The UC Santa Barbara MRSEC: Director’s Virtual Meeting, 2021
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.
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*]

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**Allocation of resources**

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**Allocation of resources**

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

<table>
<thead>
<tr>
<th></th>
<th>White Chocolate</th>
<th>Milk Chocolate</th>
<th>Dark Chocolate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cocoa Solids</td>
<td>≈ 0%</td>
<td>≥ 10%</td>
<td>≥ 35%</td>
</tr>
<tr>
<td>Cocoa Butter</td>
<td>≥ 20%</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Sugar</td>
<td>≤ 55%</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Milk Solids</td>
<td>≥ 14%</td>
<td>≥ 12%</td>
<td>&lt; 12%</td>
</tr>
<tr>
<td>Milk Fat</td>
<td>≤ 3.5%</td>
<td>≥ 3.9%</td>
<td>---</td>
</tr>
</tbody>
</table>

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.

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

National Science Foundation
UC SANTA BARBARA Materials Research Science and Engineering Center (MRSEC)
**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
... to understand and develop control over the couplings between strain, magnetization, and temperature (entropy) in single- and multiphase intermetallic compounds...

Heusler $\text{MnAu}_2\text{Al}$:
- 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

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
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
- $\text{Li}^+ t_+$ increases to 0.43 as measured using pulsed-field-gradient NMR.

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
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
... 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.
Thanks!