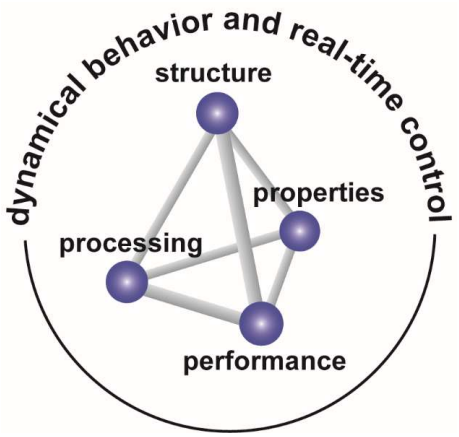
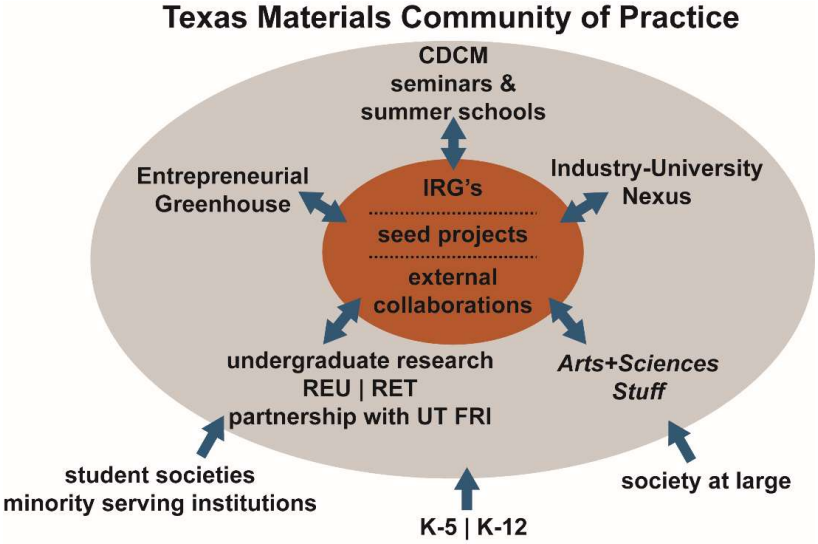
Center for Dynamics and Control of Materials: an NSF MRSEC

Edward T. Yu, Director



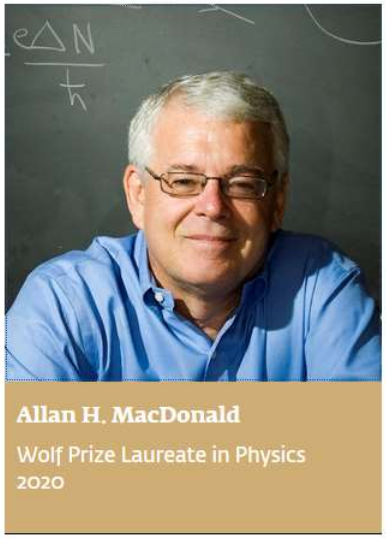


The CDCM Community of Practice

"Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly."

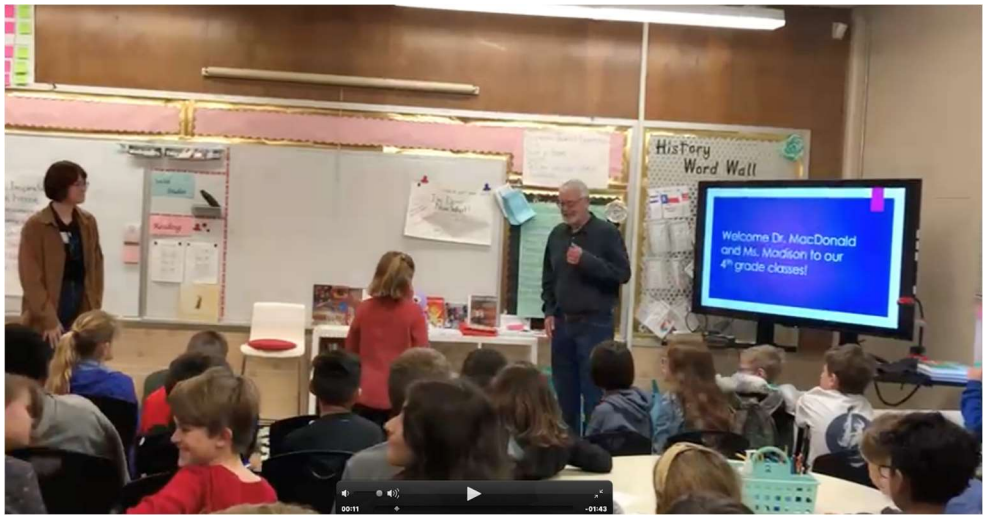
Wenger et al., *Harvard Business Review* **78**, 139 (2000); STEP Leadership Workshop for NSF STEM Talent Expansion Program (2011)

2020 Wolf Prize in Physics to Allan MacDonald



January 2020

Allan MacDonald and Madisen Holbrook at Brentwood Elementary (Austin, TX)



February 2020

The CDCM Team


E. Anslyn (Ch)


G. Fiete (Ph)


B. Korgel (ChE)


X. Li (Ph)


D. Milliron (ChE)


E. Yu (ECE)


D. Akinwande (ECE)


A. Alu (ECE)


S. Bank (ECE)


R. Bonnecaze (ChE)


A. Cavalleri


A. Ellington (MB)


B. Freeman (ChE)


V. Ganesan (ChE)

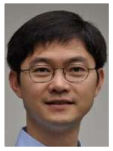

R. Huang (AE)


J. Incorvia (ECE)


R. Kaindl


M. Kumar (CAEE)


J. Kono (Rice)


K. Lai (Ph)


K. Liechti (AE)


N. Lynd (ChE)


A. MacDonald (Ph)


A. Potter (Ph)


S. Roberts (Ch)


A. Rosales (ChE)


K. Shih (Ph)


T. Truskett (ChE)


C. Werth (CAEE)


J. Zhou (ME)


T. Berry


B. Fang


R. Hartman

Graduate Students and Postdoctoral Fellows

Leke Akinola
Md Hasibul Alam
Emily Babcock
Zach Brotherton
Henry Cater
Zihan Cheng
Jeongheon Choe
Zhaodong Chu
Alex De Palma
TJ Dilenschneider
Manuel Dominguez
Chris Dundas
Jacob Embley
Tommy FitzSimons
Claire Ganski
Austin Graham
Allison Green
Yuqian Gu
Wei Guo
Madisen Holbrook
Jennifer Imbrogno
Sanket Kadulkar
Abhilasha Kamboj
Jiho Kang
Suyogya Karki
Meghan Kiker
Kihoon Kim
Ajesh Kumar
Vikram Lakhanpal
Doo-Hee Lee
Woojoo Lee
Hongze Li
Zexun Lin
Mengke Liu
David Lujan
Xuejian Ma
Soham Mane
Aniket Marne
Qian Meng
Nicolas Duran
Nate Nunley
Adrian Rylski
Sejal Shah
Alec Skipper
Ben Stacy
Lynn Stevens
William Sullivan
Yu-Ming Tu
Stephanie Valenzuela
David Villarreal
Yimeng Wang
Nemin Wei
Frances Wu
Yongjian Zhou
Jihang Zhu
Progna Banerjee
Gabriel Cossio
Emily Lin
Pengtao Lu
Martin Rodriguez-Vega
Ali Shahmohammadi
Zachary Sherman
Max Verkamp


S. Bank (ECE)


B. Keitz (ChE)


E. Marcotte (MB)


M. Maloney


A. Stanzione


C. Wood


Z. Page (Ch)

E. Tutuc (ECE)

Y. Wang (ME)

L. Garbrecht

D. Wasserman (ECE)

National Science Foundation MRSEC Materials Research Science and Engineering Centers

https://mrsec.utexas.edu

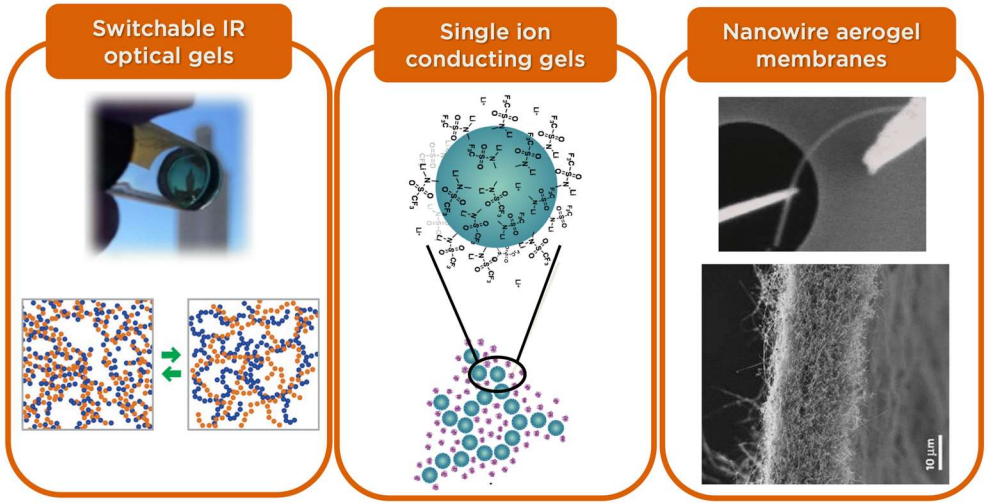
Center for Dynamics and Control of Materials: an NSF MRSEC

TEXAS The University of Texas at Austin

RICE

IRG 1: Reconfigurable Nanocrystal Assemblies

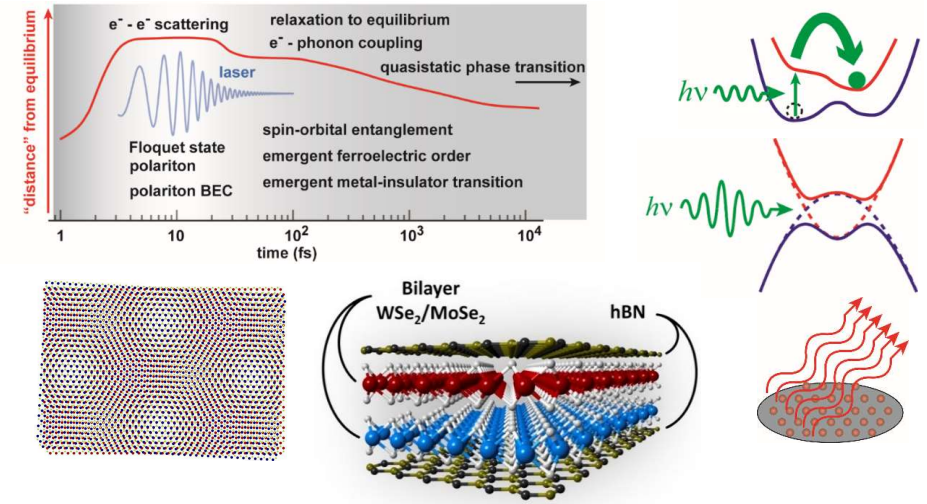
Eric Anslyn and Delia Milliron, co-leaders



Engineering nanocrystals, organic molecules, polymers, and biomolecules to create responsive and reconfigurable materials for photonics, water filtration, and energy storage

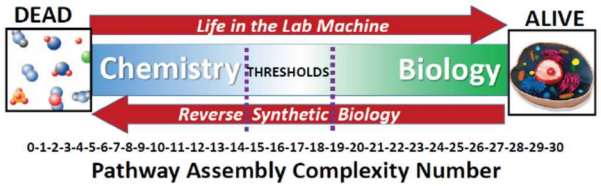
IRG 2: Materials Driven by Light

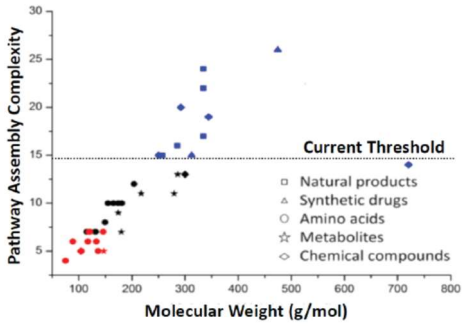
Elaine Li and Greg Fiete, co-leaders



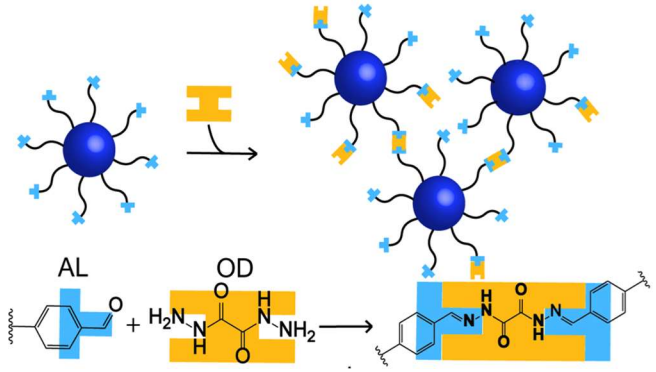
Using light to create new states of matter and engineer solid-state materials for photonics, electronics, and quantum information processing

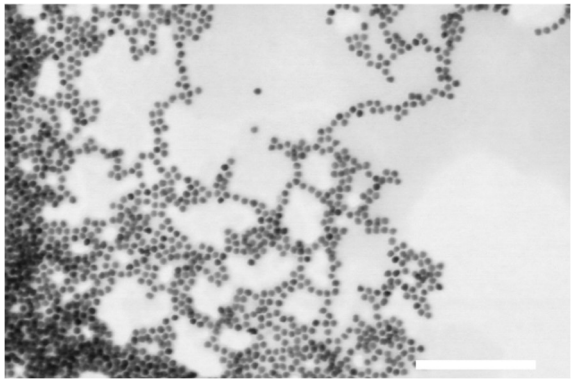
2018 SuperSeed: Universal Chemometrics for Living and Non-Living Materials

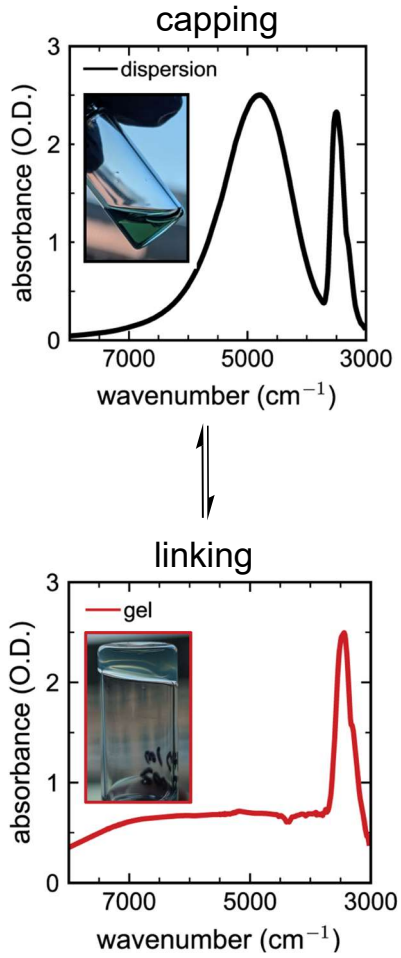


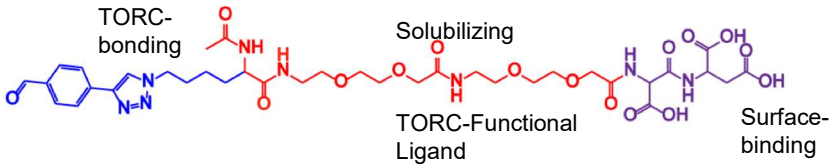


IRG 1: Reconfigurable Nanocrystal Assemblies









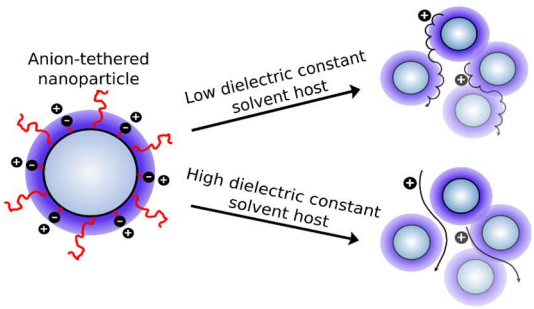
[MN Dominguez, MP Howard, JM Maier, S Valenzuela, ZM Sherman, LC Reimnitz, J Kang, SH Cho, SL Gibbs, AK Menta, DL Zhuang, A van der Stok, SJ Kline, **EV Anslyn, TM Truskett, DJ Milliron**, *Chem. Mater.* **32**, 10235-45 (2021).]

Dynamic covalent bonding enables reconfigurability between dispersed particles and gel, creating corresponding change in optical absorbance

IRG 1: Reconfigurable Nanocrystal Assemblies

Simulations (Ganesan, Truskett)

Coarse-grained simulations to clarify ion transport mechanism



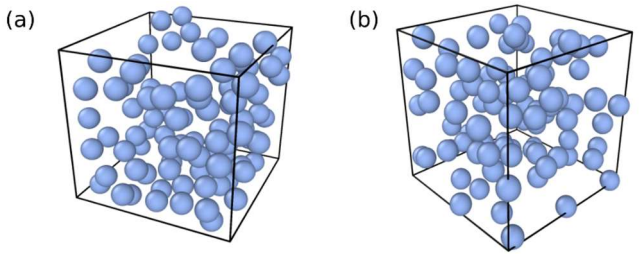
slower transport

faster transport

[S. Kadulkar, **D.J. Milliron, T.M. Truskett, V. Ganesan**, *J. Phys. Chem. Lett.* **11**, 6970–75, (2020).]

Machine-learning assisted discovery of optimal structures

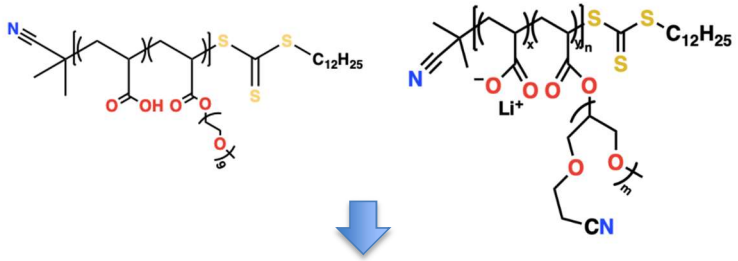
high conductivity | low conductivity



[S. Kadulkar, M.P. Howard, **V. Ganesan, T.M. Truskett**, *in preparation* (2021).]

Experiments (Milliron, Lynd)

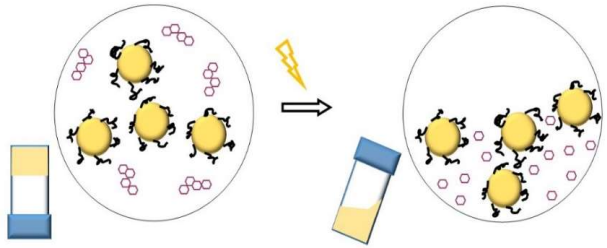
Synthesis of high dielectric constant polymers



Nanoparticle functionalization in high dielectric constant solvents

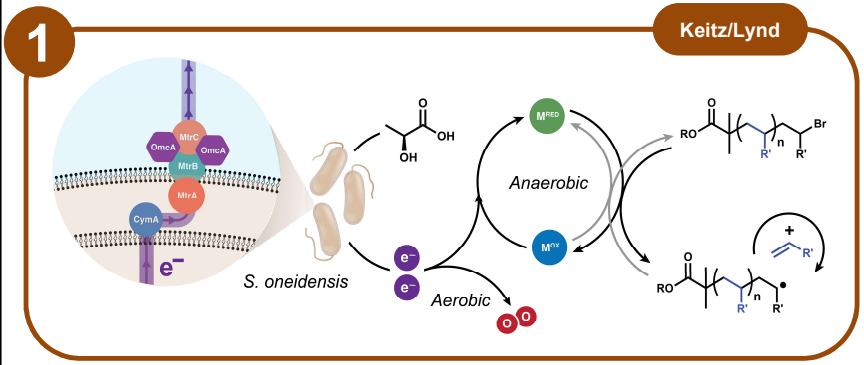
+

Depletant induced structural reconfigurability

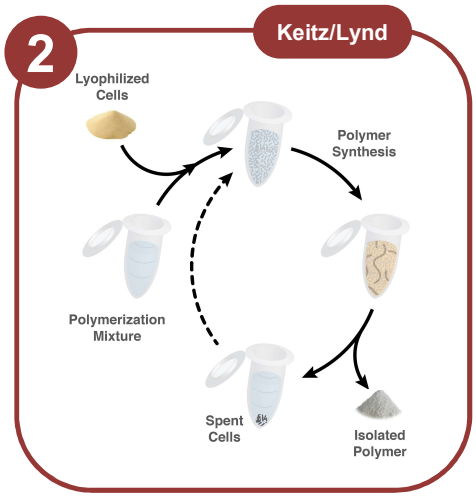


Interplay between simulation/machine learning, material synthesis, and characterization leads to new proposed concept for stimuli-responsive gel electrolytes for Li-ion battery applications

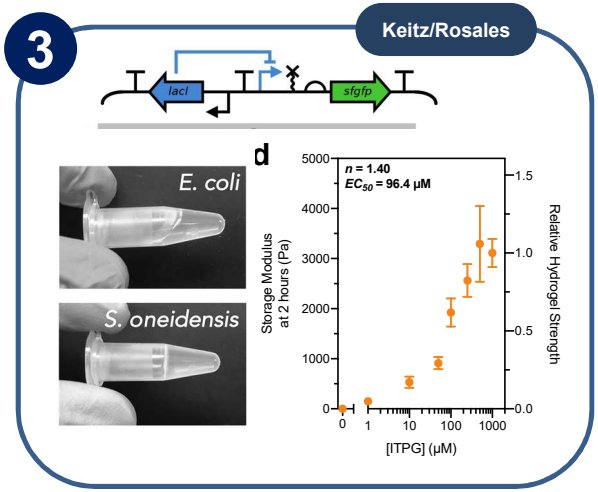
IRG 1: Reconfigurable Nanocrystal Assemblies



[Fan G, Dundas CM, Graham AJ, **Lynd NA, Keitz BK**. ***Proc. Natl. Acad. Sci. U. S. A.*** 2018; 115(18):4559-4564.]



[Fan G, Graham AJ, Kolli J, **Lynd NA, Keitz BK**. ***Nat. Chem***. 2020; 12:638-646.]



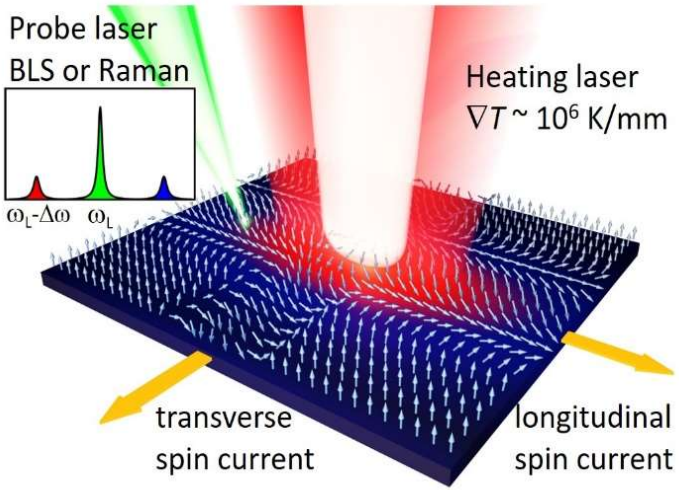
[Graham AJ, Dundas CM, Hillsley A, Kasprak DS, **Rosales AM, Keitz BK**. ***ACS Biomater. Sci. Eng***. 2020; 6(3):1375-1386.]

1. Extracellular electron flux (EET) from *Shewanella oneidensis* facilitates biological control over radical polymerization.

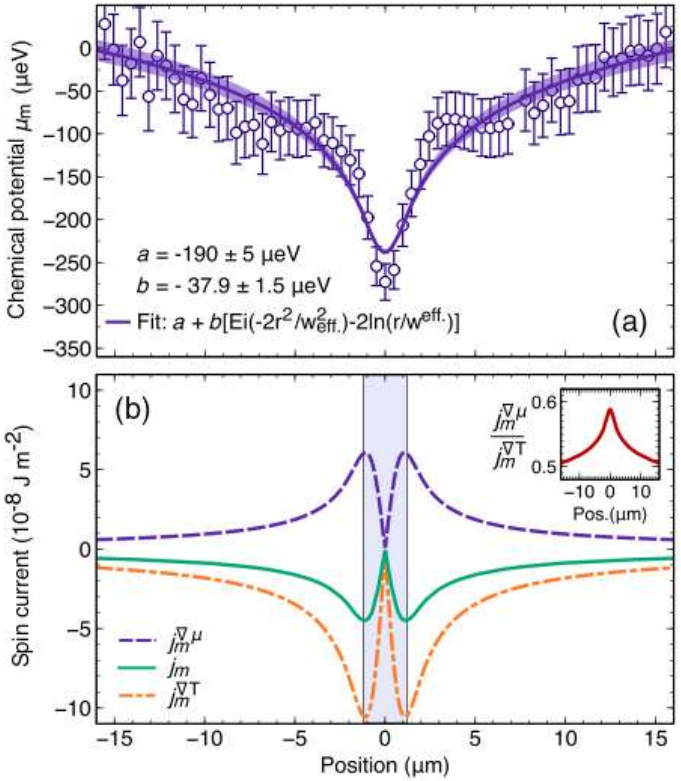
2. Microbial polymerizations can be performed under ambient conditions with lyophilized cells.

3. Controlled expression of EET-relevant genes allows for genetic control over hydrogel mechanics.

IRG 2: Materials Driven by Light



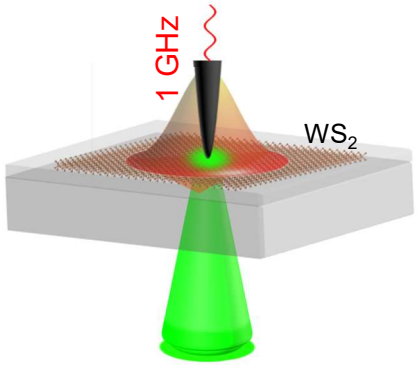
[KS Olsson, …, **GA Fiete, J Zhou, X Li**, *Phys. Rev. X* **10**, 021029 (2020).]

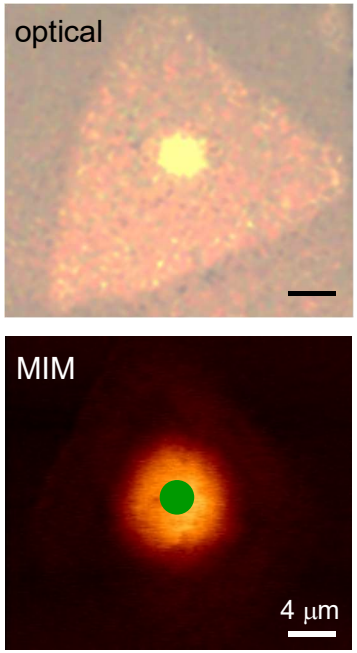


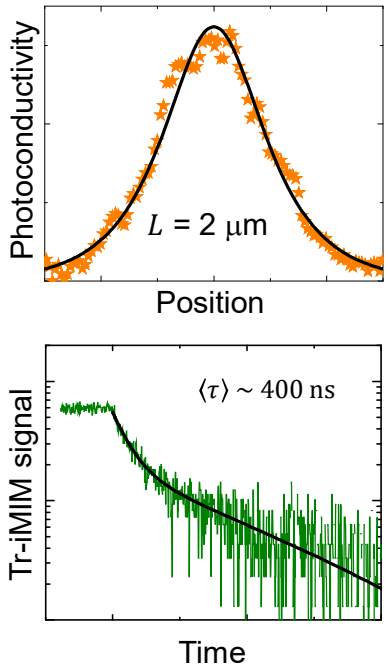
Laser heating combined with Brillouin scattering in $Y_3Fe_5O_{12}$ enables creation and characterization of nonequilibrium phonon and magnon (spin wave) excitations with distinct temperatures

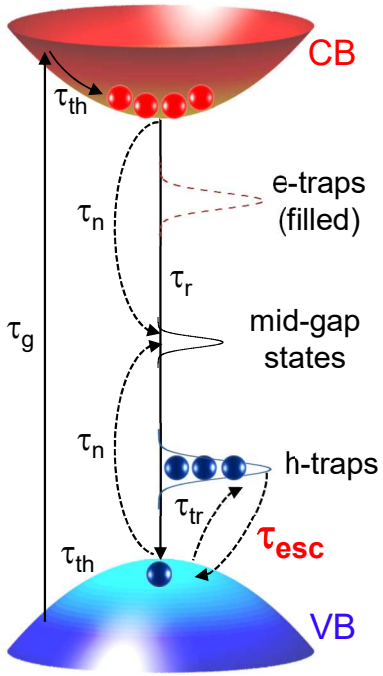
Formulation of magnon chemical potential enables quantitative assessment of temperature-driven and potential-driven spin currents

IRG 2: Materials Driven by Light





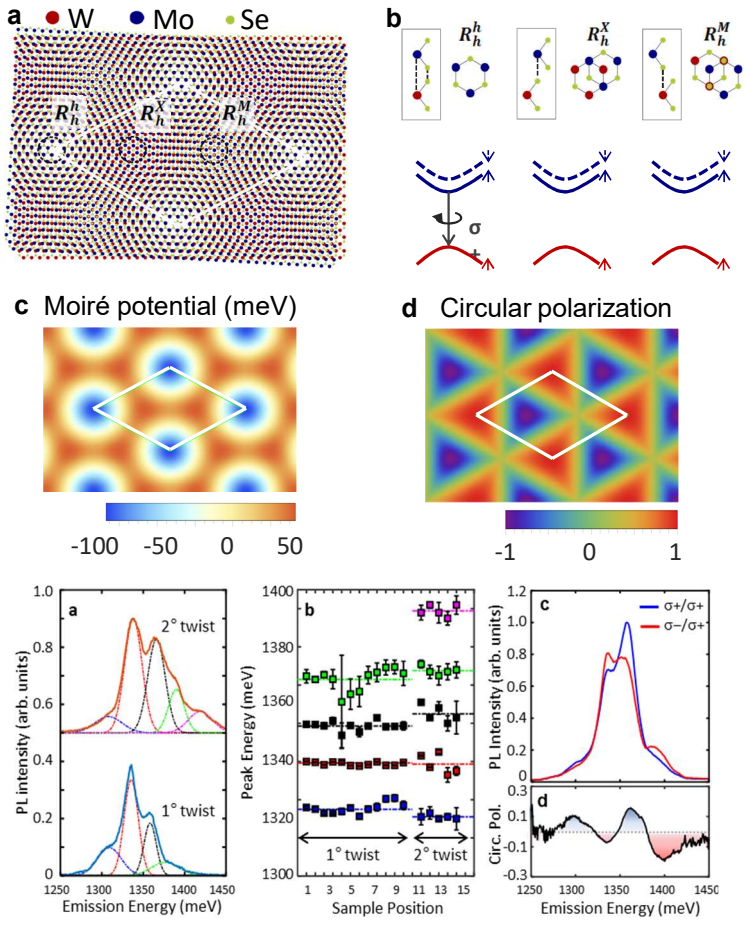




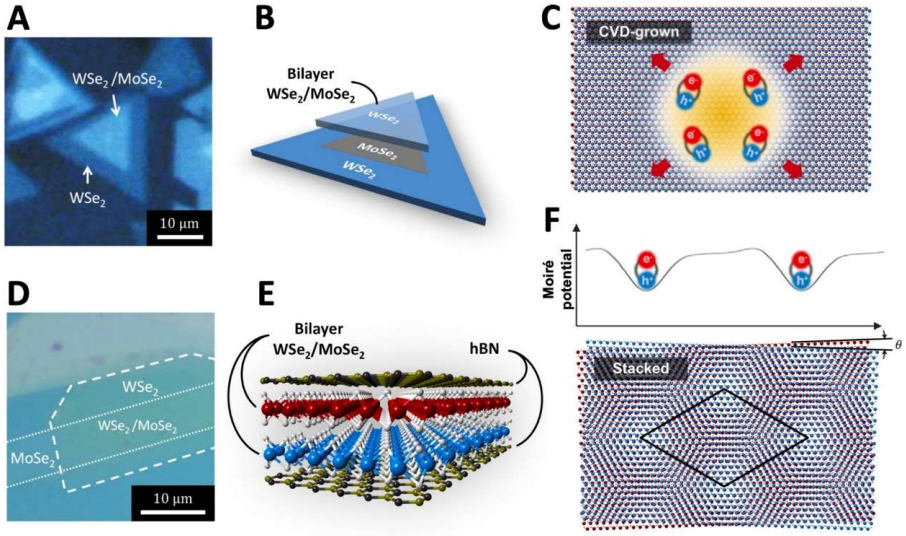
[ZD Chu, …, **AH MacDonald, XQ Li, CK Shih, KJ Lai**, *Proc. Natl. Acad. Sci. U.S.A.* **117**, 13908-13 (2020).]

Light-assisted microwave impedance microscopy (MIM) enables localized characterization of electrical conductivity, photoconductivity, minority carrier diffusion, carrier trapping dynamics at submicron length scales

IRG 2: Materials Driven by Light



[K Tran, …, **E Tutuc, AH MacDonald, X Li**, *Nature* **567**, 71 (2019).]



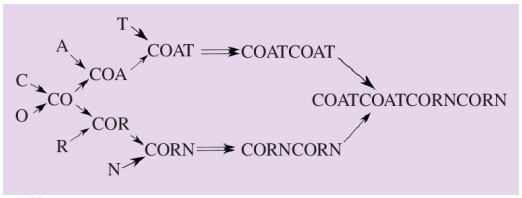
[J Choi, WT Hsu, …, **CK Shih, X Li**, WH Chang, *Sci. Advances* **6**, eaba8866 (2020).]

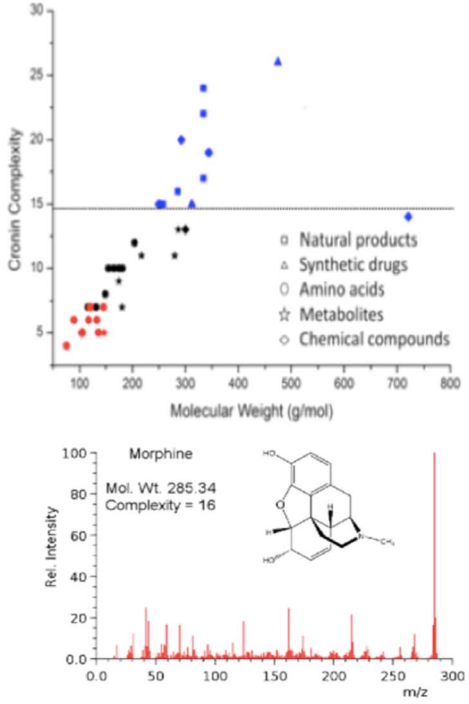
Rotational misalignment in transition metal dichalcogenide bilayers creates periodic potential modulation in Moiré superlattices

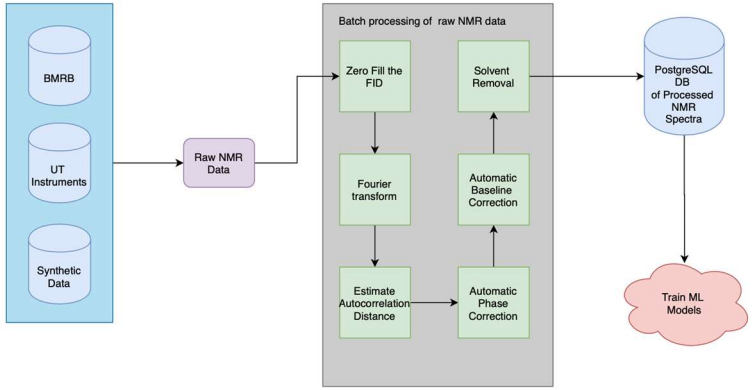
Exciton energy spacings and optical selection rules modulated by Moiré superlattice periodicity and local variations in atomic alignment between layers

Moire potentials offer route to highly controlled engineering of exciton confinement and diffusion at the nanoscale

2018 SuperSeed: Universal Chemometrics for Living and Non-Living Materials

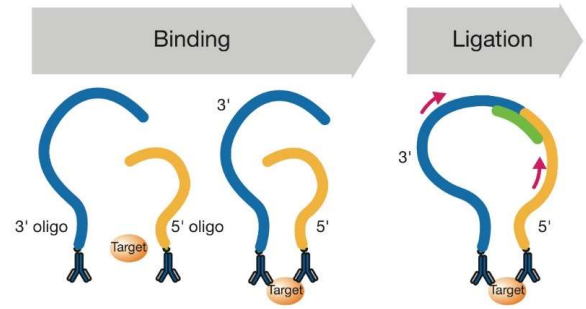






Machine learning for analysis of biotic and abiotic materials, e.g., from NMR spectra

+



Oligonucleotide tags and affinity reagents to characterize surface structure

Cronin pathway complexity quantifies assembly complexity of molecules and materials, and correlates with molecular weight, mass spectra, NMR, and other experimental measures

Creation of training data set combined with machine learning (DP4-AI source code) being used to explore patterns in biotic and abiotic materials, connecting to NSF Big Ideas on “Rules of Life” and “Data Revolution”

‘Sense’ materials by using statistical correlations between their chemical composition, oligonucleotide arrays that physically bind to them, and proximity of binding to create a DNA sequence space ‘fingerprint’ of the material

[Anslyn, Ellington, Marcotte, Korgel, Milliron]

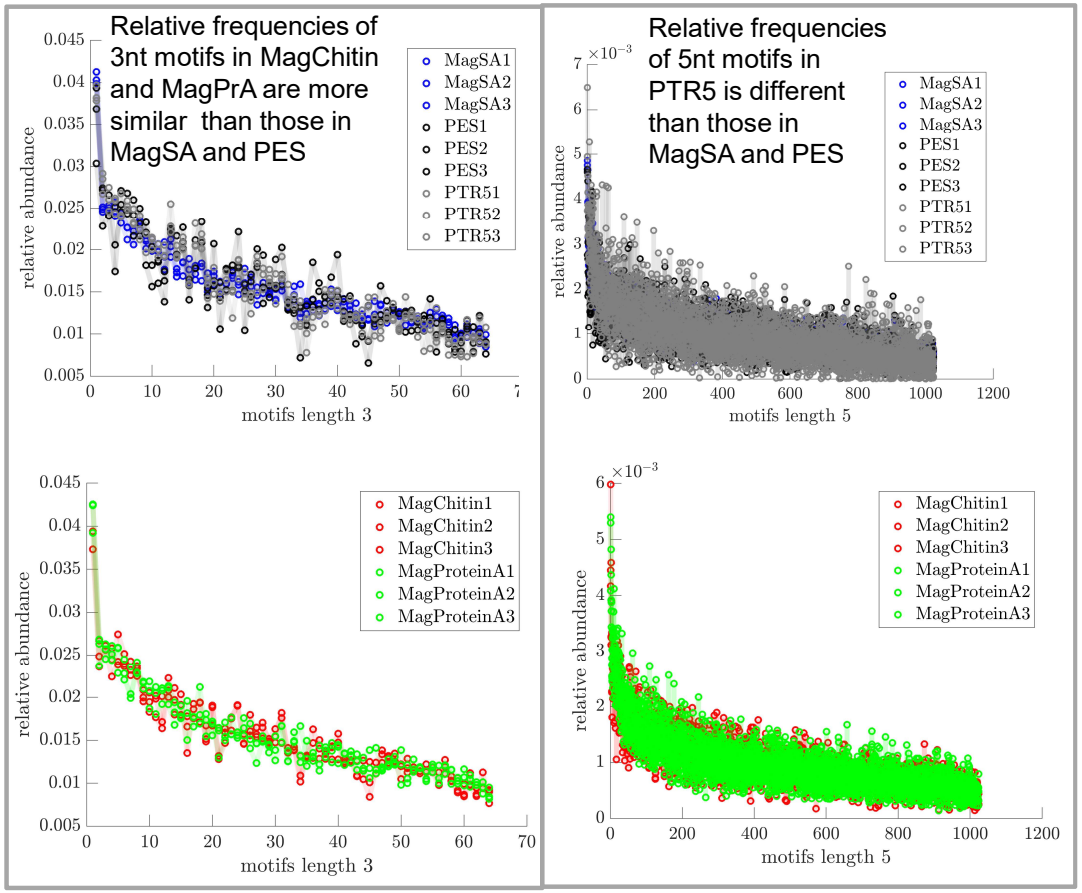
2018 SuperSeed: Universal Chemometrics for Living and Non-Living Materials

Samples sequenced

- Streptavidin (MagSA)
- Protein A (MagPrA)
- Chitin (MagChitin)
- Polyethersulfone (PES)
- Glass fiber conjugate (PTR5)

Samples being sequenced

- Probe libraries
- Background ligation and amplification products
- Streptavidin (MagSA) – with unbound probe library background
- ssDNA – with unbound probe library background



Confirmation that expected sized PLA products are being generated

Exploration and refinement of motif analysis goals and approaches for material distinction

Assessment of additional experimental and sequence information required for training the analyses

[**Anslyn, Ellington, Marcotte**, et al, in preparation (2021)]

Education and Outreach – Reaching Broad Audiences

MRSEC faculty visit to UT Rio Grande Valley

Bias Busting Workshop

Year	CDCM REU students		
	Total	Female	URM
2018*	5	4	1
2019	11	6	4
2020	14	6	5

* 2 REU students from 2018 are now Ph.D. students at UT Austin

Arts + Sciences Artist Residency Program

MRSEC – Art & Science Residency 2018

- Proactive outreach to underrepresented populations via faculty recruiting visits and REU program
- Events to foster diversity and inclusion
- Annual climate surveys, regular pulse checks and strategic assessments with center participants
- COVID-19 specific programming to address best practices, climate, mental health and well-being
- Arts+Sciences program promotes public awareness of and engagement with science

Education and Outreach – K-5 RET Program

"Many elementary school teachers, the proverbial jacks-of-all-trades, face a trio of issues when it comes to teaching science: they don't like science, they don't feel confident in their knowledge of science, and they don't know how to teach science effectively."

From R. Allen, *Priorities in Practice: The Essentials of Science, Grades K–6* (2006)

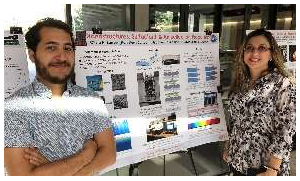
"If you don't get kids interested in science by the time they leave elementary school, it's usually too late."

Jo Ann Isken, Interim Program Director
Teacher Education Program UCLA

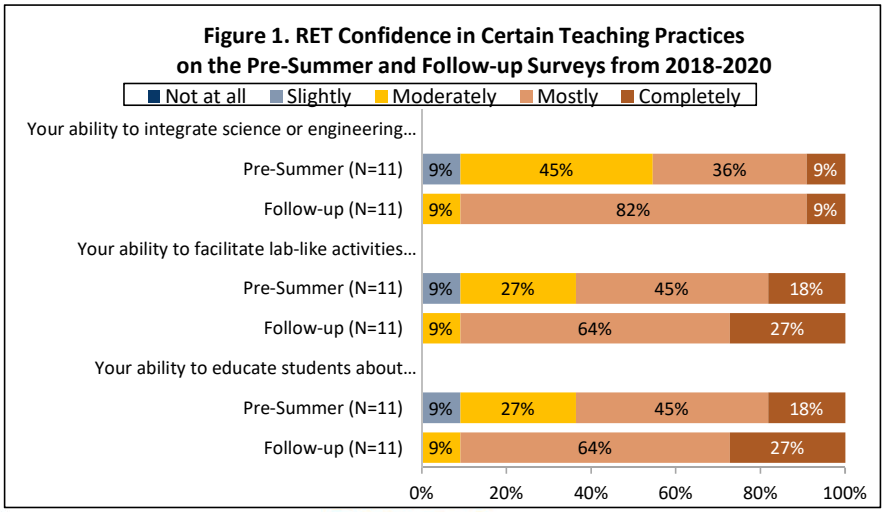
Elementary school students learn science best when they are involved in first-hand exploration and investigation [...]

National Science Teachers Association
http://www.nsta.org/about/positions/elementary.aspx

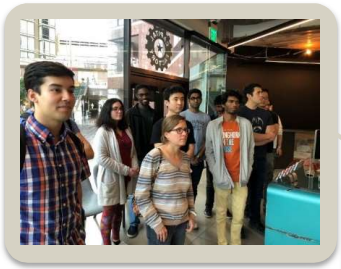
MRSEC RET Program Impact (2018-2020)	
Teachers in the RET Program	19
RET lessons created	19
Students impacted through RET lessons	>600
Conference/workshop presentations on RET lessons	8
RET class fieldtrips to MRSEC labs	5
Science Clubs initiated at RET schools	4
Past RETs serving as mentors in program	5

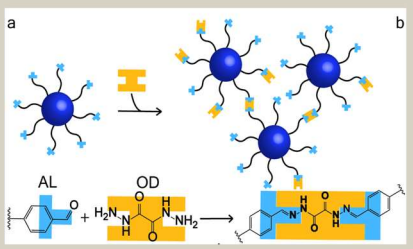


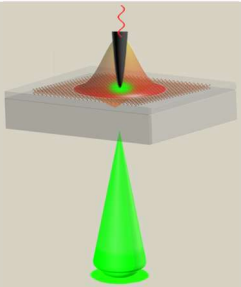
"This program has pushed me to think outside of the box when delivering lessons. Instead of just using canned science lessons that can often be dry and boring, it has pushed me to use up-to-date information and inquiry methods that truly get at the heart of flat sciences and excite the students into wanting to be more engaged." - *MRSEC RET participant*

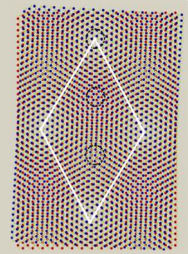


Summary









Texas Materials Community of Practice

CDCM seminars & summer schools

Entrepreneurial Greenhouse

IRG's

seed projects

external collaborations

Industry-University Nexus

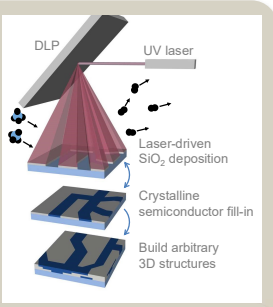
undergraduate research
REU | RET
partnership with UT FRI

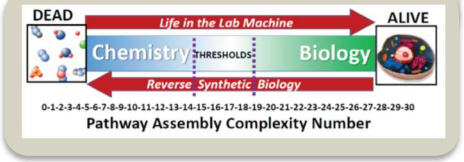
Arts+Sciences Stuff

student societies
minority serving institutions

K-5 | K-12

society at large





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