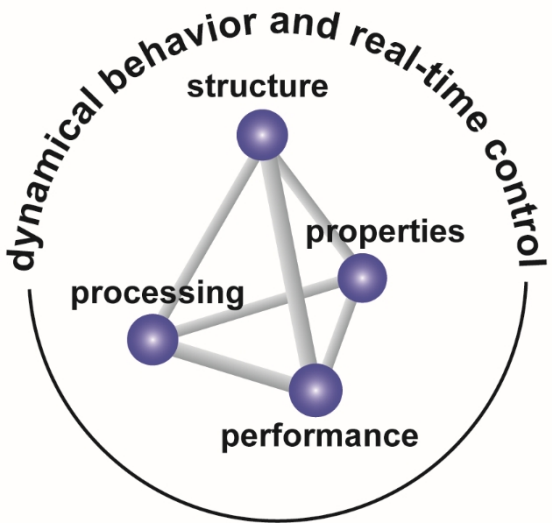
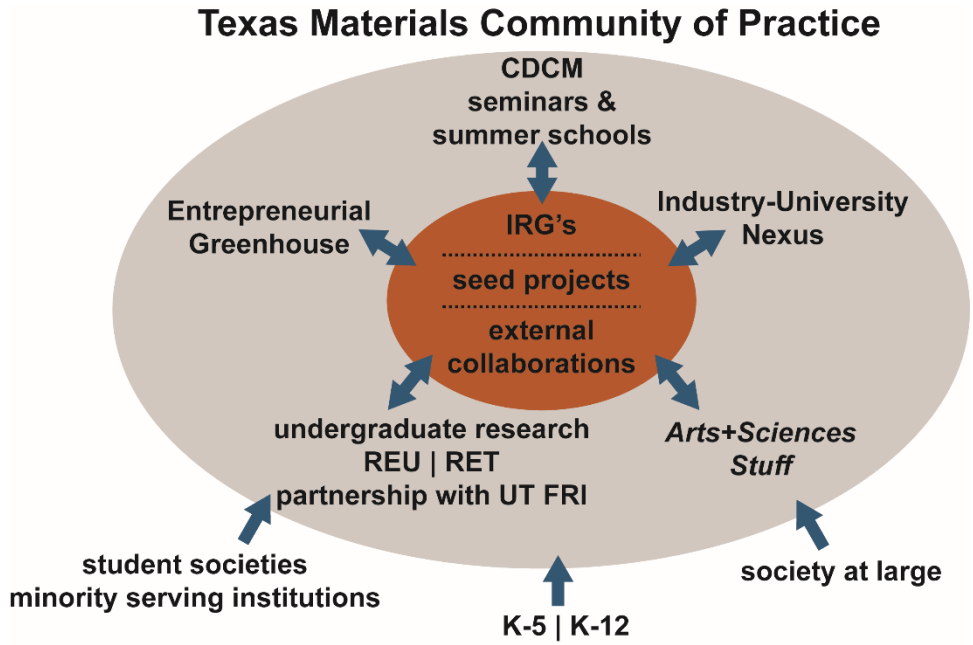
Center for Dynamics and Control of Materials: an NSF MRSEC

Edward T. Yu, Director
The University of Texas at Austin





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. Demkov (Ph)

A. Ellington (MB)

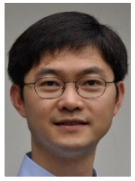
B. Freeman (ChE)

V. Ganesan (ChE)

R. Huang (AE)

R. Kaindl

J. Kono (Rice)


K. Lai (Ph)

K. Liechti (AE)

N. Lynd (ChE)

A. MacDonald (Ph)

A. Rosales (ChE)

K. Shih (Ph)

T. Truskett (ChE)

J. Zhou (ME)

T. Berry

C. Duckworth

B. Fang

R. Hartman

L. Garbrecht

C. Wood

J. Incorvia (ECE)

B. Keitz (ChE)

E. Marcotte (MB)

Otitoaleke Akinola
Mahshid Alamdar
Enrique Antunano
Debapriya Banerjee
Revanth Bodepudi
Junho Choi
Zhaodong Chu
Gabriel Cossio

Alex De Palma
Manuel Dominguez
Liang Du
Jacob Embley
Gang Fan
Thomas Fitzsimons
Claire Ganski
Yuqian Gu

Adrien Guillaussier
Wei Guo
Madisen Holbrook
Jennifer Imbrogno
Dan Ironside
Taizhi Jiang
Sanket Kadulkar

Suyogya Karki
Fardin Khabaz
Vikram Lakhanpal
Woojoo Lee
Xintong Li
Zongyao Li
Beth Lindquist
Soham Mane
Aniket Marne
Timothy Nunley
James Reuther
Camila Saez
William Sullivan

Kha Tran
Stephanie Valenzuela
Vinisha Venugopal
Emily Walker
David Wannlund
Andre Zepeda
Zhongjian Zhang

and many others ....

External Advisory Committee

Jillian Buriak
Professor of Chemistry
Canada Research Chair
University of Alberta
Materials chemistry

Sang-Wook Cheong
Board of Governors Professor
Director, Rutgers Ctr for Emergent Materials
Rutgers University
Physics of complex materials

Michael Doyle
Professor of Chemistry
Feik Distinguished University Chair
University of Texas at San Antonio
Organic and medicinal chemistry

Giulia Galli
Liew Family Professor
Institute for Molecular Engineering
University of Chicago
Computational materials science

James Hedrick
Distinguished Research Staff Member
Advanced Organic Materials
IBM Almaden Research Center
Polymers

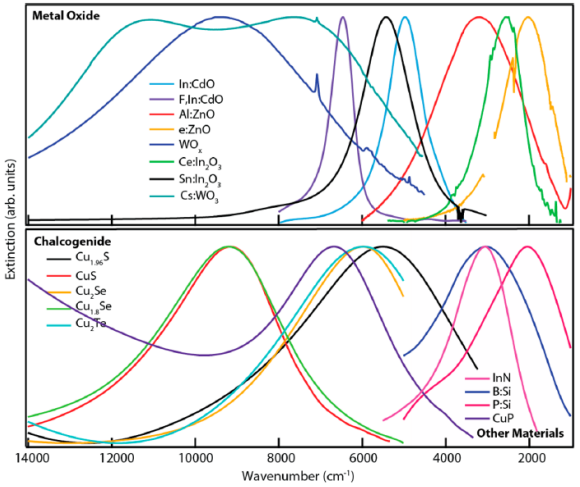
Chunqiang Li
Associate Professor of Physics
University of Texas at El Paso
Nonlinear optics and biophysics

Thomas Mallouk
Evan Pugh University Professor
Head, Department of Chemistry
Penn State University
Materials chemistry

Antoinette Taylor
Laboratory Fellow
Los Alamos National Laboratory
Ultrafast optical spectroscopy

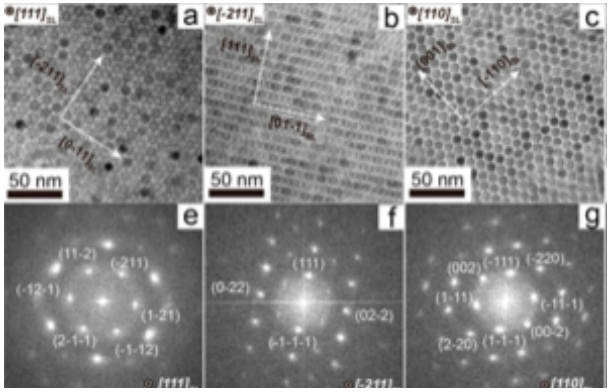
IRG 1: Reconfigurable Porous Nanoparticle Networks

Individual nanoparticles:



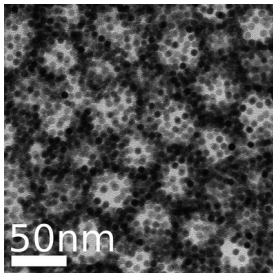
Milliron et al., *Chem. Rev.* (2018)

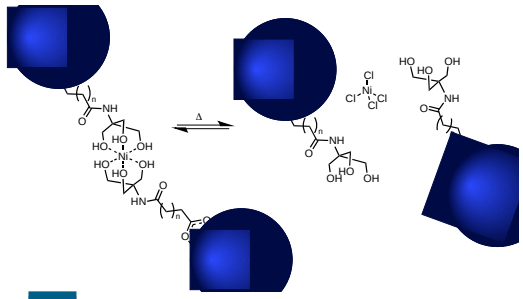
Static nanoparticle assemblies:

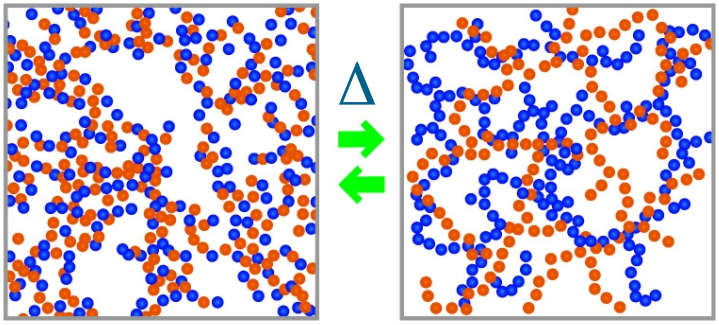


Korgel, Truskett et al., *Nano Lett.* **16**, 7814 (2016)

Dynamically controllable networks:







Eric Anslyn

Delia Milliron

MRSEC: DMR-1720595

2018

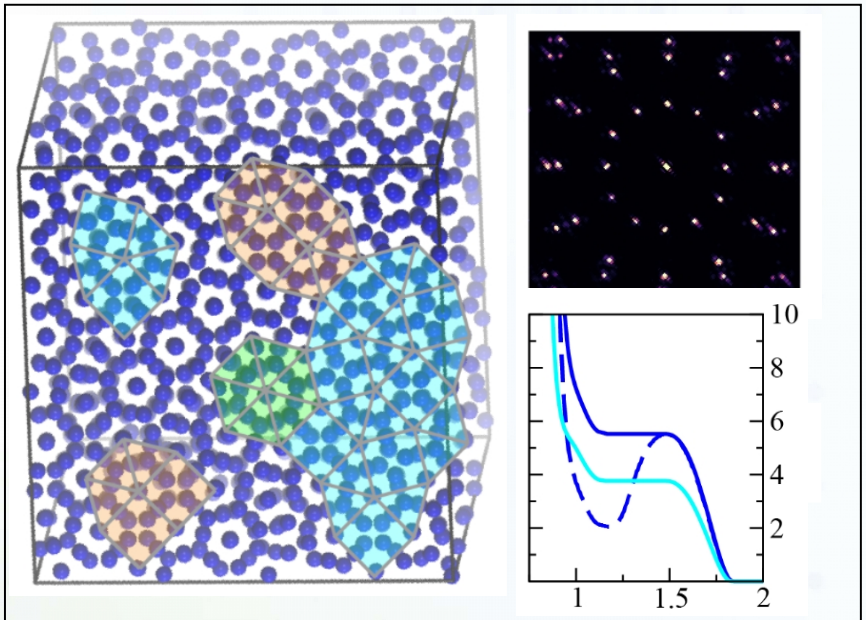
Inverse Design for Self-Assembly

T. M. Truskett: University of Texas at Austin

Spontaneous self-assembly of colloids into specific architectures is a promising strategy to fabricate novel materials with sub-micron features.

We have developed an inverse design methodology that allows for the discovery of interparticle interactions that self-assemble into a desired target structure *in silico*. We employed this approach to discover several pair potentials that prompt self-assembly of a variety of complex structures, including dodecagonal quasi-crystals (DDQCs, shown at right) and related periodic lattices.

With known pair potentials in hand, colloids can be intelligently designed that are predicted to self-assemble into complex structures that may possess novel material properties.



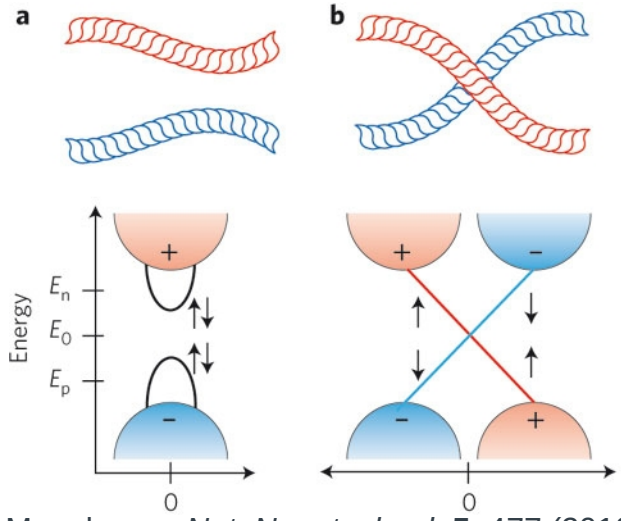
(left) Simulation snapshot of a DDQC with different square-triangle motifs highlighted. (top right) Corresponding diffraction pattern showing 12-fold symmetry. (bottom right) Interaction potentials that were discovered to prompt self-assembly of DDQCs.

NSF DMR DIVISION OF MATERIALS RESEARCH
DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES

B. A. Lindquist, R. B. Jadrich, W. D. Pineros, and T. M. Truskett, *J. Phys. Chem. B*, DOI:10.1021.acs.jpcb.7b11841 (2018).

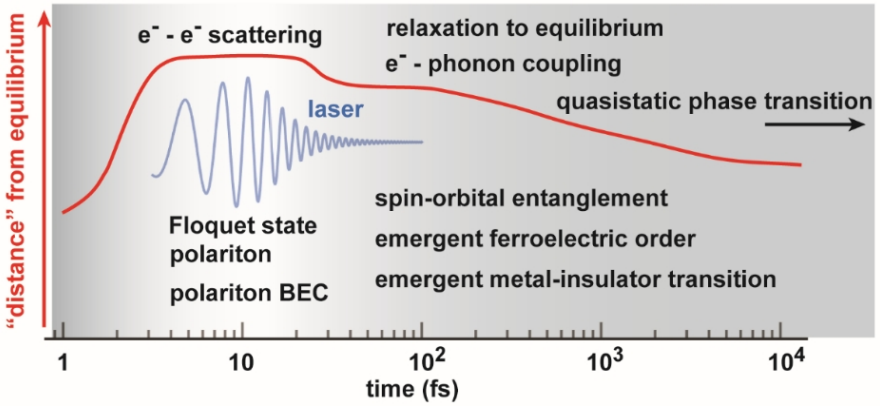
IRG 2: Materials Driven By Light

Band phenomena:

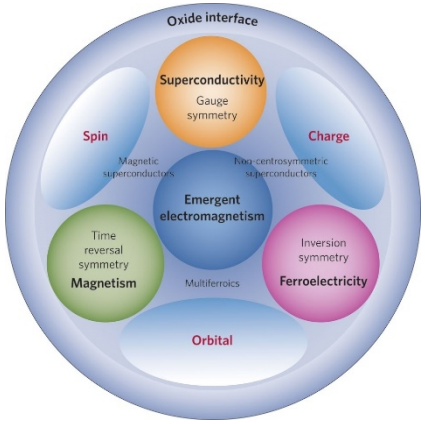


Manoharan, *Nat. Nanotechnol.* **5**, 477 (2010)

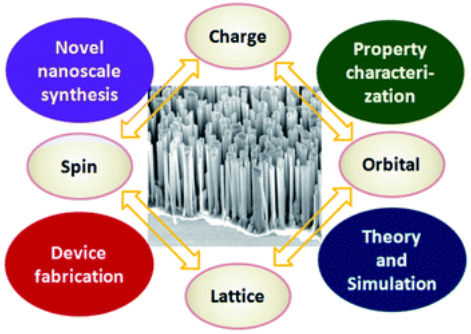
Dynamics and non-equilibrium behavior under optical excitation:



Correlated electron behavior:



Hwang et al., *Nat. Mater.* **11**, 103 (2012)



Wu et al., *Nanoscale* **4**, 1529 (2012)

Gregory Fiete

Elaine Li

MRSEC: DMR-1720595

2018

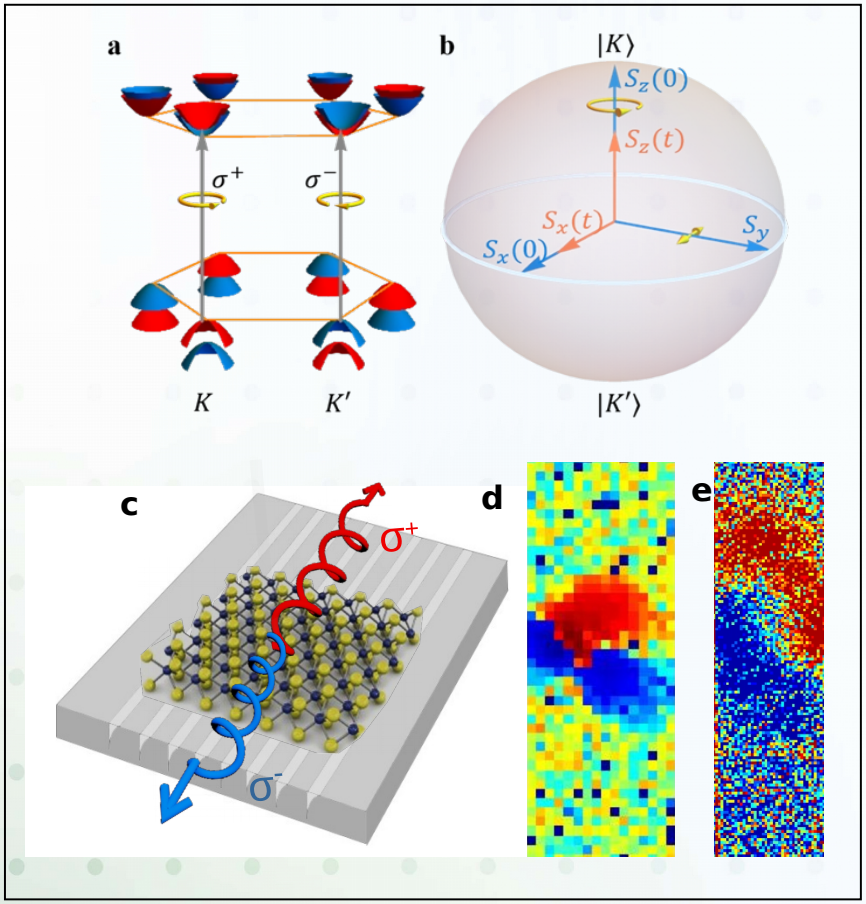
Routing Valley Excitons with a Metasurface

X. Li, A. Alu, C. K. Shih: University of Texas at Austin

The search for new quantum degrees of freedom has the potential for transformative impact on information processing technology. Currently, transistors or other switches in all electronic information processing devices rely on moving a puddle of electrons.

Valleys – extreme points in the energy band structure of periodic crystals – have been proposed as a new information carrier. In most materials, the valley degree of freedom does not couple to any external field. A unique situation in monolayer semiconductors has been discovered: light with opposite helicity may be used to control valley occupation.

We have discovered a new method to separate valley index using a designed metasurface. Excitons that carry different valley index are routed toward different directions in real space and momentum space, and photons emitted go to different directions according to their helicity.



DMR DIVISION OF MATERIALS RESEARCH
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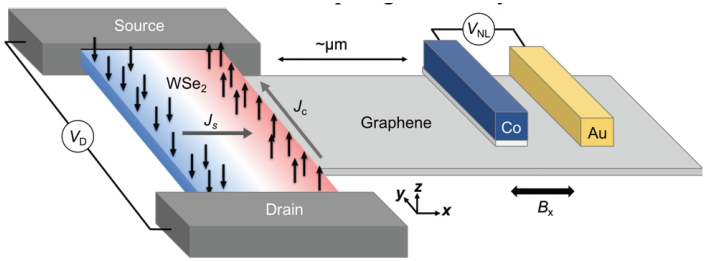
L. Sun, C. Wang, A. Krasnok, J. Choi, J. Shi, J. Gomez-Diaz, A. Zepeda, S. Gwo, C.-K. Shih, A. Alu, and X. Li, arxiv.org/abs/1801.06543 (2018).

Seed Programs

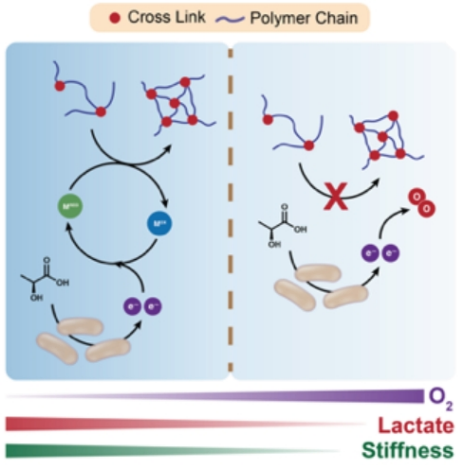
Measuring and Controlling Spin in Strong Spin-Orbit Coupling Low-Dimensional Materials

Jean Anne Incorvia



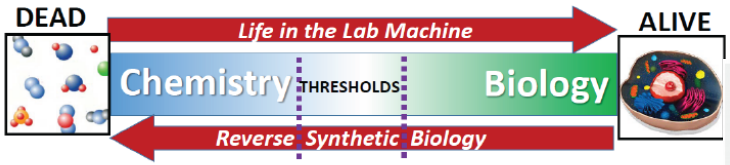
Responsive Polymer Networks Controlled via Bacteria

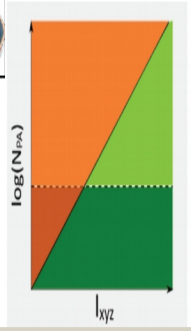
Benjamin (Keith) Keitz

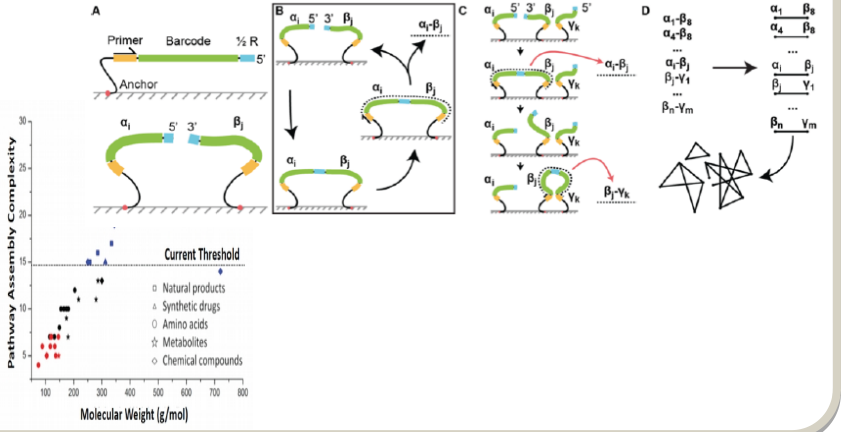


NSF SuperSeed: Universal Chemometrics for Living and Non-Living Materials

Eric Anslyn, Andy Ellington, Edward Marcotte, Brian Korgel, Delia Milliron



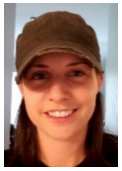




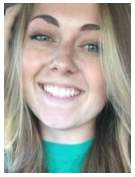
Education and Outreach Programs

REU/RET Summer Research Programs

2018 REUs:



2018 RETs:

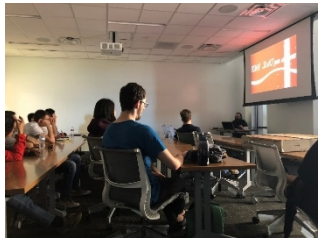
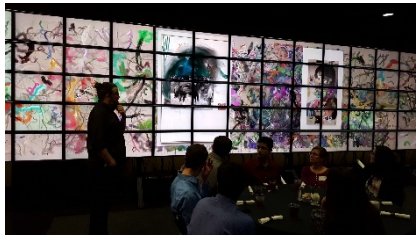


+5 REU's funded from other sources

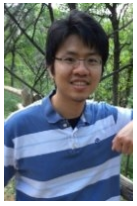
RET focuses on K-5 teachers

Arts+Sciences: Engaging New Audiences in Materials Science and Technology

CDCM Artist-in-Residence Siebren Versteeg:

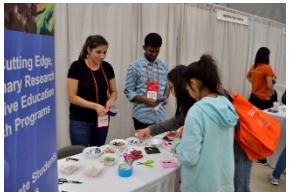
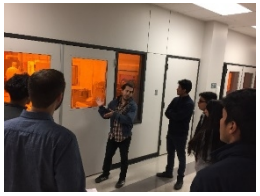



Student/Postdoc Professional Development



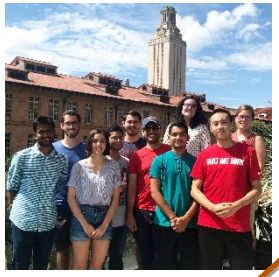
Panel Discussion – Post-PhD Career Paths:
Dr. Vaishno Dasika, Texas Instruments (Bank/Yu lab alum)
Dr. Daniel Derkacs, SolAero Technologies (Yu lab alum)
Dr. Jean Anne Incorvia, UT Austin ECE faculty
Dr. Ping-Chun Li, Intel (Yu lab alum)
Dr. Danielle Smith, Phillips 66 (Korgel lab alum)

Outreach Activities (~monthly)

Summary

After 15 months….



Texas Materials Community of Practice

CDCM seminars & summer schools

Entrepreneurial Greenhouse

IRG's

seed projects

external collaborations

Industry-University Nexus

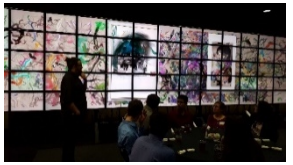
undergraduate research
REU | RET
partnership with UT FRI

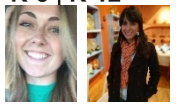
Arts+Sciences Stuff

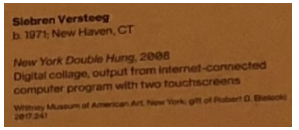
student societies
minority serving institutions

K-5 | K-12

society at large

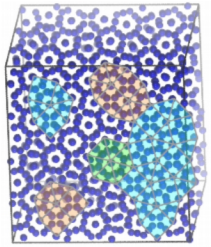




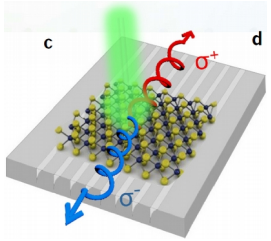


The Center for Dynamics and Control of Materials (CDCM) is supported by the National Science Foundation under NSF Award Number DMR-1720595. Additional support is provided by The University of Texas at Austin.

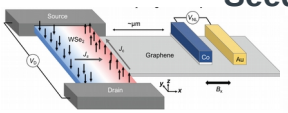
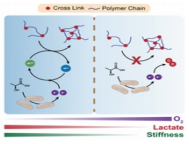
IRG 1

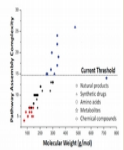


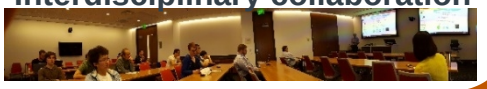
IRG 2



Seed projects



Facilities

Interdisciplinary collaboration