TAU will be arriving at NU to work with professors in the departments of mechanical and industrial engineering at Northwestern University. In the department of materials science and engineering, there are currently two postdoctoral students from TAU hard at work. Recently, Tel Aviv University managed to obtain a private donation to support a collaboration between Tel Aviv University and Northwestern University in the field of nanotechnology.

We are deeply appreciative of the following units at Northwestern University for their generous support of this joint workshop: McCormick School of Engineering and Applied Science; Global McCormick; Office of the Provost; Office for Research; Office of the Vice-President for International Relations; Department of Materials Science and Engineering; Department of Electrical Engineering and Computer Science; Department of Chemistry; Materials Research Science and Engineering Center; and Crown Family Center for Jewish and Israel Studies. We are also thankful for the support of the Iby and Aladar Fleischman Faculty of Engineering and the department of materials science and engineering at Tel Aviv University.

This workshop will end on Wednesday afternoon with a visit to the Advanced Photon Source at Argonne National Laboratory. We wish you a very productive, stimulating, enjoyable and sociable workshop.

Yours respectfully,

Professors David Seidman (NU) and Noam Eliaz (TAU), Co-Chairs

COMMITTEES

Workshop Chairs

David N. Seidman, Walter P. Murphy Professor of Materials Science and Engineering, Northwestern University
Noam Eliaz, Professor, Department of Materials Science and Engineering, Tel Aviv University

Organizing Committee

David N. Seidman, Walter P. Murphy Professor of Materials Science and Engineering, Northwestern University
Noam Eliaz, Professor, Department of Materials Science and Engineering, Tel Aviv University
Julio M. Ottino, Dean, Robert R. McCormick School of Engineering and Applied Science, Northwestern University
Yossi Rosenwaks, Professor and Dean, Faculty of Engineering, Tel Aviv University

Scientific Committee

David N. Seidman, Walter P. Murphy Professor of Materials Science and Engineering, Northwestern University
Noam Eliaz, Professor, Department of Materials Science and Engineering, Tel Aviv University

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Northwestern University

Office of the President

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July 2018

Dear Attendees,

Thank you for your participation in the third Northwestern University and Tel Aviv University (TAU) collaborative workshop. We are honored to welcome faculty from TAU as they work together with Northwestern faculty to research topics encompassing themes of electronic materials, energy, sustainability, and advanced characterization techniques.

Your being here reflects the success of the 2015 and 2016 workshops, at which we began to foster long-term scientific and engineering relationships between our two institutions. We are pleased to continue this initiative and look forward to advancing this collaboration toward solutions and discoveries in these fields.

All the best,

Morton Schapiro
President and Professor

Northwestern

Northwestern University
Office of the Provost
633 Clark Street
Evanston, Illinois 60208

July 2018

Professor David N. Seidman
Department of Materials Science and Engineering
Northwestern University

Professor Noam Eliaz
Department of Materials Science and Engineering
Tel Aviv University

Dear Colleagues:

I write to welcome you and all of your attendees back to Northwestern University's Evanston campus for the third Northwestern University/Tel Aviv University (TAU) workshop, focusing on recent advances in materials science in engineering. As home to the first academic department in the United States to focus on materials science, Northwestern University is very aware of the importance of this field in building solutions to address the many changing needs of our global society. Like us, Tel Aviv University is committed to groundbreaking teaching, learning, and research in one of the world's most cosmopolitan cities. It is inspiring to see this collaboration between two great universities continue to flourish and to foster more innovative research that will address the many energy, sustainability, and information technology challenges of the 21^{st} century.

I am pleased to be able to support this important work, and I look forward to learning more about the workshop.

Sincerely,

Jonathan Holloway
Provost

Northwestern | RESEARCH

Jay Walsh, PhD
Vice President for Research

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July 16, 2018

Dear Participants,

Welcome to the 2018 Northwestern–Tel Aviv University Workshop. Once again, we are proud to host this valuable initiative, one that builds on a foundation established three years ago to encourage greater scientific collaboration among our respective faculty members.

Since February 2015, these Workshops have provided an opportunity for our institutions to come together to advance discovery and to share knowledge. I congratulate the Workshop organizers — and each of you — for making important, tangible efforts to extend our understanding and to create a forum for rich discussion and the exchange of new research insights.

We are pleased to continue this partnership rooted in research excellence and a commitment to global scientific collaboration. I look forward to seeing how the ideas generated during the Workshop will exert a beneficial impact on your disciplines and on society.

While on our campus, I also invite you to make time to visit our University's research facilities to gain a firsthand experience of Northwestern's research ecosystem.

I wish you an exciting and rewarding Workshop — one that leads to additional successful research engagement between Tel Aviv University and Northwestern!

Jay Walsh
Vice President for Research
Northwestern University

Northwestern | ENGINEERING

Office of the Dean

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Robert R. McCormick School of
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Office 847. 491. 5220
www.mccormick.northwestern.edu

June 15, 2016

Dear Attendees:

It is my great pleasure to welcome you to Northwestern University's Robert R. McCormick School of Engineering and Applied Science for the fourth Northwestern-Tel Aviv University joint workshop.

It has been a pleasure to see the collaborations between our institutions continue to grow. I hope that this workshop will serve as another catalyst for partnership as we explore new research collaborations at the frontiers of science and engineering.

Events of this magnitude do not happen without significant planning. I want to give a special thanks to Professors David Seidman and Noam Eliaz, as well as numerous other faculty and staff, for leading the efforts to host this workshop.

I hope that you enjoy your time in Evanston and wish you a productive and invigorating workshop.

Best regards,

Julio M. Ottino
Dean
Robert R. McCormick Institute Professor
Walter P. Murphy Professor of Chemical and Biological Engineering

Fruma Yehiely, PhD
Associate Vice President for Research

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Northwestern | RESEARCH

June 12, 2018

Dear Attendees,

It is my great pleasure to welcome you to the Northwestern University–Tel Aviv University Workshop, at Northwestern University.

This is the third workshop of an international series that initiated from the mutual science and engineering interests and expertise, between the two institutions. The long-term goal of the workshops is to translate this strong intellectual foundation to sustainable collaborations, team science excellence, and development of new and innovative research avenues.

The inaugural Northwestern University–Tel Aviv University Workshop was held in February 2015 at Tel Aviv University and focused on semiconductors, electronic materials, thin films and photonic materials. Fifteen investigators from each intuition attended the workshop that led to fruitful scientific relationships. Building on that success, the scientific scope in September 2016 expanded to energy, sustainability and biomaterials, and included a special theme of materials for water applications. An important outcome of these workshops has been the formation of strong research relationships among faculty at the two universities. This year we bring together innovative scholars from both Universities to discuss Recent Advances in Materials Science and Engineering.

As an alumna of Tel Aviv University, the close cooperation between the two Universities is of special and personal value to me. I support it wholeheartedly and will continue to contribute to the joint efforts to see it flourish.

I wish you stimulating and productive scientific sessions as well as enjoyable social events.

All the best,

Fruma Yehiely

Fruma Yehiely, Ph.D.
Associate Vice President for Research

Northwestern | MRC

Mark C. Hersam
Center Director

Materials Research Center
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Phone 847-491-3606
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http://materials.northwestern.edu

May 17, 2018

Dear Attendees,

It is my pleasure to welcome you to the Third Northwestern University-Tel Aviv University Workshop.

The scientific scope of the workshop is well-aligned with the mission of the Northwestern University Materials Research Center (MRC) to advance cross-disciplinary materials science and engineering research, collaboration, and commercial innovation. First established in 1959, the MRC has received continual external funding for the past 6 decades, making it a signature unit on campus that administers a diverse portfolio of high-impact infrastructure and programs in materials research and education.

I invite you to learn more about the MRC and its multi-faceted research activities and facilities during your visit to Northwestern. I wish you a productive and intellectually stimulating workshop.

Best regards,

Mark C. Hersam
Director, Northwestern University Materials Research Center
Walter P. Murphy Professor of Materials Science and Engineering
Professor of Chemistry, Medicine, and Electrical Engineering (by courtesy)

Prof. Erik Luijten
Materials Science and Engineering
Northwestern University
2220 Campus Dr.
Evanston, Illinois 60208-3108
Office 847.491.7823
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Email: luijten@northwestern.edu

Dear David and Noam,

Congratulations on organizing the third NU-TAU workshop. Based upon my experiences at the previous workshop I am confident that you will make it an inspiring event, that reinforces the connections between our institutions and leads to new and renewed interactions between our faculty.

The Department of Materials Science and Engineering is pleased to again play a role in hosting this event, and I wish to express my hope that this is another part of a continuing series of exchanges between Tel Aviv University and Northwestern University.

I wish you and all participants a fruitful and productive workshop.

With kind regards,

Erik Luijten
Chair and Professor of Materials Science and Engineering
Professor of Engineering Sciences and Applied Mathematics
Professor of Physics and Astronomy (by courtesy)

Northwestern | McCORMICK SCHOOL OF ENGINEERING
Electrical Engineering and Computer Science

Electrical Engineering and Computer Science
Technological Institute
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Alan V. Sahakian, Ph.D.
Chair, Electrical Engineering and Computer Science
John A. Dever Professor
E-mail: sahakian@eecs.northwestern.edu
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July 2018

Dear Attendees,

It's my pleasure to welcome you to the third Northwestern University (NU) - Tel Aviv University (TAU) collaborative workshop. This is the second held on the NU campus, the first being in 2016.

The Electrical Engineering and Computer Science department of NU is especially eager to hear about the work being done at TAU and to find new collaborative partnerships with our visiting colleagues. These would add to those already underway in the areas of materials, devices, circuits and systems.

I hope that all the attendees have an opportunity to enjoy our campus and the cities of Evanston and Chicago. I look forward to meeting many of you during the workshop.

Sincerely,

Alan V. Sahakian
John A. Dever Professor and Chair of Electrical Engineering and Computer Science
Professor of Biomedical Engineering
McCormick School of Engineering and Applied Sciences

●●● Prof. Joseph Klafter, President

TEL AVIV UNIVERSITY אוניברסיטת תל אביב

●●● פרופ׳ יוסף קלפטר, נשיא

May 2018

Dear Participants,

I am delighted that the Northwestern University –Tel Aviv University Workshop has now entered its third year, providing yet again a vital channel for academic interaction across the spectrum of the sciences.

Tel Aviv University fully endorses the international cooperation that forms the basis of this Workshop, and which signifies common goals between universities driven by the same mission to enhance scientific and academic productivity at the highest institutional level.

We take pride in our growing relationship with Northwestern, which has already launched a variety of projects in science, public health, law, business management, post-doctoral exchanges, has resulted in the formation of strong research relationships among professors of the two engineering schools, and has been successful in bringing new funded projects and joint publications. At the same time, a framework has been established for partnerships with the dynamic Chicago-area academic and business communities and alumni of both universities, thereby serving the national interests of both our countries.

We look forward to new collaborative programs that will evolve from this workshop and to many more future workshops that are critical in ensuring continual flow of knowledge.

I wish you all a rewarding and enjoyable workshop.

Sincerely,

Professor Joseph Klafter
President

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TEL AVIV UNIVERSITY אוניברסיטת תל אביב

Dear Friends and Colleagues,

The third joint Northwestern University-Tel Aviv University workshop, "Recent Advances in Materials Science and Engineering", is a cause for celebration, as it represents the breadth and profoundness of the ties between our two institutions.

We recently hosted a conference at Tel Aviv of Vice Presidents from a dozen of American research universities, which obviously included Northwestern University. In the discussions conducted during this conference, it became clear to all attendees that the strategic partnership between Tel Aviv University and Northwestern University is more substantial than our research collaborations with the other American universities present on this occasion.

Due to the vision and commitment of the academic leadership on both sides of the Atlantic, the agreement we signed several years ago has offered opportunities for new initiatives in a wide variety of fields and projects, including joint research, study programs and student exchange across disciplines and departments. As I have stated on other occasions, the purple color of Northwestern University is seen all over our campus.

The joint workshop of our Iby and Aladar Fleischman Faculty of Engineering and your McCormick School of Engineering and Applied Science is by now almost a tradition to which we attach much importance. We are proud to be partners of Northwestern and this amazing School.

I would like to thank the organizers and participants in this workshop, especially Professors David Seidman and Noam Eliaz, as well as to the authorities of Northwestern University, and wish you all a productive meeting.

Sincerely,

Prof. Raanan Rein
Vice President

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TEL AVIV UNIVERSITY אוניברסיטת תל אביב

May 29, 2018

Dear participants, colleagues and friends,

It gives me a great pleasure to welcome you all to the third Northwestern University and Tel Aviv University Joint Workshop. This workshops series is an important step in enhancing the scientific collaboration between the two universities at all levels of research and teaching.

Both universities share the same global challenges, goals and responsibilities. Collaboration in the field of semiconductors, electronic materials, thin films and photonic materials will intensify the research in materials science and engineering and physical electronics.
Both universities have already made a major impact in all these areas. With a joint work we can take these to new heights.

I am looking forward to hearing the scientific news from the workshop and the future plans for continuation.

With best wishes,
Prof. Yaron Oz
Rector

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TEL AVIV UNIVERSITY אוניברסיטת תל אביב

סגן הנשיא למחקר ופיתוח VICE PRESIDENT FOR RESEARCH AND DEVELOPMENT

May 22, 2018

Northwestern University and Tel-Aviv University joint
Workshop on Recent Advances in Materials Science and Engineering

Prof. Noam Eliaz (Tel Aviv University),
Professor David Seidman (Northwestern University)

Dear attendees,

Tel Aviv University in general, and the science and engineering faculty members in particular, believe in international research as a tool of value enhancement. In modern science, exchange of ideas, knowhow and the mutual nurturing of interdisciplinary and cooperative research endeavors have become a major tool in advancing knowledge. Importantly, they also play a major role in building a basis for future developments that can improve the world that we live in for the good of science and humanity.

Northwestern University and Tel Aviv University have started to cooperate in the current workshops on engineering. This important collaboration was highly successful, as evidenced by its current expansion to additional fields. These interactions are a good example for the ability of universities to cooperate for the advancement of research and science. The mutual research workshops organized in the framework of this cooperation have already led to the development of new research directions by bringing together scientists from the two institutions. On the basis of the workshops conducted thus far, we strongly believe that this fruitful cooperation will continue to develop, and will give rise to new projects that will contribute to the general scientific knowledge for the benefit of mankind.

The current workshop is centered on recent advances in materials science and engineering. As such, we are confident that they will serve to identify potential collaborators on from both sides, and we anticipate that the personal interactions that will arise will provide the basis for fruitful collaboration.

I wish us all a most interesting and successful meeting.

Sincerely,

Y. Henis

Prof. Yoav Henis, Ph.D.
The Zalman Weinberg Chair in Cell Biology
Vice President for Research and Development
Tel Aviv University

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Prof. Yossi Rosenwaks
Dean

TEL AVIV UNIVERSITY
אוניברסיטת תל אביב

פרופ' יוסי רוזנווקס
דקאן

Iby and Aladar Fleischman
Faculty of Engineering
Tel Aviv University

הפקולטה להנדסה
ע"ש איבי ואלדר פליישמן
אוניברסיטת תל-אביב

Dear Friends and Colleagues,

I am honored to take part, for the third time, in this Northwestern-Tel-Aviv University workshop. This year I am even more excited because we have just launched a prestigious joint postdoctoral program between our universities. We have two outstanding awardees: Reut Noham, from industrial engineering, will join the research group of Prof. Karen Smilowitz, and Lior Medina, from mechanical engineering, who will join the group of Prof. Horacio Espinoza.

I am sure that David and Noam have organized a very high-level program, which will expose top scientists and engineers from both universities to state-of-the-art research in different areas, and I'm again grateful to them for arranging this event. There are already several ongoing collaborations between the two faculties, and even some that were initiated following the last meeting at Northwestern, September 2016. We expect that the coming workshop will lead to additional collaborations between the two institutes and I am looking forward to meeting all of you in Evanston in July 2018.

Sincerely,

Prof. Yossi Rosenwaks
Dean, Faculty of Engineering

TEL AVIV UNIVERSITY אוניברסיטת תל אביב

31 May 2018

Dear Friends and Colleagues,

The third bi-annual Northwestern University – Tel Aviv University workshop on Recent Advances on Materials Science and Engineering is fast approaching. The inaugural event was hosted by Tel Aviv University in 2014, then by Northwestern University in 2016, and the third one will take place once again at Northwestern University this July (2018).

This workshop is one of the most useful manifestations of the collaboration agreement between the two universities signed a few years ago, and a great example of its successful implementation on the ground. Close academic ties between Northwestern's McCormick School of Engineering and Applied Science and Tel Aviv's Iby and Aladar Fleischman Faculty of Engineering, formed between the researchers in course of those workshops, have already started bearing fruit, be it joint bi-nationally funded research initiatives or postgraduate student exchange.

Owing to dedication and all the hard work invested by the initiators, Professors David Seidman (NU) and Noam Eliaz (TAU), into organization of the joint NU-TAU workshops, these workshops have every chance of becoming a fine, and hopefully long standing, tradition. This is also a good opportunity to acknowledge the contribution of Northwestern University authorities and their kind willingness to host this event for the second time in a row.

Finally, I would like to wish all the participants a very successful, fruitful, and enjoyable meeting.

With kind regards,

Prof. Ilan Goldfarb

Head of Materials Science and Engineering

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PROGRAM

Agenda and General Information

PROGRAM

Monday, July 16, 2018

Guild Lounge Scott Hall, Northwestern University, 601 University Place, Evanston, IL 60208
northwestern.edu/norris/events/satellite-venues/guild-lounge/index.html

8:30 - 9:00 am	**OPENING SESSION** **David N. Seidman, Ph.D.** (Co-Chair of workshop, NU) **Lindsay Chase-Lansdale, Ph.D.** (Vice Provost for Academics and Associate Provost for Faculty, NU) **Julio M. Ottino, Ph.D.** (Dean, Robert R. McCormick School of Engineering and Applied Science, NU) **Yossi Rosenwaks, Ph.D.** (Dean, The Iby and Aladar Fleischman Faculty of Engineering, TAU) **Tamar Seideman, Ph.D.** (Professor, Department of Chemistry, NU) **Noam Eliaz, Ph.D.** (Co-Chair of workshop, TAU)
	SESSION CHAIR: David N. Seidman, Ph.D. (MSE, Director, NUCAPT, NU)
9:00 - 9:45 am	**Mark A. Ratner, Ph.D.** (Chemistry & MSE, NU) Moving Electrons: Buttiker Probe, Silicene, and Excited-state Spectroscopy
9:45 - 10:15 am	**Yossi Rosenwaks, Ph.D.** (Dean of Engineering, EE and MS&E, TAU) Selective Molecular Sensing Using CMOS Compatible Nanowire Transistor
10:15 - 10:45 am	**Selim M. Shahriar, Ph.D.** (EECS, NU) Schroedinger Cat Atomic Interferometry at Decillion Hz Compton Frequency: Ultraprecise Gyroscopes, Accelerometers and Clocks
10:45 - 11:00 am	**COFFEE BREAK**
	SESSION CHAIR: Noam Eliaz, Ph.D. (MS&E, TAU)
11:00 - 11:30 am	**Erik Luijten, Ph.D.** (Chair, MSE, NU) Predictive Modeling of Dielectric Effects in Materials
11:30 - 12:00 pm	**Dvir Gur, Ph.D.** (NICHD, NIH, Bethesda, MD & Janelia Research Campus, VA, TAU) Light-Induced Tunable Structural Colors in Fish and Copepods
12:00 - 12:30 pm	**Derk Joester, Ph.D.** (MSE, NU) Nucleation and Growth of Crystalline Carbonates from Amorphous Precursors
12:30 - 1:00 pm	**Shachar Richter, Ph.D.** (MS&E, TAU) From (Bio) Organic Materials to Electronic and Photonic Devices

1:00 - 2:00 pm	**LUNCH BREAK**
2:00 - 2:10 pm	**Jay Walsh, Ph.D.** (Vice President for Research, NU) Welcome Address
	SESSION CHAIR: Jacob (Koby) Scheuer, Ph.D. (EE, TAU)
2:10 - 2:40 pm	**Semën Gorfman, Ph.D.** (MS&E, TAU) Using Time-Resolved X-Ray Diffraction to Reveal The Mechanisms of Piezoelectricity in Ferroelectrics
2:40 - 3:10 pm	**Mercouri G. Kanatzidis, Ph.D.** (Chemistry, NU) Amazing 3D and 2D Halide Perovskites: All the Things They Do
3:10 - 3:40 pm	**Jacob (Koby) Scheuer, Ph.D.** (EE, TAU) Towards Metal-Halide Based Perovskite Integrated Photonics
3:40 - 4:10 pm	**James M. Rondinelli, Ph.D.** (MSE, NU) Polar Oxide Thin Films From Vacancy and Chemical Order
4:10 - 4:25 pm	**COFFEE BREAK**
	SESSION CHAIR: Ilan Goldfarb , Ph.D. (Chair, MS&E, TAU)
4:25 - 4:55 pm	**Oswaldo Diéguez, Ph.D.** (MS&E, TAU) Polymorphism in Bi-Based Perovskite Oxides: A First-Principles Study
4:55 - 5:25 pm	**Christopher Wolverton, Ph.D.** (MSE, NU) Using Machine-Learning to Create Predictive Material Property Models and Accelerate Combinatorial Searches
5:25 - 6:15 pm	**BREAK**
6:15 pm	**Shuttle departs the Hilton Orrington Hotel for Banquet** Hilton Orrington Hotel: 1710 Orrington Avenue, Evanston, IL 60201 (hotelorrington.com) Banquet at Shallots Bistro: 7016 Carpenter Rd., Skokie, IL 60077 (shallotsbistro.com) After dinner, the shuttle will return to the Hilton Orrington Hotel.

PROGRAM

Tuesday, July 17, 2018

Guild Lounge Scott Hall, Northwestern University, 601 University Place, Evanston, IL 60208
northwestern.edu/norris/events/satellite-venues/guild-lounge/index.html

8:30 - 8:40 am	**OPENING SESSION** **Matthew Grayson, Ph.D.** (EECS & Director, McCormick Global Initiatives, NU)
	SESSION CHAIR: Noa Lachman, Ph.D. (MS&E, TAU)
8:40 - 9:10 am	**David C. Dunand, Ph.D.** (MSE, NU) Metallic Scaffolds by Reduction of 3D-Printed Oxide Inks
9:10 - 9:40 am	**Noam Eliaz, Ph.D.** (MS&E, TAU) Directed Energy Deposition (DED) and the New Tel Aviv University 3-D Printing Research and Development Center
9:40 - 10:10 am	**Kenneth R. Shull, Ph.D.** (MSE, NU) Polyelectrolyte Complex Membranes for Water Purification
10:10 - 10:40 am	**Laurence D. Marks, Ph.D.** (MSE, NU) Understanding Corrosion in 4D at the Nanoscale
10:40 - 10:55 am	**COFFEE BREAK**
	SESSION CHAIR: Shachar Richter, Ph.D. (MS&E, TAU)
10:55 - 11:25 am	**Amit Kohn, Ph.D.** (MS&E, TAU) Mean-Inner and Space Charge Potentials in Oxides
11:25 - 11:55 pm	**Vinayak P. Dravid, Ph.D.** (MSE and Director of NUANCE Center, NU) Static and Dynamics Electron Microscopy of Nanostructured Materials
11:55 - 12:25 pm	**Noa Lachman, Ph.D.** (MS&E, TAU) Multi-Functional Composites: A Study in Silicone
12:25 - 1:40 pm	**LUNCH BREAK** **Research Discussion at The James L. Allen Center** 2169 Campus Drive

	SESSION CHAIR: Amit Kohn, Ph.D. (MS&E, TAU)
1:40 - 2:10 pm	**Scott A. Barnett, Ph.D.** (MSE, NU) High-Efficiency Electrical Energy Storage Using Reversible Solid Oxide Cells
2:10 - 2:40 pm	**Sossina M. Haile, Ph.D.** (MSE, NU) Insights into Oxygen Electrochemical Reaction Mechanisms on $(La,Sr)MnO_3$
2:40 - 3:10 pm	**Yip-Wah Chung, Ph.D.** (MSE, NU) Design and Development of High-Temperature 9% Cr Steels for Power Plant Applications
3:10 - 3:30 pm	**COFFEE BREAK**
	SESSION CHAIR: Bruce Wessels, Ph.D. (MSE, NU)
3:30 - 4:00 pm	**Ilan Goldfarb, Ph.D.** (MS&E, TAU) Nanomagnetic Size Effects in Non-Magnetic Materials
4:00 - 4:30 pm	**Alan V. Sahakian, Ph.D.** (Chair, EECS, NU) Spintronic and Magneto-Resistive Logic for Beyond-Cmos Computing
4:30 - 5:00 pm	**G. Jeffrey Snyder, Ph.D.** (MSE, NU) Understanding and Engineering Electrical Interfaces and Grain Boundaries in Oxides and Thermoelectric Materials
5:00 - 6:15 pm	**BREAK**
6:15 pm	**Dinner at Cohen Commons Faculty and Staff Dining Room** Room L482, 2145 Sheridan Road (4th floor in northwest corner of the Technological Institute Building)

PROGRAM

Wednesday, July 18, 2018

Guild Lounge Scott Hall, Northwestern University, 601 University Place, Evanston, IL 60208
northwestern.edu/norris/events/satellite-venues/guild-lounge/index.html

	SESSION CHAIR: Mark Hersam, Ph.D. (MSE, Director, NUMRC, NU)
9:00 - 9:30 am	**Koray Aydin, Ph.D.** (EECS, NU) Nanophotonics in the flatland: Engineering Novel Photonic Platforms from 2D Materials to Metadevices and Metamaterials
9:30 - 10:00 am	**David N. Seidman, Ph.D.** (MSE, Director, NUCAPT, NU) A Tale of Two Silicon Nanowires: Correlative Studies
10:00 - 10:30 am	**Ariel Ismach, Ph.D.** (MS&E, TAU) Synthesis and Characterization of 2D Materials and Heterostructures
10:30 - 11:00 am	**Mark C. Hersam, Ph.D.** (MSE, Director, NUMRC, NU) Interfacial Engineering of Two-Dimensional Nanoelectronic Heterostructures
11:00 - 11:30 am	**Hooman Mohseni, Ph.D.** (EECS, NU) Energy Efficient Optoelectronics for Science, Medical, and Consumer Applications
11:30 am - 1:00 pm	**COFFEE BREAK AND CONCLUDING REMARKS**
1:15 pm	**DEPARTURE TO THE ADVANCED PHOTON SOURCE (APS) AT ARGONNE NATIONAL LABORATORY (ANL)** A box lunch will be provided. The bus trip from NU to ANL is approximately one hour. TAU participants who need to catch flights back to Israel that evening (e.g. at 9:30 pm) are required to check out of the hotel before departure and store their luggage on the bus. On the way back to Evanston, the driver will drop you off at the Chicago O'Hare Airport (ORD).

GENERAL INFORMATION

Venue

Northwestern University, Evanston, IL USA

All workshop presentations will take place in Guild Lounge (Scott Hall, Northwestern University, 601 University Place, Evanston, IL 60208). For more information, please visit northwestern.edu/norris/events/satellite-venues/guild-lounge

Hotel

The Hotel Orrington is a seven-minute walk to the Guild Lounge. Rooms are non-smoking and come with wireless high-speed internet. Breakfast is not included. Continental breakfast will be provided at the Guild Lounge. For additional hotel information, please visit: hotelorrington.com

Abstracts

The conference program and abstracts are available on the NU-TAU Workshop website: mccormick.northwestern.edu/nu-tau-workshop

Meals

The **Monday** banquet will take place at **Shallots Bistro** (7016 Carpenter Rd., Skokie, IL 60077, shallotsbistro.com). A shuttle service will take attendees to and from the restaurant. Shuttle pickup for dinner from the Hilton Orrington Hotel will take place at 6:15 p.m.

The **Tuesday** banquet will be held at 6:15 p.m. in the **Cohen Commons Faculty and Staff Dining Room** located in room L482 on the 4th floor of the Technological Institute, 2145 Sheridan Rd. No shuttle service will be provided from the hotel.

On **Wednesday**, the APS tour participants will receive a box lunch to eat on the shuttle bus to Argonne National Laboratories (ANL).

Events

Conference attendees are invited to participate in a tour of the **Advanced Proton Source (APS) at Argonne National Laboratory (ANL)** on Wednesday, July 18. A shuttle bus will pick up tour participants from the Guild Lounge at approximately 1:15 p.m. The bus trip will take approximately 1 hour. A box lunch will be provided. Please note, the shuttle bus will stop at O'Hare airport on its way back to Northwestern University to accommodate TAU visitors who have an evening flight.

Other Information

- Complimentary wireless high-speed internet is available throughout the Northwestern University campus. Choose "Guest-Northwestern" in the list of networks presented. During registration, accept the University's acceptable use policy and provide your contact information and the name of the organization ("McCormick") sponsoring your University visit.
- Please wear your name badge at all workshop events.

WORKSHOP PRESENTERS

Biographies and Abstracts

Koray Aydin

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email: aydin@northwestern.edu, web: eecs.northwestern.edu/~aydin

Koray Aydin is an Assistant Professor in the Electrical Engineering and Computer Science Department at Northwestern University and leads the Metamaterials and Nanophotonic Devices Laboratory. He has received his B.S. and Ph.D. degrees in Physics from the Bilkent University in 2002 and 2008, respectively. He worked as a postdoctoral researcher between 2008-2010 and a research scientist between 2010-2011 at the California Institute of Technology under the supervision of Prof. Harry Atwater. His research interests are in the general area of nanophotonics, with a specific focus towards the realization of nanophotonic devices for use in energy conversion, optoelectronic device and sensing applications. Dr. Aydin received the prestigious 2017 ONR Young Investigator Program Award. He is an Associate Member of the Turkish Academy of Sciences and also the recipient of the SPIE Educational Scholarship in 2007.

Nanophotonics in the Flatland: Engineering Novel Photonic Platforms from 2D Materials to Metadevices and Metamaterials

Nanophotonic materials and devices facilitate strong light-matter interactions at subwavelength scales, thus providing unique opportunities to control and manipulate photons. In this talk, I will present novel approaches in controlling light-matter interactions at the nanoscale. I will discuss visible frequency metasurfaces broadband phase control and anomalous reflection, spectrum splitting using metallic metasurfaces enabled by phase engineering at the subwavelength scale. I will also present two different approaches for obtaining narrow-band resonant absorption filters at visible wavelengths. First structure is based on the surface lattice resonances in periodic nanowire and nanoring arrays fabricated on a reflecting metallic substrate. Enhanced photoluminescence enhancement from a single monolayer MoS_2 via plasmonic nanostructures will also be discussed. 2D layered materials received great attention due to their unique optical, electrical and mechanical properties however, due to their thickness light-matter interactions is rather weak. We utilize plasmonic nanostructures to strongly enhance electric fields locally at subwavelength scales therefore facilitating increased light emission and absorption in 2D semiconducting materials. Finally, I will present inverse-designed broadband electromagnetic metadevices that can bend and focus light using thin polymeric structured metamaterials at millimeter-wave and optical frequencies.

Scott Barnett

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Scott Barnett is a professor in the Department of Materials Science and Engineering at Northwestern University. His research utilizes physical vapor and colloidal deposition methods for producing ceramic materials with energy applications, including Li-ion battery electrodes and solid oxide fuel cells. Focus areas include three-dimensional tomography of electrode microstructure for understanding electrochemical processes and degradation phenomena, SOFC operation with hydrocarbon fuels, reversible solid oxide cells for energy storage, and development of new fuel cell anode and cathode materials.

High-Efficiency Electrical Energy Storage Using Reversible Solid Oxide Cells

Electrical energy storage is a key technology needed for enabling increased utilization of renewable wind and solar energy resources. While many technologies are being considered, the grid "load shifting" application—storing excess electricity for several hours until there is demand—remains challenging. This presentation will discuss the use of reversible solid oxide fuel cells for grid-scale energy storage. Fuel cells can provide large energy storage capacities by using large storage tanks/caverns for product gases, but until recently have not been strongly considered because of low round-trip efficiency. A new method for improving efficiency will be described, utilizing a new storage chemistry where the fuel cycles between H_2O-CO_2-rich and CH_4-rich gases, allowing much-improved round-trip efficiency > 70%. For this application, however, improved solid oxide cells are needed that can provide useful current densities at relatively low overpotentials and ~600°C. A candidate being developed in the Barnett group, utilizing doped lanthanum gallate electrolytes, will be described. Results on the stability of solid oxide cells under thousands of current-switching cycles, a key question that has not previously been explored, will be presented.

Yip-Wah Chung

Department of Materials Science and Engineering, Northwestern University
email: ywchung@northwestern.edu, web: mccormick.northwestern.edu/research-faculty/directory/profiles/chung-wah-yip.html

Yip-Wah Chung is currently Professor of Materials Science and Engineering and Mechanical Engineering as well as co-Director of the Institute for Sustainability and Energy at Northwestern. He joined the University in 1977, serving as Director of the Center for Engineering Tribology at Northwestern from 1987 to 1992, Department Chair from 1992 to 1998, and program officer in surface engineering and materials design at the U.S. National Science Foundation from 2003 to 2005. He has published over 200 papers in surface science, thin films, tribology, and alloy design, two textbooks (*Practical Guide to Surface Science and Spectroscopy, Introduction to Materials Science and Engineering*), one monograph (*Micro- and Nanoscale Phenomena in Tribology*) and was the co-editor of a six-volume *Encyclopedia of Tribology*. Current research studies include thin films and coatings, tribology, high-performance steels, and advanced lubricants for improved vehicle efficiency. He was named Fellow, ASM International; Fellow, AVS; and Fellow, Society of Tribologists and Lubrication Engineers. He also holds several pilot and instructor certificates, including commercial multi-engine and remote pilot certificates.

Design and Development of High-Temperature 9% Cr Steels for Power Plant Applications

Structural steels soften when heated above several hundred °C due to the transition from athermal dislocation glide to thermally activated glide and diffusion processes accelerating changes of the microstructure critical to strength. We utilize a combination of several strategies for the design of high-temperature 9% Cr steels: reduced carbon concentration to suppress $Cr_{23}C_6$, precipitating semi-coherent mono-carbonitride precipitates (MX, M=slow-diffusing early transition metal, X=carbon or nitrogen), minimizing the driving force and nucleation of Laves and Z-phases, for enhanced microstructural stability, and addition of Mo/W for solid solution strengthening. Our intended application is for steam generators in power plants. We will present and discuss results from computational and experimental studies, including TEM, high-temperature Vickers hardness and creep measurements as a function of exposure to 700°C.

Yao Du, Dieter Isheim, Semyon Vaynman, Yip-Wah Chung

Oswaldo Diéguez

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Oswaldo Dieguez received his PhD from University of Santiago de Compostela, Spain. After postdoctoral stays at Cambridge, Rutgers, and MIT he joined the Institute of Materials Science of Barcelona as a staff researcher. He moved to the Department of Materials Science and Engineering of Tel Aviv University in 2013, where he is a senior lecturer (assistant professor). His research involves studying the properties of materials by modelling the behavior of their electrons and nuclei with the help of computers, mainly using density-functional theory. Most of his recent work is in the field of ferroelectrics and multiferroics, both in the development of new methodology and in its application to these materials of technological interest.

Polymorphism in Bi-based Perovskite Oxides: a First-Principles Study

Under normal conditions, bulk crystals of $BiScO_3$, $BiCrO_3$, $BiMnO_3$, $BiFeO_3$, and $BiCoO_3$ present three very different variations of the perovskite structure: an antipolar phase, a rhombohedral phase with a large polarization along the space diagonal of the pseudocubic unit cell, and a supertetragonal phase with even larger polarization. With the aim of understanding the causes for this variety, we have used a genetic algorithm to search for minima in the surface energy of these materials. Our results show that the number of these minima is very large when compared to that of typical ferroelectric perovskites like BaTiO3 and PbTiO3, and that a fine energy balance between them results in the large structural differences seen. As byproducts of our search we have identified charge-ordering structures with low energy in BiMnO3, and several phases with energies that are similar to that of the ground state of BiCrO3. We have also found that a inverse supertetragonal phase exists in bulk, likely to be favored in films epitaxially grown at large values of tensile misfit strain.

Vinayak P. Dravid

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Vinayak P. Dravid is the Abraham Harris Chaired Professor of Materials Science & Engineering, in the McCormick School of Engineering at NU. He is the founding director of the characterization facility, the NU*ANCE* Center, and SHyNE Resource, an NSF-NNCI Center that provides high-tech facilities and expertise. Vinayak received B. Tech. in Metallurgical Engg in 1984 from IIT Bombay, India. He joined Northwestern faculty in 1990 after his Ph.D. in MSE from Lehigh. Vinayak's scholarly interests are at the intersection of materials and microscopy, spanning electronics, energy, environment and biomedicine. His diverse research portfolio encompasses advanced microscopy, nanotechnology, technology strategy, energy policy and emerging educational paradigms. His Google analyticsare: >475 publications, >28,000 citations, H-index >83; dozens of issued/pending patents, and some are licensed to companies related to nanotechnology, sensor and diagnostic systems. His awards include society fellowships (APS, AAAS, MSA, MRS, ACerS). As the founding director of Global McCormick Initiatives, he has helped to launch many global initiatives. Vinayak is an avid follower of chess and follows online tournaments and super GM interactions. One of his passions is to enhance the societal and global appreciation for science and technology, through the beauty, complexity and elegance of microscopy & materials science.

Static and Dynamics Electron Microscopy of Nanostructured Materials

Electron microscopy has always played an important role in materials design and establishing the classical processing-structure-property relation paradigm in materials science and engineering. The past couple decades have witnessed the rapid emergence of nanostructured materials and systems as well as designer materials tailored down to molecular and atomic scale. The characterization and analysis of such designer materials require not only higher "figures of merit" such as spatial resolution and analytical sensitivity but these often need to be performed under dynamic or so-called *in-operando* conditions. These stimuli in modern electron microscopes are varied and encompass a gamut; localized heating, *in-situ* electrical bias and even fluidic-cell, to name a few. This emergence of both, aberration-corrected and *in-situ* S/TEM have greatly advanced our understanding of static and dynamic behavior of nanostructured materials.

The presentation will introduce recently established advanced S/TEMs at the NUANCE Center; JEOL AC S/TEM (ARM200) and in-situ S/TEM (ARM300). It will cover examples of use of advanced microscopy in energy materials (Li ion battery electrodes, thermoelectrics), atomically layered 2D structures (chalcogenides, thin films) and others. The presentation will stress the need for fundamental understanding of electron-specimen interactions, which form the basis for the useful techniques. It will also emphasize challenges in acquisition and analysis in the big data world.

David Dunand

Department of Materials Science and Engineering, Northwestern University
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Dunand holds a BS/MS from ETH (Zurich) and a Ph.D. from the Massachusetts Institute of Technology where he was on the faculty until 1997, when he joined Northwestern University (NU) where he is now the Professor of Materials Science and Engineering. In 2008, he was the founding co-director of the Initiative for Sustainability and Energy at Northwestern (ISEN) and he held this position until early 2015. Dunand holds over 12 patents and has published over 340 journal articles. His research focuses on processing, structure and mechanical properties of metallic alloys, composites and foams. Dunand is a fellow of ASM International and of TMS. He has received several awards, including the 2012 *Materials Science & Engineering A* journal prize, the 2009 *Distinguished Scientist/Engineering Award* (Structural Materials Division of TMS), and twice a departmental *Teacher of the Year Award* at Northwestern. Dunand is co-Founder and co-Chief Scientist, together with Prof. David Seidman, of NanoAl, LLC, a start-up company developing novel high-temperature alloys at the intersection of nano-, energy- and green tech.

Metallic Scaffolds by Reduction of 3D-Printed Oxide Inks

We present a novel approach to metal additive manufacturing in which inks consisting of metal-oxide particles, are 3D-printed via direct ink writing (DIW) into self-supporting, cellular structures which are transformed into metallic counterparts through debinding, thermochemical reduction and sintering in hydrogen. We show that a wide variety of cellular metals (e.g., Fe, Cu, Ni, Co, W) and alloys (e.g., Cu-Ni, Fe-Ni, Fe-Ni-Co) can be fabricated from inexpensive submicron metal oxide powders using simple equipment, thus reducing cost and energy foot-print of as compared to more traditional methods based on laser or e-beam additive manufacturing of micron metallic powders. We also investigate the kinetics of debinding, reduction and sintering using synchrotron x-ray diffraction and tomography to shed light on the partially-overlapping sintering, interdiffusion and densification processes.

Adam Jakus, Shannon Taylor, Christoph Kenel, Ramille Shah, David Dunand

Noam Eliaz

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Professor Noam Eliaz is the founder of the Department of Materials Science and Engineering at Tel Aviv University (TAU). He is currently the founding Director of TAU+, TAU 3D Printing Research & Development Center. He received his B.Sc. and Ph.D. (direct track) in Materials Engineering as well as M.B.A., all *cum laude* from Ben-Gurion University. He served for three years in the Department of Materials and Failure Analysis of the Israel Air Force. He has published about 400 research publications, including three edited books. He has garnered numerous awards, including the Fulbright and Rothschild postdoctoral scholarships (1999-2001), T.P. Hoar Award for the best paper published in *Corrosion Science* (2001), JSPS fellowship (Japan, 2005-7), NACE International's H. H. Uhlig Award (2010), Fellow Award (2012), and Technical Achievements Award (2014), and Northwestern University's Eshbach scholarship (2013). In 2015 he was elected to the Israel Young Academy. Noam is an 8th generation Israeli. In January 2017 he was appointed by Israel's Minister of Science, Technology, and Space as a member of the Governing Board of The German-Israeli Foundation for Scientific Research and Development (GIF). In March 2017 he was appointed by the President of The Israel Academy of Sciences and Humanities as a member of the follow-up committee of the "State of Science in Israel." Noam is married to Billie and the proud father of Ofri, Shahaf and Shalev.

Directed Energy Deposition (DED) and the New Tel Aviv University 3D Printing Research and Development Center

The AM market of metals is rapidly growing. There are several AM processes that are used to manufacture metal parts, the two most common ones are *powder bed fusion* (PBF) and *directed energy deposition* (DED). PBF allows printing more complex geometries with finer features and surface roughness compared to DED. In contrast, DED allows for a larger materials range; denser and stronger printed materials; printing of multimaterials (ceramics, composites, and functionally graded materials, FGMs) in the same machine; printing either full parts or local features, coatings, or repair; faster build speeds; larger build volumes; printing on non-horizontal surfaces; use of larger powders for DED with laser compared to PBF with laser; printing in zero-gravity environment (in the case of processes that utilize wire-feed, electron beam, and vacuum environment). Due to the low heat input, with small melt pool and high travel speeds, the deposits cool very fast (typically, 1,000-5,000 °C/s). This generates very fine grain structures that may be one order of magnitude smaller in size than comparable wrought products. Therefore, the mechanical properties and the quality of the deposits are typically better than castings and approach properties of wrought products. Thus, PBF and DED can be regarded as complementing technologies, rather than competing technologies. Tel Aviv University is currently founding a new 3D Printing Research and Development Center, which will operate the first DED machine in Israel, which is also the first hybrid system in Israel. Collaboration is welcome with academia, industry, and defense organizations. The Laser Engineered Net Shaping (LENS™) process of Optomec (Albuquerque, NM) will be the nucleus of the new Center. More specifically, the LENS™ 3D Hybrid 20 Controlled Atmosphere System, with full 5-axes CNC machining and printing capability, 2 kW fiber laser, a glove box with argon atmosphere and an integrated gas purification system that maintains oxygen and moisture levels to below 10 ppm, 4 powder feeders, thermal imager, and melt pool sensor, will be installed.

Ilan Goldfarb

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Ilan Goldfarb is a Full Professor and Head of the Department of Materials Science and Engineering at Tel Aviv University. After obtaining his doctorate in growth and transmission electron microscopy of thin multilayered films with Prof. Danny Shechtman at Technion's Department of Materials Engineering in 1994, he was granted a British Council Post-Doctoral Award and joined the Department of Materials at Oxford University (UK), where he spent five years as a Research Fellow specializing in surface science, epitaxial growth, and scanning tunneling microscopy. He joined Tel Aviv University in 1999, and spent his 2010-2011 sabbatical year at the Nanoelectronics Research Group at Hewlett-Packard Laboratories in Palo Alto (Ca, USA) exploring electronic structure and conduction mechanisms in amorphous materials. Until recently, he has headed the TAU Wolfson Applied Materials Research Centre, and served on the Editorial Board of Applied Physics A. Prof. Goldfarb's current research focuses on self-organization of magnetic epitaxial nanostructures by scanning tunneling microscopy, electron diffraction and photoemission methods, and on electronic structure of amorphous oxide films.

Nanomagnetic Size Effects in Non-Magnetic Materials

In this work, I shall survey our work on magnetic properties of epitaxial binary silicide nanostructures. While silicides possess a set of properties useful for VLSI technology, they are not normally associated with magnetism and magnetic applications. Binary transition-metal silicides usually lack ferromagnetic order in the bulk-size crystals. Silicides of rare-earth metals, are weak ferromagnets or antiferromagnets at RT. Yet both groups tend to exhibit increased magnetic ordering in low-dimensional nanostructures, in particular at low temperatures. The origin of this surprising phenomenon is speculated to originate at undercoordinated atoms at the nanostructure boundaries, which may have 2D (surfaces/interfaces), 1D (edges) and 0D (corners) character, with our results pointing mostly to the nanostructure perimeters. Uncompensated spins of the nanostructure edge atoms align into a superspin, such that geometric shape anisotropy of the nanostructures in the array affects the resulting magnetic anisotropy stronger than the magnetocrystalline term, stabilizing ferromagnetic order against thermal excitation. Thus, in principle, magnetic response of nanostructure arrays can be controlled by manipulating size and shape of the nanostructures, providing a plausible route towards design of Si-based bit patterned magnetic recording media and spin injectors.

Semën Gorfman

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Dr. Semën Gorfman is the senior lecturer at the MSE department. He joined Tel Aviv University in October 2017. He received his MSc in Physics from Chelyabinsk State University (Russia) and obtained Ph.D. in Solid State Physics from the University of Siegen (Germany). In 2008-2011 he worked as a postdoc in the University of Warwick (United Kingdom), in 2011-2016 / 2016-2017 was a lecturer in the Universities of Siegen / Freiburg (Germany). His research interest and expertise span fundamental and X-ray crystallography, physical properties of crystals, piezoelectrics and ferroelectrics, high-resolution X-ray diffraction and precise structure analysis, in-situ X-ray diffraction studies of crystalline materials under external perturbation, application of synchrotron radiation. The research of Dr Gorfman are frequently performed at such central synchrotron radiation facilities as ESRF, PETRA III and Diamond. As a part of his appointment in TAU, he aims to build a multi-purpose four-circle X-ray diffractometer for characterization of functional materials.

Using Time-Resolved X-Ray Diffraction to Reveal the Mechanisms of Piezoelectricity in Ferroelectrics

Ferroelectrics are the broad class of materials, which may sustain spontaneous electric polarization. The applications of ferroelectrics are numerous and go far beyond the ability of their spontaneous polarization to switch between a few equivalent states. Many ferroelectric materials are piezoelectric: they are used in sensors, actuators, frequency generators and microelectromechanical devices. The piezoelectric effect in ferroelectrics (as e.g. $PbZr_{1}-_{x}Ti_{x}O_{3}$) may exceed such in non-ferroelectrics (as e.g. in α-quartz SiO_2) by three orders of magnitude. The connection between piezoelectricity and ferroelectricity remains to be long-standing puzzle and the subject of debates and research for many groups worldwide.

The goal of our work is to implement advanced X-ray crystallographic tools for characterization of structural and microstructural mechanisms of polarization switching in ferroelectrics. We question which of these mechanisms enhance piezoelectricity. We use stroboscopic X-ray data-acquisition to collect diffraction intensity as a function of time and alternating electric field. We measure *in-situ* X-ray diffraction signal (as e.g. single crystal rocking curves, reciprocal space maps and powder diffraction profiles) simultaneously with the macroscopic hysteresis loops. The angular positions of Bragg peaks are used to calculate the field dependence of lattice parameters, the profile shapes; the exchange of intensities between Bragg peaks components are used to follow the change of the domain microstructure. We will discuss the origin of piezoelectricity in single crystals of $Sr_{0.5}Ba_{0.5}Nb_{2}O_{6}$ and/or $Na_{0.5}Bi_{0.5}TiO_{3}$ and / or $PbZr_{1}$-x$Ti_{x}O_{3}$ especially focusing at the separation of intrinsic (crystal structure related) and extrinsic (domain wall motion related) contributions to the piezoelectricity.

Dvir Gur

NICHD, NIH, and Janelia Research Campus
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Dvir Gur received his Ph.D. in Chemistry from the Weizmann Institute in 2016, under the supervision of Professors Lia Addadi and Steve Weiner, working on tunable structural colors. He then moved to the Dept. of Physics of Complex Systems and the Dept. Molecular Cell Biology as a Dean of Faculty and Clore Prize Postdoctoral Fellow, with Professors Dan Oron and Gil Levkowitz. Dvir is currently a Rothschild Fellow and Human Frontiers Science Program, Cross-Disciplinary Fellow at the NIH and Janelia Research Campus, with Professors Jennifer Lippincott-Schwartz and Philipp Keller. His current research focuses on bio-inspired crystal growth and engineering, biological reflectors used in natural optical devices and vision in animals.

Light Induced Tunable Structural Colors in Fish and Copepods

Some of the most striking and vivid colors in nature are produced from guanine-based structural colors. The unique optical properties of guanine crystals are utilized by many organisms including fish, spiders, lizards, and crustaceans. Some of these organisms have the amazing ability to change their color in response to external stimuli. The copepods are small planktonic shrimps that reflect brilliant and vivid colors. We have discovered that the males can change their colors. We have identified the color change mechanism, and showed that this change is entirely reversible. Fish are utilizing guanine-based reflectors in both their eyes and skin. Using synchrotron-based micro X-ray diffraction, together with cryo-electron microscopy and optical analyses, we have demonstrated that color change in fish is due to tilting of intercellular guanine crystals and that the complex optical response of the fish iris is facilitated by the development a high-order organization of multilayered guanine-based crystal reflectors and pigments.

Sossina M. Haile

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Sossina M. Haile is the Walter P. Murphy Professor of Materials Science and Engineering at Northwestern University, a position she assumed in 2015 after serving 18 years on the faculty at the California Institute of Technology. She earned her Ph.D. in Materials Science and Engineering from the Massachusetts Institute of Technology in 1992. Haile's research broadly encompasses solid state ionic materials and electrochemical devices, with particular focus on energy technologies. She has established a new class of fuel cells with record performance for clean and efficient electricity generation, and created new avenues for harnessing sunlight to meet rising energy demands. Amongst her many awards, in 2008 Haile received an American Competitiveness and Innovation (ACI) Fellowship from the U.S. National Science Foundation in recognition of "her timely and transformative research in the energy field and her dedication to inclusive mentoring, education and outreach," the 2012 International Prize in Ceramics of the World Academy of Ceramics, and the 2010 Chemical Pioneers Award of the Chemical Heritage Foundation. She is a fellow of the Materials Research Society, the African Academy of Sciences, and the Ethiopian Academy of Sciences, and serves on the editorial boards of *Materials Horizons* and *Annual Review of Materials Research*.

Insights into Oxygen Electrochemical Reaction Mechanisms on $(La,Sr)MnO_3$

Lanthanum strontium manganite is the canonical cathode for solid oxide fuel cells. It offers an attractive balance between electrochemical activity, chemical stability, and thermomechanical compatibility with the widely used electrolyte, yttria stabilized zirconia (YSZ). Despite its widespread implementation, questions regarding the reaction pathway for oxygen electroreduction on this material remain open. Here, a fundamental study of the reduction mechanism is carried using thin film methods. Libraries of $(La_{0.8}Sr_{0.2})_{0.95}MnO_3+\delta$ (LSM) thin film microelectrodes with systematically varied thickness or growth temperature were prepared by pulsed laser deposition, and a novel robotic instrument was used to characterize these libraries in automated fashion by impedance spectroscopy. All impedance trends are consistent with a reaction pathway involving oxygen reduction over the LSM surface followed by diffusion through the film and into the electrolyte substrate. The surface activity is found to be correlated with the number of exposed grain boundary sites, which decreases with either increasing film thickness (at constant growth temperature) or increasing film growth temperature (at constant thickness). These findings suggest that exposed grain boundaries in LSM films are more active than boundary-free terminations for the rate-limiting surface process, and that oxygen ion diffusion through polycrystalline LSM films is faster than several prior studies have concluded.

Mark C. Hersam

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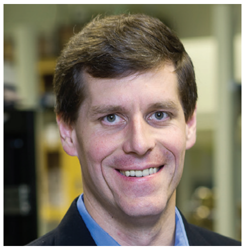

Mark C. Hersam is the Walter P. Murphy Professor of Materials Science and Engineering and Director of the Materials Research Center at Northwestern University. He also holds faculty appointments in the Departments of Chemistry, Applied Physics, Medicine, and Electrical Engineering and Computer Science. He earned a B.S. in Electrical Engineering from the University of Illinois at Urbana-Champaign (UIUC) in 1996, M.Phil. in Physics from the University of Cambridge (UK) in 1997, and a Ph.D. in Electrical Engineering from UIUC in 2000. His research interests include nanofabrication, scanning probe microscopy, semiconductor surfaces, and nanoelectronic materials. Dr. Hersam has received several honors including the Presidential Early Career Award for Scientists and Engineers, TMS Robert Lansing Hardy Award, AVS Peter Mark Award, MRS Outstanding Young Investigator, U.S. Science Envoy, MacArthur Fellowship, and seven Teacher of the Year Awards. Dr. Hersam is the co-founder of NanoIntegris, which is a commercial supplier of nanoelectronic materials, and an elected member of the National Academy of Inventors. Dr. Hersam is a Fellow of MRS, AVS, APS, AAAS, SPIE, and IEEE, and also serves as an Associate Editor of *ACS Nano*.

Interfacial Engineering of Two-Dimensional Nanoelectronic Heterostructure

Two-dimensional (2D) materials have emerged as promising candidates for next-generation nanoelectronic applications. With electronic properties spanning the spectrum from insulating (e.g., hexagonal boron nitride and montmorillonite) to semiconducting (e.g., transition metal dichalcogenides and phosphorene) to conducting (e.g., graphene and borophene), nearly any electronic device can be fabricated by stacking 2D materials into van der Waals heterostructures. However, in the atomically thin limit, the influence of surface chemistry, defects, interfaces, and the surrounding environment often play a dominant role, especially in comparison to bulk materials. Consequently, methods for controlling and characterizing heterostructure interfaces with atomic precision are critical for realizing the full potential of 2D materials. Towards this end, this talk will outline our latest efforts to engineer surfaces and interfaces in 2D heterostructures. For example, rotationally commensurate growth of MoS_2 has been realized on epitaxial graphene, which allows deterministic control over grain boundary orientation. For chemically reactive 2D materials (e.g., black phosphorus), encapsulation with atomic layer deposition and passivation with organic adlayers minimize ambient degradation and provide charge transfer doping. Finally, this talk will describe emerging efforts on the growth and chemical functionalization of synthetic 2D materials (e.g., borophene) that do not exist as layered materials in the bulk.

Ariel Ismach

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Dr. Ariel Ismach holds a BEng in Materials Engineering from Ben Gurion University of the Negev, and an MA and Ph.D. in Materials and Interfaces from the Faculty of Chemistry, Weizmann Institute. He was awarded a prize from the Israel Chemistry Society for his doctoral thesis. In 2009 he moved to Berkeley for a joint post-doctoral position at the Department of Electrical Engineering, University of California–Berkeley and the Materials Science Division of the Lawrence Berkeley Laboratory. In 2011 he joined the group of Prof. Ruoff in the department of Mechanical Engineering, at the University of Texas at Austin, where he led a small group of Ph.D. students and postdocs researching the growth and characterization of various 2D materials. He joined the Materials Science and Engineering department at Tel Aviv University in October 2014 where he had established a laboratory dedicated to the study of the growth and properties of 2D atomic-crystals. His group is working to address basic scientific questions regarding the formation and the structure-property relationship of 2D materials as well as developing new methodologies to engineer such layered materials and their heterostructures for applications in catalysis, energy storage and photovoltaics.

Synthesis and Characterization of 2D Materials and Heterostructures

The interest in 2D layered materials has been renovated with the successful isolation of single- and few-layer graphene in 2004 and the elucidation of its outstanding electronic properties. Since then, the research on graphene and other atomic-films has been exponentially increased and new interesting phenomena and applications were demonstrated. The intense study of the growth mechanism of graphene has enabled today the growth of millimeter-size single-crystal and single-layer graphene domains, a very important milestone towards integration in new and existing technologies. This was achieved by understanding the basic processes taking place during the growth. While he ability to synthesize large-area and high quality atomic films is a prerequisite for their successful integration into a wide variety of applications, little is known about the growth mechanism of other 2D materials.

In this talk, I will describe our attempts to achieve large-scale synthesis of 2D materials in general with emphasis on transition metal dichalcogenides (TMD). I will start by reviewing current methodologies for the synthesis of TMD films, with emphasis on chemical vapor deposition, due to its proven record with graphene and other 2D materials. Then I will cover our modifications to such methodologies in order to achieve better homogeneity and control, including the use of volatile precursors and the development of a seeded-growth approach. Beside planar films, the formation of 3D structures, few-layer graphene/TMD heterostructures, will be discussed, from the synthetic and applications point of view.

Derk Joester

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Derk Joester is originally from Munich (Bavaria, Germany) and studied Chemistry in Tübingen. He travelled to the US on a Fulbright Scholarship to study Chemistry and Biochemistry, and then went on to get his Diploma in Organic Chemistry at ETH Zurich, Switzerland, in 1998. He received his Ph.D. for work carried out in organic, supra-molecular chemistry with Prof. François Diederich at ETH Zurich in 2003, and in the same year became a Postdoctoral Fellow at Weizmann Institute of Science in the lab of Prof. Lia Addadi in the Department of Structural Biology. From 2005-2007 he continued his research at the Weizmann Institute as a Minerva Fellow. In September 2007 he accepted a position at the Materials Science & Engineering Department at Northwestern University, Evanston, Illinois. In 2013, he was promoted to Associate Professor. His research interests include biological mechanisms of crystal growth, the role of organic/inorganic interfaces and confinement in phase transformations, metastable precursor phases, and the structure and properties biomineral-organic composites with hierarchical architectures.

Nucleation and Growth of Crystalline Carbonates from Amorphous Precursors

Biomineralizing organisms routinely assemble materials with sophisticated design and advanced functional properties, often using amorphous precursors to access compositional and structural states far from equilibrium. Organic macromolecules and inorganic additives such as magnesium ion are thought to play an important role in controlling phase transformations in these systems. However, it has proven extremely challenging to accurately describe pathways and determine mechanisms, even for extensively studied system such as amorphous calcium carbonate (ACC). I will discuss recent work in my laboratory in which we use liposomes[1] and microfluidic droplets as nano-to-microscale reactors to study the impact of confinement,[2] biomolecules, and inorganic additives on the kinetics of crystallization of ACC and its barium-substituted derivative (ACBC). In the course of this work, we discovered bulk syntheses leading to two other metastable, yet crystalline carbonates that we call balcite and gortotowskite.[3] Balcite is isostructural with a high temperature modification of calcite and has exceptional hardness; its kinetics of formation hint on a complex, possibly non-classical mechanism. Gortatowskite on the other hand is a barium carbonate monohydrate that crystallizes in quasi-two-dimensional habit. These findings demonstrate that microfluidic devices are a powerful tool in the study of phase transformations of the rich-chemistry of metastable carbonates.

[1] C. C. Tester, M. L. Whittaker, D. Joester, *Chem Commun* **2014**, 50, 5619-5622.
[2] M. L. Whittaker, P. M. Dove, D. Joester, *MRS Bull* **2016**, 41, 388-392.
[3] (a) M. L. Whittaker, P. J. M. Smeets, H. Asayesh-Ardakani, R. Shahbazian-Yassar, D. Joester, *Angew Chem Int Ed* **2017**, 11, 16028-16031; (b) M. L. Whittaker, D. Joester, *Adv Mater* **2017**, 29, 1606730.

Mercouri G. Kanatzidis

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Mercouri G. Kanatzidis received his B.S. in chemistry from Aristotle University, Thessaloniki, Greece, in 1979 and his Ph.D. in chemistry from the University of Iowa in 1984. He was a postdoctoral research associate at Michigan and Northwestern from 1985 to 1987; a University Distinguished Professor at Michigan State from 1987 to 2006, and is currently a Charles E. and Emma H. Morrison Professor in Chemistry at Northwestern. Most recently his awards include: AIC Chemical Pioneer Award, 2018; Honorary Doctorate Degree, University of Crete, 2017; Samson Prime Minister's Prize for Innovation in Alternative Fuels for Transportation, 2016; American Physical Society James C. McGroddy Prize for New Materials, 2016; ENI Award for "Renewable Energy Prize", 2015; Royal Chemical Society De Gennes Prize, 2015; Materials Research Society Medal, 2014; American Chemical Society Award in Inorganic Chemistry 2016; and was elected Fellow, American Association for the Advancement of Science, 2012. His research has generated seminal work in metal chalcogenide chemistry through the development of novel "solvents" for solid state synthesis including flux methods, hydrothermal and solvothermal techniques. He is also active in the field of new thermoelectric materials, synthetic design of framework solids, intermetallic phases and nanocomposite materials. His work is described in more than 1,130 research publications.

Amazing 3D and 2D Halide Perovskites: All the Things They Do

Three-(3D) and two-dimensional (2D) layered halide perovskites are highly promising semiconductors for optoelectronic applications ranging from solar cells, light emitting diodes, soft radiation detector, hard radiation detectors, etc. The 3D versions of these compounds adopt the three-dimensional ABX3 perovskite structure, which consists of a network of corner-sharing BX6 octahedra, where the B atom is a divalent metal cation (typically Ge^{2+}, Sn^{2+} or Pb^{2+}) and X is a monovalent anion (typically Cl^-, Br^-, I^-); the A cation is selected to balance the total charge and it can be a Cs^+ or a small molecular species. Another class of materials gaining significance are the two-dimensional (2D) perovskites -a blend of perovskites with layered crystal structure- (Ruddlesden-Popper type) offer a greater synthetic versatility and allow for more specialized device implementation due to the directional nature of the crystal structure. A remarkable advantage of the 2D perovskites is the readily tunable functionality by incorporating a wide array of organic cations into the 2D framework and by controlling the slab thickness, in contrast to the 3D analogues which have limited scope for structural engineering. We present the new homologous series, $(C(NH_2)_3)(CH_3NH_3)_nPb_nI_{3n+1}$ (n = 1, 2, 3), of layered 2D perovskites which is different from Ruddlesden-Popper type.

Amit Kohn

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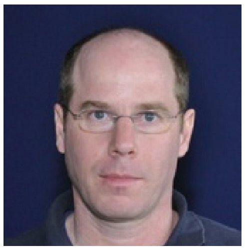

Amit Kohn has been an Associate Professor at the Department of Materials Science and Engineering at Tel Aviv University since 2015. Amit's research projects are in the field of magnetic and electronic materials used for information storage devices. The contribution of the research is to relate between structure and composition of these materials to the magneto-transport properties of the devices. The objective is therefore to improve on, or design new so-called 'spin-electronic' devices.

Structural and chemical characterization is mostly achieved by analytical transmission electron microscopy, which probes the properties of the materials at the nanoscale and up to the atomic level. In addition, Amit applies and develops Lorentz electron microscopy and electron holography in order to image magnetic and electrostatic fields in materials and devices at the nanometer scale.

Professor Kohn holds a Ph.D. in Materials Engineering from the Technion (IIT). He was a Royal Academy of Engineering Research Fellow at the Materials Department, University of Oxford followed by a faculty position at Ben-Gurion University of the Negev.

Mean-Inner and Space Charge Potentials in Oxides

The mean inner potential (MIP) of a material is the volume averaged electrostatic (Coulomb) potential between bulk and vacuum. Thus, it is a fundamental material property, which depends on composition and structure. However, MIP measurements are lacking for a wide range of materials due to experimental challenges. I will present a methodology using off-axis electron holography (OAEH) to measure the MIP, demonstrated on α-Al_2O_3 sapphire.

Charge distribution in nanoscale granular oxides results in the formation of a space charge potential (SCP), which then determines functional properties. Explanations for this phenomenon are reported though quantitative experimental evidence is indirect. I will show direct measurements of the SCP in nanoscale non-stoichiometric granular magnesium aluminate spinel (MAS, $MgAl_2O_4$) using OAEH and Electron Energy-Loss Spectroscopy. Thus, the effect of MAS composition, grain size, and applied electric field during annealing on the SCP is examined. We demonstrate that regardless of grain size, excess Mg^{+2} or Al^{+3} cations resides in the vicinity of grain-boundaries of Mg- and Al-rich MAS, respectively. We then discuss the role of grain size on the SCP, especially when comparable to the Debye length. Furthermore, applying a moderate electric field during annealing modifies lattice ordering.

Noa Lachman

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Dr. Noa Lachman is a new member in the department of materials science and engineering, previously a postdoctoral Associate at the department of Aeronautics and Astronautics at MIT. She received a B.S. (2003) in Chemistry and Physics from the Hebrew University in Jerusalem, Israel, and completed her Ph.D. work (2010) at the Weizmann Institute of Science, in the department of Materials and Interfaces. Her research with Prof. Wardle at MIT focused on tailoring and imaging of VA-CNT based composites for various applications, including energy storage and multi-functional structure materials. Dr. Lachman uses experimental techniques to obtain knowledge of nano-structure effect on mechanical and functional properties of these new materials, and she aims to develop a structure-function dataset which will enable the design of new materials with improved efficiency and performance. Dr. Lachman has authored and co-authored 20 journal articles, which have been cited together more than 500 times.

Multi-functional Composites: A Study in Silicone

Multi-functional materials are materials with specific properties allowing them to perform multiple functions within their system. Such “smart” materials can be designed to preform multiple tasks and even change their properties in response to external stimuli. Here we focus on the manufacturing and characteristics of a multifunctional silicone rubber (VMQ-Vinyl Methyl Silicone rubber), as a soft conductive rubber. Silicone rubber has excellent properties including nontoxicity, biocompatibility, flexibility, low cost, and ease of fabrication. However, silicone is naturally an insulator, and conductive fillers usually reduce tensile strength, shear strength, softness, and most importantly, elasticity.
We thus apply industrial procedures to make conductive silicone rubber using carbon nanotubes (CNT). We found that VMQ with as little as 4%wt of CNT is softer (45 Shore A) compared to the silver or carbon black reinforced VMQ (60-70 Shore A), conductive enough to satisfy the anti-static requirements (up to 100 Ω-cm) and almost as elastic as pure rubber (20%-30% compression set). Moreover, the addition of CNT allows for tension measurement using resultant changes in conductivity, as well as structural integrity degradation using Raman spectroscopy. The morphological origins of the superior electrical and mechanical behavior will also be discussed.

Erik Luijten

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Professor Erik Luijten studied physics in The Netherlands, where he received his MSc from the Institute for Theoretical Physics at Utrecht University and his Ph.D. (cum laude) from Delft University of Technology in 1997. He has worked as a postdoctoral research associate at the Max Planck Institute for Polymer Research and the University of Mainz, Germany, with Prof. Kurt Binder and at the Institute for Physical Science and Technology of the University of Maryland, with Prof. Michael E. Fisher and Prof. Athanassios Panagiotopoulos. From 2001 to 2008 he was an assistant professor and later associate professor in the Department of Materials Science and Engineering and (by courtesy) the Department of Physics at the University of Illinois at Urbana-Champaign. In January 2009 he joined Northwestern University, with appointments in Materials Science and Engineering and Applied Mathematics. As of September 2016, he serves as chair of the Department of Materials Science and Engineering. Professor Luijten received the 2003 IAPWS Helmholtz Award in recognition of "Fundamental and innovative contributions enhancing the state of the art of computer simulations of theoretical models that are directly relevant to the critical and phase behaviour of aqueous systems." He also received an NSF CAREER Award (2004) and a Xerox Award for Faculty Research (2006). In 2013 he was elected Fellow of the American Physical Society.

Predictive Modeling of Dielectric Effects in Materials

Efficient computer simulation strategies that offer predictive capabilities play a crucial role in the design of new materials. A frequently overlooked factor in this type of modeling, in particular for polymeric and colloidal systems, is the role of dielectric effects. New computational developments have now made it possible to incorporate these effects in predicting self-assembled structures as well as ionic charge transport. I will illustrate the methods that provide these capabilities. Moreover, I will illustrate the consequences of nonuniform permittivity in nanoparticle aggregates as well as ionic transport in confined geometries.

Laurence Marks

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Laurence Marks holds a Ph.D. in Physics from the University of Cambridge, and is a Professor of Materials Science and Engineering at Northwestern University. He has published more than 375 referred publications in many different areas of materials science, focusing upon the science fundamentals and combing experiment and theory as equal partners. He has worked extensively using crystallographic methods mainly with electron microscopy and diffraction but in some cases using x-ray scattering. He has published on dynamical diffraction and imaging theory, direct methods for surfaces, precession electron diffraction, and outside crystallography on nanoparticles, tribology, oxide surfaces, catalysis, corrosion and fixed-point algorithms. Among his honors are the 2015 Warren award of the ACA and the 2017 Surface Structure Prize.

Understanding Corrosion in 4D at the Nanoscale

Corrosion in its various forms, from aggressive salt solutions in the sea or in vivo to high or low temperature oxidation has serious economic consequences, which have been estimated to be several trillion dollars annually internationally. Despite its importance there are significant knowledge gaps in our scientific understanding. Most of the established science predates modern computational or characterization tools, and often has been observational rather than defining the fundamentals. This talk will focus on some recent work where we have been able to combine density functional surface science with characterization to define the role of chloride ions and how they can lead to protective film breakdown due to morphological instabilities.

Hooman Mohseni

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Hooman Mohseni is the AT&T professor at the Department of Electrical Engineering and Computer Sciences, and Physics and Astronomy Department, at Northwestern University. He is the recipient of several research and teaching award including W.M. Keck Foundation Award, NSF CAREER Award, DARPA Young Faculty Award, and Northwestern Faculty Honor Roll. Mohseni serves at several editorial boards including IEEE Photonics, IEEE Selected Topics in Quantum Electronics, and Frontiers in Material. He has published over 120 peer-reviewed articles in major journals including Nature, Nano Letters, and ACS Nano. He has presented more than 72 plenary and invited talks, and holds 14 issued US and International patents. He is a Fellow of SPIE and OSA.

Energy Efficient Optoelectronics for Science, Medical, and Consumer Applications

What is the common challenge between reading a million neurons in the brain, searching for life in distant exoplanets, and turning your smartphone camera into a 3D depth camera? It turns out that receiving and sending information with very low energy is the key to achieving these and many more breakthroughs. I will present our efforts in making novel nanophotonics and optoelectronics to achieve extremely low energy per bit of information. I will also share some of our recent breakthroughs, including an infrared camera, based on Electron Nano-Injection, with extreme sensitivity and speed. This new technology is being developed for the 8 m Subaru Telescope for imaging of Earth-like exoplanets for the first time. This same detector has recently been used in a commercial medical optical tomography system, in collaboration with Zeiss, and achieved ~1000 times higher sensitivity at very low light conditions. I will present our research on using Photonic Jets that show strong and lossless photon coupling to quantum dots. Finally, I will present novel quantum wells optical shutters with record energy efficiency, leading to record performance in our infrared 3D depth camera for robotics and consumer applications.

Mark Ratner

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Mark Ratner is a materials chemist, whose work focuses on the interplay between molecular structure and molecular properties. This includes such aspects as molecular electronics, molecular optoelectronics, molecular systems design and biomolecular behavior, as well quantum and classical methodologies for understanding and predicting molecular structure and response. The major focus of his research for the last three decades has been the understanding of charge transfer and charge transport processes based on molecular structures, ranging from nonadiabatic intramolecular behavior to aspects of molecular devices, including photovoltaics, conductive polymers, molecular transport junctions and molecular switches.

His professional history involves undergraduate work at Harvard, graduate work at Northwestern, postdoctoral work at Aarhus and Munich, and faculty positions at New York University and Northwestern. He is currently Professor Emeritus in the Department of Chemistry at Northwestern. Ratner recently served as Interim Dean at Weinberg College, Dumas University Professor at Northwestern and Co-Director of the Initiative for Sustainability and Energy at Northwestern (ISEN). He has very active international collaborations, particularly in Denmark, Israel and the Netherlands. He has been awarded the Feynman Prize, the Langmuir Award of the American Chemical Society, the ACS Peter Debye Award, the J.W. Gibbs Award and is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the International Academy of Quantum Molecular Sciences, and the Royal Danish Academy of Sciences. He has an annual canoe trip which puts all things back into perspective.

Moving Electrons: Buttiker Probe, Silicene, and Excited-state Spectroscopy

Molecular electronics, the study of molecules under electronic charge application, is a very widely examined phenomenon. Essentially all the papers treat the behavior from viewpoint of an electronic system, discussed in energy space. In this work, we examine how charge moves starting from a particular *time-dependent* point in a photo-excited molecular entity. The time dependence is very helpful in understanding the actual behavior, since it tells us about the sequential motion of the electrons.

Once the molecule has been examined and the pathways noted, it is possible to introduce a Buttiker probe, which can be placed at any point in the molecular moiety. At each point, the time-dependent analysis shows us the pathways by which the charge is moved. It is also possible to observe and understand the interference in the molecular pathways, which can be controlled by the Buttiker probe. The probe can act as a tool, to control the pathways, and the interferences, in the molecular entity.

Given the understandings that arise from the time-dependent analysis, it is possible to design new structures, which can be controlled and can act as Full photonic agents.

Guanhua Chen, Shuguang Chen and Mark Ratner

Shachar Richter

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Shachar Richter (Ph.D. material Science and Chemical Physics, Weizmann Institute of Science, Israel) is the head of the Bio-and molecular electronics Lab and faculty member at the Department of Materials Science and Engineering at Tel Aviv University. Prof. Richter was a post-doctorate fellow and independent staff member (MTS) at Bell-Laboratories and Agere Systems (NJ, USA). In 2001 he joined Tel Aviv University where he established the Nano-Electronics lab at the Center for Nanoscience and Nanotechnology where he serves as a core member. He was a faculty member at the School of Chemistry, and from 2013 he moved to the Department of Materials Science and Engineering. His current research interests are molecular- and bio-electronics, bio-nanocomposites, and novel patterning technologies. Recently one of his patents (vertical molecular transistor) was sold to a large company. Among his previous and current public roles, are the heading of the departments' MSc Programs, serving as the president of the Israel Vacuum Society, and member of the NGO "EREZ rescue and search." Prof. Richter in the editorial board of *Scientific Reports Journal* and the advisory board member of *Advanced Sustainable Systems*. He has authored more than 70 papers and patents and won several prizes including several "excellence in teaching awards" and IVS honorary member award.

From (Bio) Organic Materials to Electronic and Photonic Devices

Proteins form the very basis of life. They regulate a variety of activities in all known organisms, from replication of the genetic code to transporting oxygen, and are responsible for regulating the cellular machinery and determining the phenotype of an organism. From a material-science point of view, proteins can serve as excellent building blocks for the development of new structures, composites, and devices. In this talk, I will cover some of our efforts in this direction. In short, we exploit the hydrophobic voids and the reduction properties of some glycoproteins to form new biocomposites materials.

Recently we demonstrated a stable film that can be used for White LED applications. This bio-composite material, entirely composed of biological- (crystalline nano-cellulose and porcine gastric mucin) and organic- (light emitting dyes) compounds exhibits excellent optical and mechanical properties as well as resistance to heat, humidity, and UV radiation.

We further show that a protein templated synthesis can be used to incorporate various types of metals and alloys in the protein matrix. Examples include Chiral Ag nanoparticles, Pd and Pd-Ag alloys and Au nanoparticles and micro-crystals. The latter is successfully used as a local heat source used in light-induced thermotherapeutic applications.

James M. Rondinelli

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Rondinelli is the Morris E. Fine Junior Professor in Materials and Manufacturing at Northwestern University (NU). His interests are in electronic structure theory and first-principles design of functional inorganic materials using picoscale structure-property relationships. He is a 2018 Kavli Frontiers of Science Fellow and the 2017 Materials Research Society (MRS) Outstanding Young Investigator. In 2016 he received a Sloan Research Fellowship in Physics, the Presidential Early Career Award for Scientists and Engineers (PECASE), and the 3M Non-Tenured Faculty Award. Additional honors include a NSF-CAREER Award (2015), DARPA Young Faculty Award (2012), and ARO Young Investigator Program (YIP) award (2012). He also received the 2014 Ross Coffin Purdy Award from the American Ceramic Society. Rondinelli has (co)-authored more than 120 peer-reviewed publications and holds 1 patent. He is a member of the APS, MRS, ACS, TMS, ACerS, and ASEE. He is a Member-at-Large for the APS Division of Materials Physics and Chair of the Argonne Center for Nanoscale Materials (CNM) Users' Executive Committee (2016-19). He holds a Ph.D. in Materials from the University of California, Santa Barbara (2010) and was the Joseph Katz Named Fellow in the X-Ray Science Division at Argonne National Laboratory (2010).

Polar Oxide Thin Films from Vacancy and Chemical Order

Here I describe a crystal-chemistry design approach for realizing digital oxides without inversion symmetry by combining two centrosymmetric compounds, utilizing periodic anion-vacancy order to generate multiple polyhedra that together with cation order produce a polar structure. The strategy is applied to two brownmillerite (perovskite-derived) oxides known to display centrosymmetric crystal structures in their bulk, $Ca_2Fe_2O_5$ and $Sr_2Fe_2O_5$, with ordered arrangements of oxygen vacancies dependent on a variety of competing crystal-chemistry factors. A microscopic understanding of the interactions among these structural descriptors, including ionic size, distortions of nominally regular oxygen octahedral, and in-plane and out-of-plane separation of tetrahedral chains, enables the design and experimental realization of epitaxial $(SrFeO_{2.5})_1/(CaFeO_{2.5})_1$ thin film superlattices. The ordered superlattices possess both anion-vacancy order and Sr and Ca chemical order at the subnanometer scale, confirmed through synchrotron-based diffraction and aberration corrected electron microscopy. Our results demonstrate how control of anion and cation order at the nanoscale can be utilized to produce acentric structures markedly different than their constituents and open a path toward novel structure-based property design.

This research is performed in collaboration with S. May (Drexel), V. Gopalan and N. Alem (Pennsylvania State Univ.) and is supported by the National Science Foundation (DMR-1420620) and U.S. DOE, Office of Basic Energy Sciences (DE-AC02-06CH11357).

Yossi Rosenwaks

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Prof. Yossi Rosenwaks, Dean of the Faculty of Engineering, and the founder of Tel Aviv University's Center for Renewable Energy, has been a professor of electrical engineering at TAU since 2005 after joining the faculty in 1996. Prof. Rosenwaks leads a research group of 10 graduate students and scientists, and his current research interests include nanowire transistors and sensors, two-dimensional materials and devices, and charge carrier dynamics and transport in semiconductors. Prof. Rosenwaks is a co-author of more than 170 peer reviewed articles, and has presented 70 invited talks at international meetings.

He served as the president of the Israel Vacuum Society (2003-2006), and as the director of TAU's Wolfson Center for Applied Materials Research and Gordon Center for Energy Studies (2005-2008), and the head of the Physical Electronics department (2011-14).

Selective Molecular Sensing Using CMOS Compatible Nanowire Transistor

For the past several decades, there is a growing demand for the development of low-power gas sensing technology for the selective detection of volatile organic compounds (VOCs), important for monitoring safety, pollution and healthcare. We present the selective detection of various VOCs using the electrostatically formed nanowire (EFN) transistor without any surface modification of the device. Selectivity towards specific VOC is achieved by training machine-learning based classifiers using the calculated changes in the threshold voltage and the drain-source on current, obtained from systematically controlled biasing of the surrounding gates (junction and back gates) of the field-effect transistors (FET). Specific biasing of the device has recently shown superb sensitivity to Ammonia and other molecules under very high humidity conditions. This makes the EFN platform a selective sensor, working under ambient conditions and room temperature, which is suitable for mass production and low-power sensing technology.

Alan V. Sahakian

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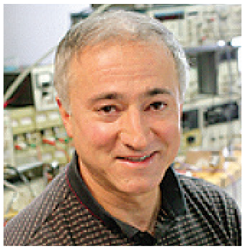

Alan V. Sahakian is the John A. Dever Professor and Chair of Electrical Engineering and Computer Science, and Professor of Biomedical Engineering at Northwestern University. He received the Ph.D. in ECE with a minor in CS, and the MSEE from the University of Wisconsin-Madison, working in the Willis Tompkins/John Webster group. During his graduate study he was also a Senior Electrical Engineer at Medtronic, Inc. His BS was in Applied Science and Physics from the University of Wisconsin-Parkside. He is also on the academic affiliate staff at NorthShore University HealthSystem (Evanston Hospital). He is a Fellow of AIMBE and of the IEEE "for contributions to electrophysiology of atrial cardiac arrhythmias." In addition to cardiac electrophysiology, his lab studies microwave and millimeter wave methods for medical imaging and non-contact patient monitoring, irreversible electroporation for tumor ablation, and spintronic and other beyond-CMOS logic circuits. His recent research is funded by the NIH, the NSF, the Department of Defense Breast Cancer Research Program, the Defense Intelligence Agency, Intel and Medtronic.

Spintronic and Magneto-Resistive Logic for Beyond-CMOS Computing

Dennard scaling of the MOSFET transistors used in CMOS logic and its contribution to the Moore's law increase in transistor count has taken us through four decades of faster, smaller and lower-power VLSI but is now encountering fundamental physical limits. This is an opportunity for engineers to step back and consider new logic structures and computing paradigms which will take us into the future. The MOSFET uses electric field effects to modulate conduction through a channel but magnetic fields may also be used to control conduction in semiconductor devices. In this talk I will discuss some of our work in novel logic circuit topologies and device structures which use magnetic field effects to gain logical efficiency and speed, and to realize other unconventional computing properties such as non-volatility. This is joint work with my Ph.D. student Joseph Friedman (now an Assistant Professor at the University of Texas-Dallas) and collaborators Professors Bruce Wessels and Gokhan Memik of Northwestern University.

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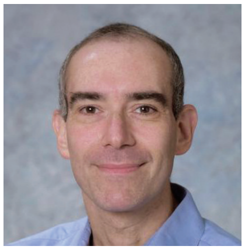

Jacob (Koby) Scheuer is a professor of Electrical Engineering and the head of department of Physical Electronics at the School of Electrical Engineering, Tel Aviv University. He received the B.Sc. degree (summa cum laude) in electrical engineering and in physics, and the Ph.D. degree in electrical engineering from the Technion-Israel Institute of Technology, Haifa, Israel, in 1993 and 2001, respectively. He was a Chief Designer with Lambda crossing—an optical component startup specializing in microring resonators for two years. Then, he joined the Center for the Physics of Information and the Department of Applied Physics, the California Institute of Technology, Pasadena, as a Research Associate. In 2006 he joined the School of Electrical Engineering, Tel Aviv University. His main fields of research involve metasurfaces, plasmonics, integrated optics and telecommunications. Prof. Scheuer is the author or co-author of more than 130 scientific paper in peer-review journal, 4 book chapters, more than 100 papers in conference proceeding, and 10 patent applications. He is a Fellow of the Optical Society of America and a fellow of the SPIE.

Towards Metal-Halide Based Perovskite Integrated Photonics

Metal-halide perovskites have emerged in recent years as a powerful material system in the field of photonics. Due to their promising electronic and optical properties, tremendous progress has been made in perovskites solar cell performance. This was followed by the demonstration of their great potential in the field of light emitting devices as well. However, the ability to pattern these materials remains a major challenge. Here, a complete lithographic scheme for thin perovskite films is demonstrated and utilized for the realization of micro lasers. The process is simple, fast, scalable, and exhibits sub-micron resolution. The optical properties of the perovskite films are obtained by characterizing distributed feedback laser fabricated from these films as well as by employing additional analytical tools. It is shown that the material properties are not impaired by the lithographic process. Using this approach, on chip, micro lasers are fabricated. Experimental characterization of these lasers shows that they exhibit low threshold levels and single-mode lasing. This process offers an important tool towards integrated perovskite photonics and is highly applicable also for the fields of photovoltaics, meta-surfaces, electronics and more.

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David Seidman is a W. P. Murphy professor of materials science & engineering and is founding director of the Northwestern University Center for Atom-Probe Tomography. He was awarded a Ph.D. degree from UIUC and B.S. and M.S. degrees from N.Y.U. He is a member of the National Academy of Engineering, fellow of American Academy of Arts & Sciences, American Association for the Advancement of Science, American Physical Society, ASM International, Materials Research Society, John Simon Guggenheim Foundation, Microscopy Society of America, and TMS (Minerals•Metals•Materials). He is a recipient of: AIME Honorary Member Award (TMS), Albert Sauveur Achievement Award (ASM International), ASM Gold Medal, Alexander Von Humboldt Stiftung Prize, David Turnbull Lecturer Award (MRS), Edward DeMille Campbell Memorial Lectureship (ASM), Institute of Metals Lecture & Robert Franklin Mehl Award (TMS), Max-Planck Research Prize of the Max-Planck-Gesellschaft, Robert Lansing Hardy Gold Medal (TMS), and Sackler Lecturer (Sackler Institute of Advanced Studies). He is or was on the editorial boards of: *Journal of Materials Science*, *Materials Research Letters*, *Materials Today*, *MRS Bulletin*, *NanoLIFE*, *NANO Science and NANO Technology* series, and *Review of Scientific Instruments*. Seidman is co-founder of NanoAl.com, with David C. Dunand, which develops high-temperature Al-based alloy.

A Tale of Two Silicon Nanowires: Correlative Studies

The first tale concerns Si nanowires (NWs) grown by the vapor-liquid-solid technique, which were doped *ex situ* with boron (B) and phosphorous (P), yielding two monolayer line sources on two sides of the cylindrical Si NWs, with diameters ranging from 35 to 75 nm. This sandwich structure was rapidly thermally annealed at 10^{-2} Torr Ar at 970 ^{o}C to drive in B and P, for times ranging from 3 to 80 s. Utilizing atom-probe tomography we found a highly P-doped outer region and a uniformly B-doped interior, which were not predicted using the bulk diffusivities of P and B. Utilizing scanning tunneling microscopy, which detects only the electrically dopants, we determined the fraction of the total dopants that are electrically active.

The second tale involves Raman spectroscopy, electron microscopy and electron diffraction studies to identify strain energy release mechanisms of bent diamond-cubic Si NWs, which were elastically strained to >6% at room temperature and then annealed to activate relaxation mechanisms. High-temperature annealing of bent Si NWs leads to the nucleation, glide and climb of dislocations, which align to form polygonally-shaped grains separated by grain boundaries (GBs) consisting of aligned edge dislocations; this phenomenon is called polygonization (R. W. Cahn, 1949).

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Dr. Selim Shahriar is a Professor in the Department of Electrical Engineering and Computer Science, and in the Department of Physics and Astronomy at Northwestern University. He is also the Director of the Solid State and Photonics Research Interest Group within EECS, and a council member of the LIGO Scientific Collaboration. He is the founder and the chairman of the board of directors of Digital Optics Technologies, a company specializing in developing precision optical and atomic sensors. He received his Ph.D. from MIT in 1992. He has published 512 papers, including 209 in peer-reviewed journals. His work has been cited nearly 18,000 times; he has 32 papers with more than 100 citations each, an H-index of 53, and an i-10 index of 152. His research interests include Applications of Slow and Fast Light, Quantum Computing with Trapped Atoms, Gravitational Wave Detection, Tests of General Relativity, Holographic and Polarimetric Image Processing, Atomic Clocks, Atom Interferometry, and Spin Squeezing. In 2016, for his contribution to the first detection of gravitational waves, he was a co-recipient of the Gruber Prize in Cosmology and the Special Breakthrough Prize in Fundamental Physics. He is a Fellow of SPIE and OSA.

Schroedinger Cat Atomic Interferometry at Decillion Hz Compton Frequency: Ultraprecise Gyroscopes, Accelerometers and Clocks

Optical interferometers, such as those used for rotation sensing and gravitational wave detection, are among the most precise metrological devices. This is due to the high frequency of lasers: ~$5*10^{14}$ Hz. In this talk, I will describe how interferometry at a frequency that is nearly nineteen orders of magnitude higher than this can be carried out by accessing the Compton Frequency (CF) of an ensemble of a hundred million atoms acting as a single particle. To reach this condition, an ensemble of Rb atoms are cooled in a magneto-optic trap. Each atom is then split into spin-up and spin-down states, followed by interaction with a detuned probe beam in a cavity, which produces one axis twist spin-squeezing. When the squeezing interaction is tuned to a critical value, the ensemble becomes a Schroedinger-Cat (SC) state, as a superposition of two collective states: one where all atoms are spin-down and another where all atoms are spin-up. For N atoms in the ensemble, each of these collective states has a CF of Nmc^2/h, where m is the mass of each atom. For $N=10^8$, the CF is ~2 decillion (10^{33}) Hz. I will describe how to realize ultra-precise gyroscopes, accelerometers and clocks using this SC-state of atoms.

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Ken Shull is Professor of Materials Science and Engineering at Northwestern University. His research interests involve the interfacial properties of polymers, with a particular emphasis on adhesion, fracture and the behavior of thin films and coatings. Recent interests include the large-strain deformation and fracture behavior of 'soft' materials including polymer nanocomposites, the mechanical properties and phase behavior of polyelectrolyte complexes, and advanced uses of the quartz crystal microbalance.

He received B.S. and M.S. degrees in Materials Science from MIT, followed by a Ph.D. in Materials Science from Cornell University, which he received in 1990. He worked as a research staff member at the IBM Almaden Research Center for 3 years before joining Northwestern University in 1993. He is a fellow of the American Physical Society and of the Adhesion Society.

He is a past president of the Adhesion Society, served as chair of the Adhesion Gordon Research Conference for 2013, and is the 2016 recipient of the Adhesion Society Award for Excellence in Adhesion Science.

Polyelectrolyte Complex Membranes for Water Purification

Polyelectrolyte complexes are a fascinating class of soft materials that can span the full spectrum of mechanical properties from low-viscosity fluids to glassy solids. This spectrum can be accessed by modulating the extent of electrostatic association in these complexes, either by changing the structure of the component polymers are by or by adding salt to the system. With an appropriate choice of polyelectrolytes it is possible to design a system that can be dissolved in aqueous solutions of high ionic strength, but which which separates into polymer-rich and water- rich phases when the salt concentration is decreased. Porous membranes can be produced by a salt-induced phase inversion process that is conceptually similar to the common solvent-induced phase inversion process used to produce porous polymeric membranes. The properties of these membranes and a preliminary assessment on their utility in water purification applications will be discussed.

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G. Jeffrey Snyder is a professor of Materials Science and Engineering at Northwestern University. His interests are focused on the materials physics and chemistry for thermoelectric engineering, such as band engineering, design of complex Zintl compounds and use of nanostructured composites. His interdisciplinary approach stems from studies of Solid State Chemistry at Cornell University and the Max Planck Institute for solid state research, Applied Physics at Stanford University and thermoelectric materials & device engineering at NASA/Jet Propulsion Laboratory and California Institute of Technology (Caltech).

Understanding and Engineering Electrical Interfaces and Grain Boundaries in Oxides and Thermoelectric Materials

The electrical resistivity in many oxide and semiconducting polycrystalline compounds appears thermally activated but this is often dominated by the poorly understood effect of grain boundaries. In heavily doped semiconductors for example we often expect ionized impurity scattering to dominate electrical transport especially when mobility increasing with temperature is observed. However, the inadequacy of this description in thermoelectric materials such doped $SrTiO_3$ or the new high-performance n-type Mg3Sb2, becomes apparent when trying to consistently explain various experimental observations like the enhanced mobilities in larger grain samples and sharp crossovers to metal-like mobilities that decrease with temperature. The underlying cause of such complications is largely associated with the conventional Mathiessen's rule that interprets or models all of the charge carrier scattering as homogeneous events. The inhomogeneous nature of materials, such as that caused by grain boundaries, must be taken into account to rethink engineering strategies to improve material performance.

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Chris Wolverton is the Jerome B. Cohen Professor of Materials Science and Engineering at Northwestern University. Before joining the faculty, he worked at the Research and Innovation Center at Ford Motor Company, where he was group leader for the Hydrogen Storage and Nanoscale Modeling Group. He received his B.S. degree in Physics from the University of Texas at Austin, his Ph.D. degree in Physics from the University of California at Berkeley, and performed postdoctoral work at the National Renewable Energy Laboratory (NREL). His research interests include computational studies of a variety of energy-efficient and environmentally friendly materials via first-principles atomistic calculations, high-throughput and machine learning tools to accelerate materials discovery, and "multiscale" methodologies for linking atomistic and microstructural scales. He has published over 250 papers with >17,000 citations and an h-index of 68. He is a fellow of the American Physical Society.

Using Machine-Learning to Create Predictive Material Property Models and Accelerate Combinatorial Searches

Rational, data-driven materials discovery has the potential to make research and development efforts far faster and cheaper. In such a paradigm, computer models trained to find patterns in massive chemical datasets would rapidly scan compositions and systematically identify attractive candidates. Here, we present several examples of our work on developing machine learning (ML) methods capable of creating predictive models using a diverse range of materials data. As input training data, we demonstrate ML on both large computational datasets of DFT calculations, as implemented in the Open Quantum Materials Database (oqmd.org), and also experimental databases of materials properties. We construct ML models using a large and chemically diverse list of attributes, which we demonstrate can be used as an effective tool to automatically learn intuitive design rules, predict diverse properties of crystalline and amorphous materials, such as formation energy, specific volume, band gap energy, and glass-forming ability, and accelerate combinatorial searches.

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