The UC Santa Barbara MRSEC: Director's Virtual Meeting, 2021

National Science Foundation
MRSEC
Materials Research Science and Engineering Centers

UC SANTA BARBARA
MRL
Materials Research Laboratory

NSF Materials Research Science and Engineering Center [DMR 1720256]

Center Background: Vision of Sustained Excellence with Innovative New Directions

The UC Santa Barbara MRSEC:

- Is a collaborative research and training infrastructure to advance materials science in the national interest.
- Involves a diverse group of committed participants working collectively toward transformative research outcomes, while nurturing future leaders in materials research who address societal needs and impact job creation.
- Emphasizes ***fundamental understanding of materials that will have sustained utility and impact beyond the duration of the project***, especially through the development of methods and tools.

All three key components, the **IRG** and **Seed** research, **Education** and **Outreach**, and **Shared Facilities (SEFs),** synergistically engage K–12 students and teachers, undergraduate research interns, graduate student and postdoctoral researchers, faculty investigators and facilities staff, other collaborators, start-up researchers, and more established industry partners.

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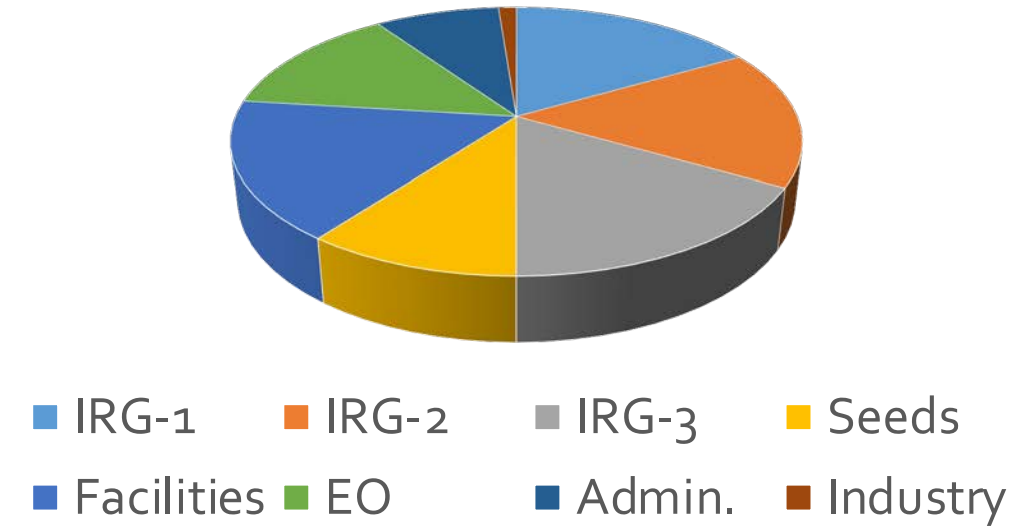
IRGs (all new in 2017), leadership changes, and budget allocation

New IRG Selection: Town hall followed by down-selection from 6 to 3 with help from EAB.

- IRG-1: Magnetic Intermetallic Mesostructures [*Dan Gianola*, *Stephen Wilson*]
- IRG-2 Polymeric Ionic Liquids [*Rachel Segalman*, Glenn Fredrickson]
- IRG-3 Resilient Multiphase Soft Materials [*Matt Helgeson*, Megan Valentine]

Chris Bates is the new Associate Director, taking over from **Ania Jayich** (who now co-Directs the NSF Q-Amase-I Quantum Foundry)

Allocation of resources



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Seeds [DMR-appropriate, investigators not previously supported, a plan for evolution]

First round (Awards made in March 2018) emphasizing ***Quantum Leap***:

Search for Majorana Fermions in Topological Superconductors
John Harter (Materials, Assistant Professor), **Cenke Xu** (Physics)

Perturbing Topological Crystalline Insulators with Strain, Dopants, and Ferroelectricity, **Kunal Mukherjee** (Materials, Assistant Professor)

Point Defects in Boron Nitride for Quantum Information Science
Chris Van de Walle (Materials)

All involved in the NSF Q-AMASE-I Quantum Foundry

Second round (Awards made March 2019)
Selecting for phase-separating nucleic acid coacervates, **Irene Chen** (Chemistry & Biochemistry), **Omar Saleh** (Materials)

Electronic structure and scattering mechanisms in twisted bilayer graphene, **Andrea Young** (Physics), **Vojtech Vlcek** (Chemistry & Biochemistry)

MATERIALS RESEARCH SCIENCE AND ENGINEERING CENTER AT UCSB

PROPOSAL CALL FOR SEED GRANTS

We are happy to announce this proposal call for a Seed Project from UCSB faculty, to start March 1, 2019, providing research support of up to $300,000: $150,000 per year for two years (the amount includes indirect cost/overhead).

Early-career faculty investigators venturing in new directions, and investigators who have not previously collaborated together are strongly encouraged to apply. Proposals involving jointly-advised students and postdoctoral fellows are particularly welcomed.

Review criteria will address: [1] Is the proposed research area **appropriate for NSF DMR** support? [2] Are the investigators new to the MRSEC? While Seed applicants are urged to seek collaborations with MRSEC Interdisciplinary Research Groups, currently supported investigators cannot receive new Seed support. [3] Will the research advance the UCSB MRSEC vision of collaborative materials research with the potential for transformative outcomes?

The proposals (3 pages max., including a brief budget and references) should be submitted as a single PDF file to Sara Bard (Administrative Manager – sara@mrl.ucsb.edu) by Thursday, January 31th 2019.

Prior to submission, applicants are strongly urged to contact:
Ania Jayich, Associate Director: ania@physics.ucsb.edu
Ram Seshadri, Director: seshadri@mrl.ucsb.edu

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Seeds: iSuperSeed2 from MRSEC, September 2018

Shape from Activity-Driven Folding: A Path to Materials Morphogenesis [Rules of Life Big Idea]

Mark Bowick, KITP and Physics
Zvonimir Dogic, Physics
Cristina Marchetti (lead), Physics
Sebastian Streichan, Physics (Assistant Professor)

Enhancing STEM through Diversity and Inclusion [Includes Big Idea] (jointly to CU Boulder MRSEC and UC Santa Barbara (Dr. Dorothy Pak)]

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Center Background: 598 publications thus far acknowledging 1720256 [≈70 % from SEFs]

COVID-19: Education/Outreach activities continue virtually [Dr. Dorothy Pak]

The Materials Science of Chocolate (local schools)

Processing: pure cocoa is too bitter, we need additional ing

	White Chocolate	Milk Chocolate	Dark Chocolate
Cocoa Solids	≈ 0%	≥ 10%	≥ 35%
Cocoa Butter	≥ 20%	---	---
Sugar	≤ 55%	---	---
Milk Solids	≥ 14%	≥ 12%	< 12%
Milk Fat	≤ 3.5%	≥ 3.39%	---

Source: US FDA, CFR Title 21 (2019)
--- indicates no restrictions placed on this ingredient

Summer REU

Public Outreach

Materials Mondays

A virtual presentation of materials research, aimed at all audience levels, and presented by current and past researchers from the Materials Research Laboratory

Zoom Link: https://ucsb.zoom.us/j/82825992338
Mondays at 4:30 pm, approximate duration: 30 min. to 45 min.

art by Dr. Lingling Mao

January 25, 2021 – Dr. Angela Pitenis
Assistant Professor, Materials Department
Lessons from the Lollipop: Friction, Wear, and Corrosion

February 1, 2021 – Dr. Prajakta Kulkarni
Founder and President, SciKare Inc.
Smart Devices for Early Detection of Diseases

February 8, 2021 – Timnit Kefela
Graduate Student, Bren School of Environmental Science & Management
Small but Mighty: Microplastics in Our Urban Environments

Materials Research Laboratory: An NSF MRSEC
University of California Santa Barbara
http://www.mrl.ucsb.edu

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IRG-1: Magnetic Intermetallic Mesostructures

Participating Faculty:
Dan Gianola (Matrl.) – IRG Co-Leader
Stephen Wilson (Matrl.) – IRG Co-Leader
Irene Beyerlein (Mech. Eng. & Matrl.)
Samantha Daly (Mech. Eng.)
Ania Jayich (Physics)
Tresa Pollock (Matrl.)
Ram Seshadri (Matrl. & Chem.)
Anton Van der Ven (Matrl.)

Affiliates:
Leon Balents (UCSB).
Marc de Graef (CMU),
Olivier Thomas (Aix-Marseille)

Expertise spanning bulk crystal synthesis, multiphasic microstructure control and prediction, alloy design, 3D materials characterization, strain mapping, local magnetism probes, multiscale modeling

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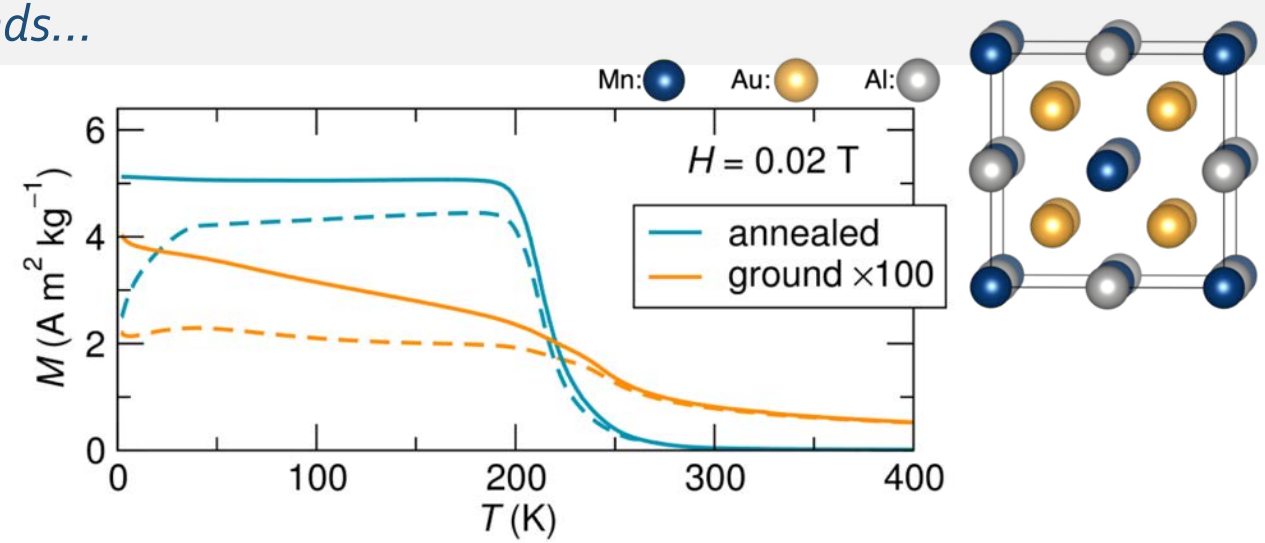
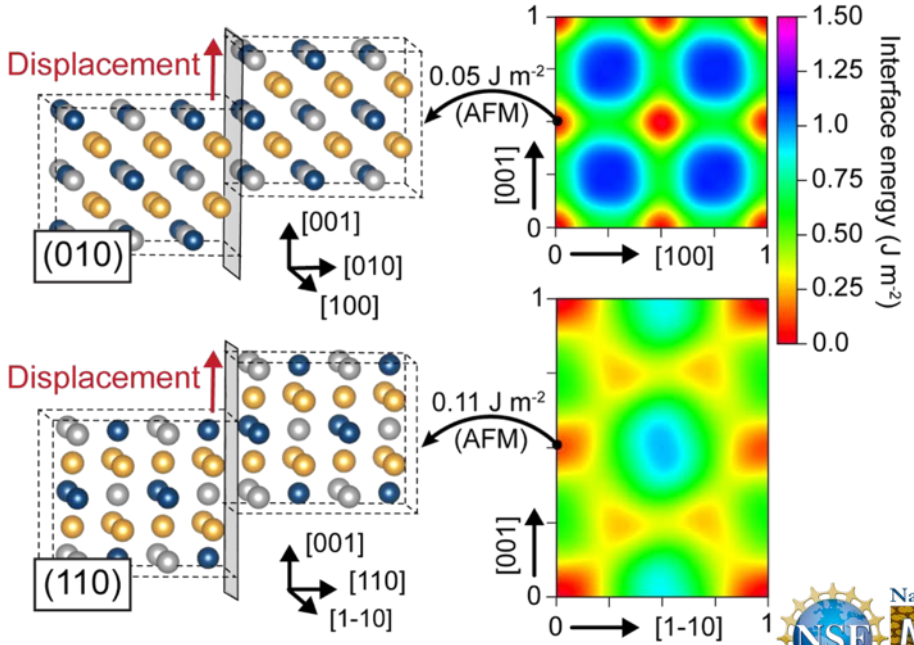
IRG-1: Magnetic Intermetallic Mesostructures

… to understand and develop control over the couplings between strain, magnetization, and temperature (entropy) in single– and multiphase intermetallic compounds…

Heusler $MnAu_2Al$:

- Dramatic change in net magnetization in response to plastic deformation
- Antiferromagnetic interactions in the otherwise ferromagnetic compound (when ordered)
- Chemical changes at the antiphase boundaries created by the deformation





Influence of plastic deformation on the magnetic properties of Heusler $MnAu_2Al$, Levin, Kitchaev, Eggeler, Mayer, Behera, **Gianola**, **Van der Ven**, **Pollock**, **Seshadri**, *Phys. Rev. Mater.* **5** (2021) 014408.

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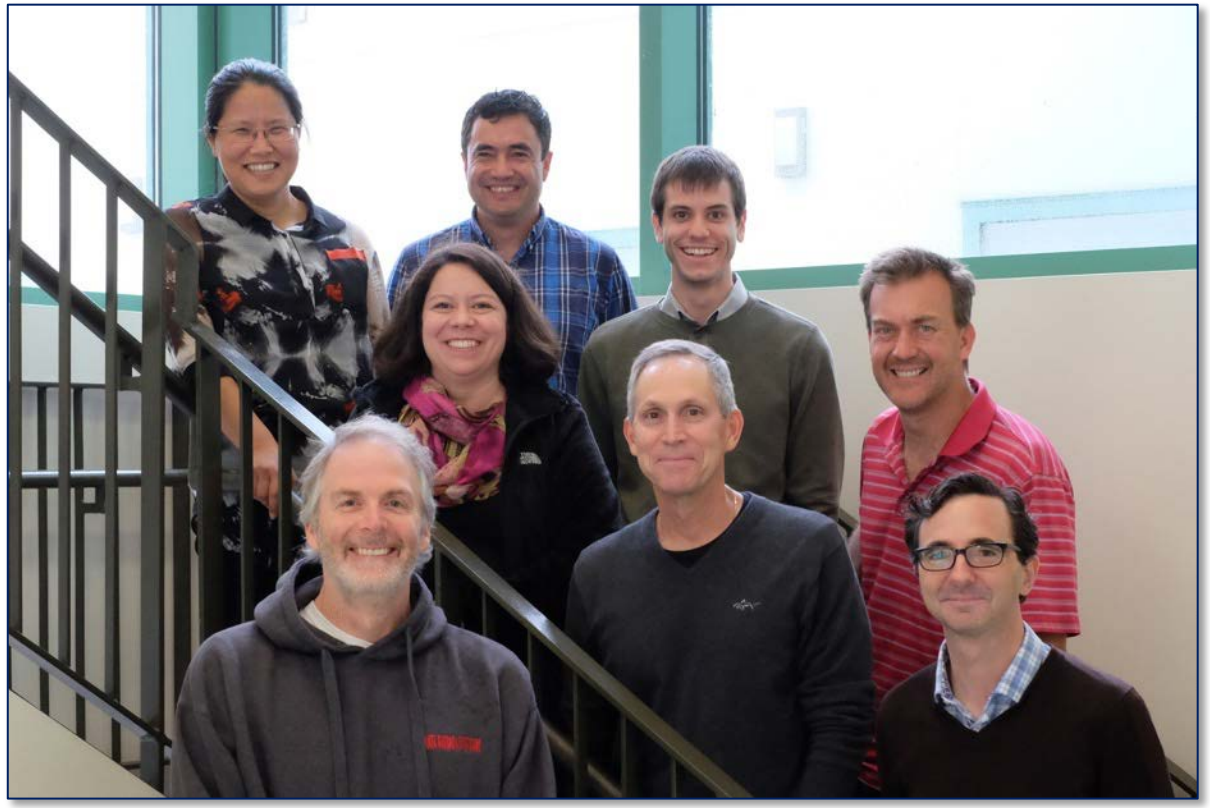
IRG-2: Polymeric Ionic Liquids

Participating Faculty:
Rachel Segalman (Chem. Eng. & Matrl.) Co-Leader
Glenn Fredrickson (Chem. Eng. & Matrl.) Co-Leader
Christopher Bates (Matrl.)
Michael Chabinyc (Matrl.)
Raphaële Clément (Matrl.)
Songi Han (Chem. & Chem. Eng.)
Craig Hawker (Matrl. & Chem.)
Javier Read de Alaniz (Chem.)
Todd Squires (Chem. Eng.)

Affiliates:
Philip Pincus, Omar Saleh (UCSB)
Amalie Frischknecht (Sandia)

Expertise spanning polymer synthesis, photochromic materials design, electrochemistry, advanced structural, mechanical, and property characterization, multi-scale modeling



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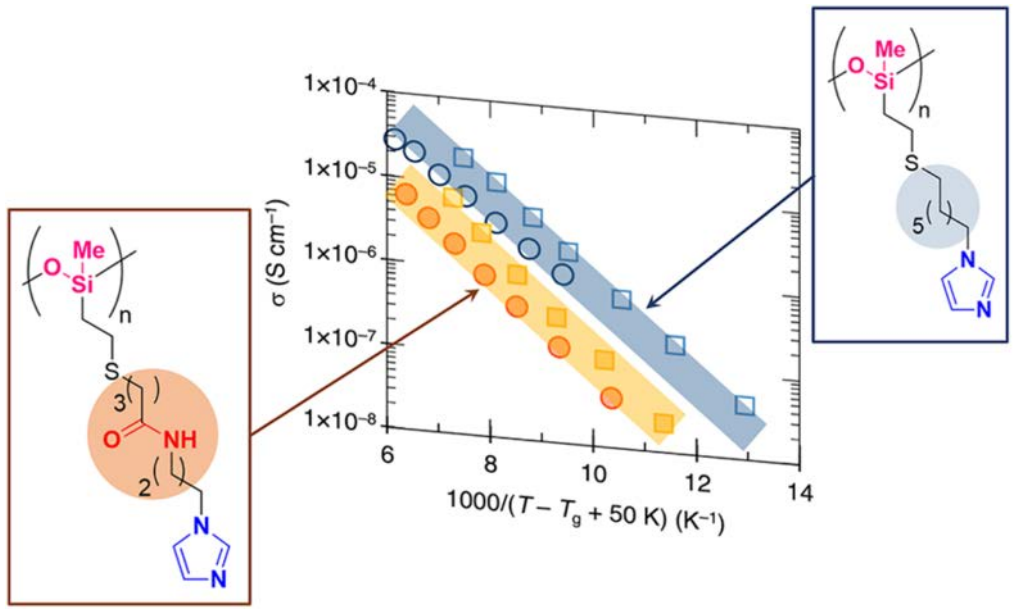
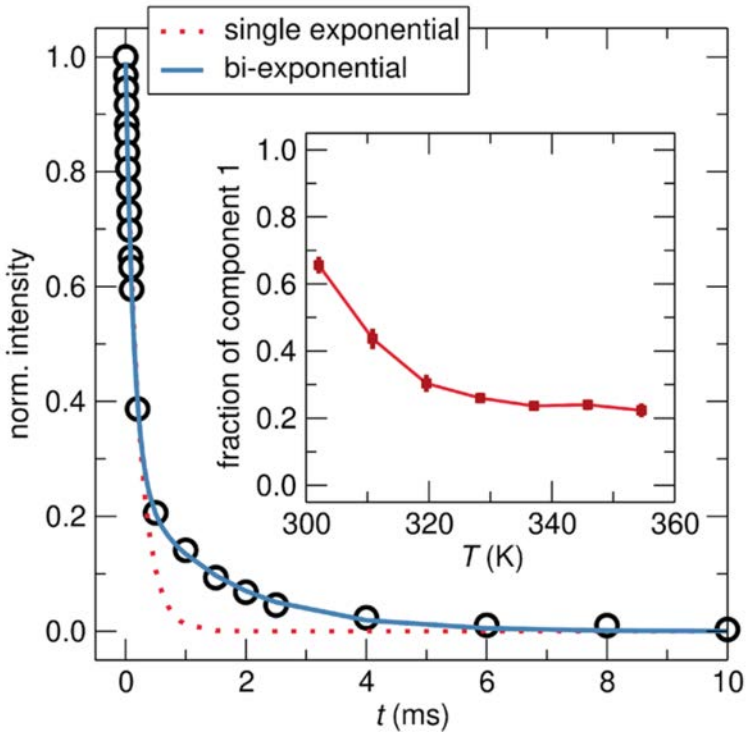
IRG-2: Polymeric Ionic Liquids

… connecting molecular architecture and charge physics with material properties in polymeric ionic liquids to advance diverse applications including electrochemical membranes and soft robotics…

Subtle associations within the polymer electrolyte entrain both the anion and the cation.

- When removed, the conductivity increases by almost two orders of magnitude.
- Enhancement only partially attributable to the decreased glass transition temperature
- Li^+ t_+ increases to 0.43 as measured using pulsed-field-gradient NMR.





Glass transition temperature and ion binding determine conductivity and lithium–ion transport in polymer electrolytes, Schauser, Nikolaev,… **Clément, Read de Alaniz, Segalman**, *ACS Macro Lett.* **10** (2021) 104–109.

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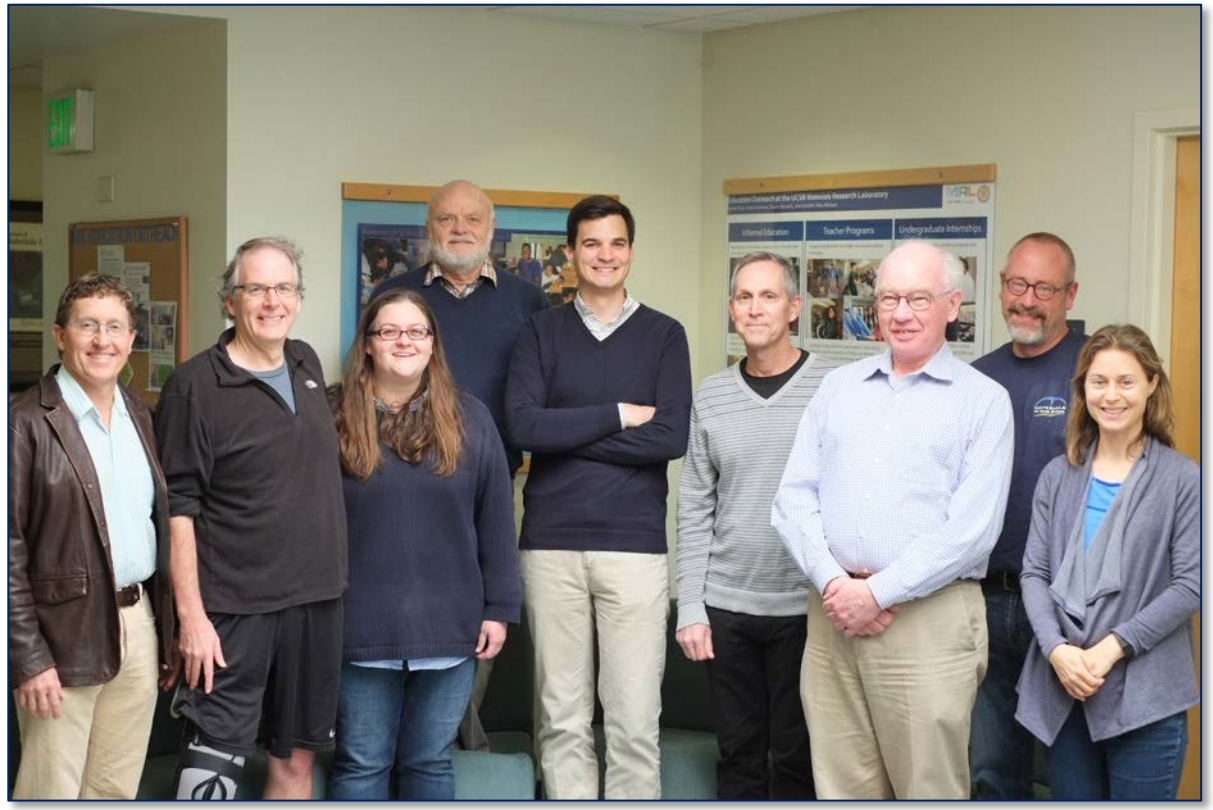
IRG-3: Resilient Multiphase Soft Materials

Participating Faculty:
Matt Helgeson (Chem Eng.) – Co-Leader
Megan Valentine (Mech. Eng.) – Co-Leader
Matt Begley (Mech. Eng. & Matrl.)
Brad Chmelka (Chem. Eng.)
Glenn Fredrickson (Chem. Eng. & Matrl.)
Craig Hawker (Chem. & Matrl.)
Robert McMeeking (Mech. Eng. & Matrl.)
Angela Pitenis (Matrl.)
Joan Shea (Chem. & Physics)
J. Herbert Waite (MCD Bio., Chem. & BMSE)



Affiliates:
François Barthelat (McGill University)
Claus Eisenbach (U. Stuttgart)

Expertise spanning marine/molecular biology, organic & biochemical synthesis, multi-scale materials characterization, fluid mechanics and rheology, atomistic simulation, polymer thermodynamics & mesoscale modeling, colloidal assembly, microfluidics, solid mechanics

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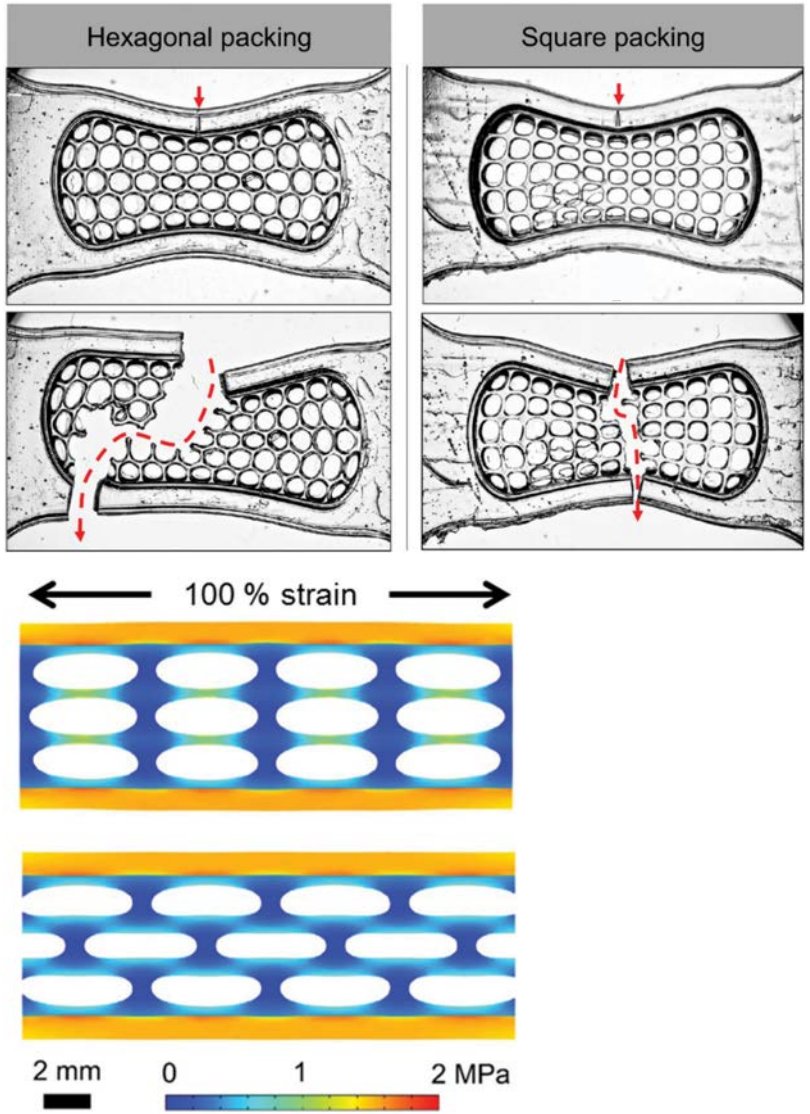
IRG-3: Resilient Multiphase Soft Materials

… provide the foundational design rules for creating new classes of versatile, multiphase soft materials …

Multimaterial printing approach (solution mask liquid lithography) used to produce porous polymer–polymer composites inspired by tough, hierarchical structures found in nature.

- Varying the size and packing of pores in the core structure leads to significant enhancement in crack deflection.
- Finite element analysis reveals geometry-dependent stress distribution.



Engineering crack tortuosity in printed polymer– polymer composites through ordered pores, Gockowski, … **McMeeking, Hawker, Valentine,** *Mater. Horiz.* **7** (2020) 1854

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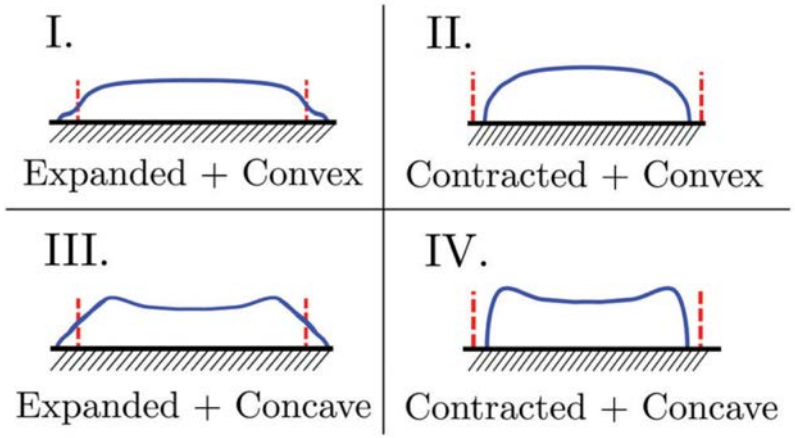
iSuperSeed2: Shape from activity-driven folding: A path to materials morphogenesis

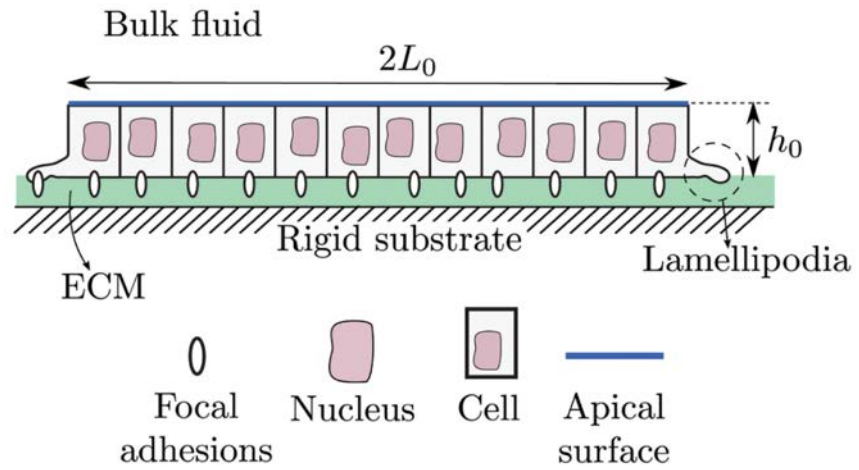
… understanding how the shape of organs and organisms emerge from the spontaneous organization of active processes at the molecular scale, applying this understanding to the design of self-shaping functional materials…

Continuum modelling of epithelial tissues in various morphogenetic events during development is often 2D

- A full 3D description of the tissue captures surface features, asymmetry, and the spatial geometry of the tissue.
- Variations of active stresses across the apical-basal axis drive the curvature transitions critical to morphogenesis.
- Implications of our results for some biologically relevant processes such as tissue folding at the onset of lumen formation described.

Cultural changes at UCSB





Shape and size changes of adherent elastic epithelia, Loewe, Serafin, Shankar, **Bowick**, **Marchetti**, *Soft Matter* **16** (2020) 5282.

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Thanks !


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