



# IPRIME

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Industrial  
Partnership for  
Research in  
Interfacial and  
Materials  
Engineering

# IPRIME History

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- CIE (Center for Interfacial Engineering)
  - Funded by NSF from 1988 to 1999
  - Industrial outreach, 114 resident fellows, 393 PhDs
  - Fostered culture of integrated research, education and **industrial interaction**
- Members encouraged continued collaboration
- **IPRIME** (Industrial Partnership for Interfacial and Materials Engineering)
  - Legacy organization from CIE

Industry

A University–Industry Partnership based  
on Two-Way Knowledge Exchange

University

- **Highly Interdisciplinary** (47 faculty in 9 departments)
  - Biochemistry, Molecular Biology and Biophysics
  - Bioproducts and Biosystems Engineering
  - Chemical Engineering and Materials Science
  - Chemistry
  - Physics
  - Mechanical Engineering
  - Biomedical Engineering
  - Electrical and Computer Engineering
  - Pharmaceuticals

*“Knowledge is one. Its division into subjects is a concession to human weakness.”*  
- Halford Mackinder

- **Research is Pre-Competitive and Non-Proprietary**
- **Focus on fundamental science that underlie industrial products and processes**
- **7 Interdisciplinary Research Programs**

# 7 Research Programs

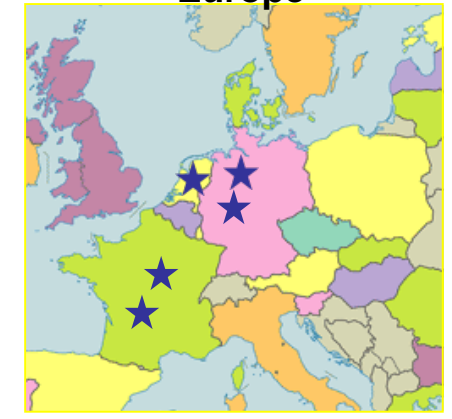
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- Biocatalysis and Biotechnology (BB)
- Biomaterials and Pharmaceutical Materials (BPM)
- Coating Process Fundamentals (CPF)
- Electronic Materials and Devices (EMD)
- Flexible Electronics and Photovoltaics (FEP)
- Microstructured Polymers (MP)
- Nanostructural Materials and Processes (NMP)

# Members Across the Globe



Europe



**France (1)** Total  
**Netherlands (1)** DSM  
**Germany (3)** BASF, Evonik, Henkel

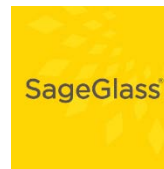


**China (1)**  
Wanhua Chemical  
**Japan (3)**  
Mitsui  
Dai Nippon Printing  
Toray



**Saudi Arabia (1)** SABIC

# IPRIME Member Companies



# Industrial Support

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Contributions over \$1,500,000 per year from 40+ companies

- **Sponsor Membership** (\$60,000 per year)
  - Participation in up to 4 research programs
  - Opportunity to utilize Industrial Fellow Program
  - Representative on the Policy and Planning Board (PPB)
- **Affiliate Membership** (\$48,000 per year)
  - Focus on one 1 research program, no Industrial Fellow
- **Small company option**
  - \$7,500 minimum *or*
  - 0.03% of sales per year, up to \$40,000

# Why IPRIME?

- **Partnership**
- **Future employees**
- **Facilities**
- **Knowledge Transfer**



# Partnership

## Companies

- Scientific exchange with academic sector
- Influence research directions
- Leverage government funding (NSF, NIH, DOE)
- Portal/referral to other U resources/capabilities
- Industrial Fellows

## Faculty & Students

- Ready source of “hard problems”
- Funding support
- Technology implementation
- Fosters faculty interactions
- Industrial Fellows



# Industrial Fellows

<u>Company</u>	<u>Employee</u>	<u>Research Topic</u>	<u>Faculty</u>
Abbott	David Powell	TBD	Francis
Boston Scientific	Greg Sherwood	High sensitivity alpha-particle detectors	Steve Koester
Dai Nippon Printing	Koichi Nakano	Coating flow of non-Newtonian liquid in tensioned-web-over-slot die coating	Lorraine Francis/ Satish Kumar
Ecolab	TBD	TBD	TBD
Evonik Industries	TBD	TBD	TBD
Mitsui	TBD	TBD	Mark Hillmyer
Toray	Kei Nomura	TBD	Ellison
Valspar	Gunnar Duner	TBD	Greg Haugstad
Wanhua Chemical	Xueshun Ji	Cryo-SEM observation of Dispersions by Pre-polymer Synthesis Method	Francis

# Future Employees

## Companies

- Early access to PhD students
- Most graduates work at IPRIME companies



Annual Meeting Poster Session

## Faculty & Students

- Early student access to employers
- Learn industrial research process and interactions
- Hone communication skills
- Resumes distributed

# Supporting Facilities

## Companies

- CharFac\*  
(training + analysis)
- Imaging Center
- Polymer Characterization Facility\*
- Polymer Synthesis
- Coating Process and Visualization Lab
- Tissue Mechanics\*

## Faculty and Students

- In-kind equipment contributions
- Industrial utilization of facilities



- ~\$20 million of equipment (replacement value):
- ❖ 10 Electron microscopes (6 TEM, 4 SEM; analytical/cryo)
- ❖ 11 X-ray scattering (8 wide-, 3 small-angle, 2 micro, T)
- ❖ 9 proximal nanoprobes (4 AFM, profilometer, 4 indentors)
- ❖ Surface analytical (XPS, Auger, micro-contact angle)
- ❖ Chemical spectro/microscopy (3D Raman, FTIR)
- ❖ Thin film analysis (RBS w/PIXE/FReS, spectro. ellipsom.)

- 13 scientific professionals (not students)
- ~600 research users/yr, ~120 external
- 130 faculty users from ~30 UMN departments/units
- ~250 students/yr in curricular classes & short courses
- ~50 companies per year (users/clients)

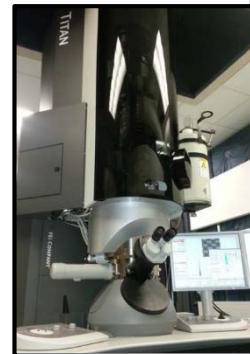
• ~20 external academic institutions per year

[www.charfac.umn.edu](http://www.charfac.umn.edu)

- ❖ Hard & soft materials, liquids, biological/medical, geo/archeo
- ❖ Expert analytical services, custom methodologies
- ❖ Industry collaborations
- ❖ Workshops & short courses

**Other facilities on campus:**

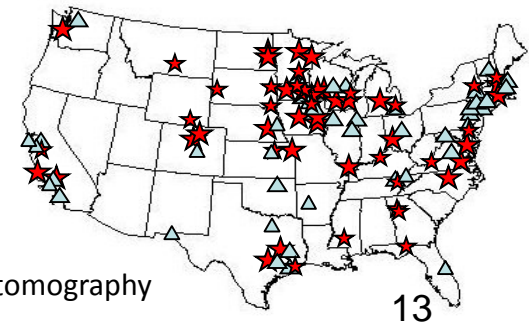
Time-resolved TEM/spectroscopy  
 Electronic/Magnetic measurements  
 High-end light microscopy (superresolution, etc.), Rheology/DSC/TGA, NMR, Mass spectrom., X-ray tomography  
 Micro-/Nano-fabrication, Bioprocessing (fermentation, etc.)



Ion beam analysis (RBS, PIXE, FReS...)  
 Aberration-corrected TEM; HAADF/STEM/EELS/EDS  
 Small-angle X-ray scattering, in-line physical



**Clientele: "Like a national lab"**



Blue: New or upgraded within last ~4 years

## Scanning and Transmission Electron Microscopes (10)

JEOL 6500 FE-SEM (BS, EDS, EBSD, cathodoluminescence)  
 JEOL 6700 FE-SEM (high-resolution)  
[Hitachi SU8220 FE-SEM \(ThermoNoran EDS, high-res., cryo, BS/mix\)](#)  
 Hitachi S-4700 FE-SEM (cryo, BS)  
 JEOL 1200 TEM (bio)  
 FEI Tecnai G2 Spirit Bio-Twin (cryo/bio) + [iCorr fluorescence LM](#)  
 FEI T12 TEM (EDS)  
 FEI Tecnai G2 F30 FEG-TEM (EF-TEM, cryo/bio, 2-axis tilt for tomog.)  
[FEI Tecnai G2 F30 and Titan aberration-corrected FEG-TEMs \(EDX, EELS, STEM, HAADF,...\)](#)  
 Two full suites of [specimen prep tools](#) (SEM/TEM; also AFM/Raman) for hard and soft materials, biological; two cryomicrotomes

## Proximal nanoprobes: AFM, nanoindentors & related (9)

[Two Bruker Nanoscope V Multimode 8's \(PeakForce QNM, EFM, MFM, KPFM, FMM, force volume\)](#), nPoint closed loop scanner  
 Two Keysight 5500's; [closed loop scanners](#); [inverted light microscope](#); current sensing, T, RH control, [easy fluid cells](#); multifrequency modes  
 Digital pulsed force mode add-on, LabView and custom methods developed in-house: setpoint ramping, [shear modulation](#)  
[Anasys nanoTA2 + SThM: heated tip methods](#)  
 Hysitron Triboindenter, Picoindenter (inside TEM), Triboscope  
 Keysight Nanoindenter XP (oscillatory loading, storage/loss)  
 Custom-built micromechanical tester (MMT)  
 Tencor stylus profilometer (up to 14" wide, 2" thick samples)

## Visible light analysis & imaging

Woollam Spectroscopic Ellipsometer (film thickness and optical constant characterization over  $\lambda=200-1100$  nm)  
[Nikon light microscope - bright/dark field, polarization, phase, fluorescence, differential interference contrast \(DIC\)](#)

## X-ray Diffraction & Scattering (11)

Bruker AXS (Siemens) D5005 XRD  
 Siemens D500 X-Ray XRD (multi-sample changer)  
 Scintag XDS 2000 Theta-Theta XRD; broad temperature control  
 Bruker AXS microdiffractometer with 2D detector  
 Pananalytical X'pert Pro high-angular resolution XRD  
 Bruker D8 Advance XRD with temperature and humidity control  
[Bruker D8 Discover 2D microdiffractometer](#)  
[Laue diffractometer \(crystal orientation\)](#)  
 2D SAXS, 2 meter line  
 2D SAXS, 6 meter line; in-line DSC, rheometer, mechanical strain, temp. stage  
 SAXSess (simultaneous wide- and small-angle detection)

## Ion Beam Analysis (elemental composition, depth profiles)

Rutherford backscattering (RBS); FReS, PIXE/PIGE, NRA  
 NEC 5.1 MeV accelerator, He<sup>+</sup>, He<sup>++</sup> and H<sup>+</sup> beams  
 Goniometer, channeling: depth/element-specific crystallinity

## Surface analytical (elemental, chemical) & depth profiles

X-ray photoelectron spectrometers (XPS/ESCA) ([one with UPS, new in 2016](#)), monochromated/small spot/angle resolved (SSI)  
[Auger spectroscopy \(AES; scanning and depth profiling\)](#)  
 Micro contact angle system with high-speed camera (dynamic)

## Vibrational spectroscopy (chemical, 3D imaging)

[Thermo FTIR spectrometer \(DTGS and MCT detectors\), Transm., Refl., ATR, DRIFTS; FTIR microscope](#)  
 Witec confocal Raman spectrometer/microscope; full spectroscopic imaging in XY and XZ; [532-nm and 785-nm lasers](#) with dedicated spectrometers; [down to 30 cm<sup>-1</sup> vibrations](#)

(not shown: ~30 ancillaries & specimen prep tools)

# CharFac Technical Staff (10 FTE)

13 professionals (10.65 FTE) manage 3-site capabilities.  
Includes expert analytical services, methods development, collaboration, education/training, assistance/consultation.

**Electron microscopy**  
**X-ray scattering**  
**Proximal probes**  
**Vibrational spectroscopy**  
**Surface Analytical**  
**Thin film analysis**

Chris Frethem	SEM (cryo and bio/soft material emphasis)
Dr. Javier Garcia-Barriocanal	XRD, Small-angle X-Ray scattering, IBA, ellipsometry
Dr. Bob Hafner	High-contrast and cryo TEM (bio, soft materials)
Dr. Greg Haugstad	AFM, Ion beam analysis (IBA: RBS, PIXE, FReS & related), XPS
Dr. Han Seung Lee (0.5 FTE)	SEM/TEM (cryo emphasis)
Dr. Bing Luo	Confocal Raman/FTIR, XPS/Auger, micro-contact angle
Dr. Jason Myers	FEG-TEM (HR/STEM/EDS/EELS), FIB
Dr. John Nelson (0.1 FTE)	Nano/micro-mechanical, profilometry
Dr. Geoff Rojas	Auger/XPS, STM/AFM, TEM
Dr. Nick Seaton	Materials SEM, EDS/EBSD/cathodoluminescence
Dr. Seema Thakral (0.6 FTE)	XRD, Small-angle X-Ray scattering
Dr. Wei Zhang (0.45 FTE)	Cryo FEG-TEM, 3D reconstruction, tomography
Fang Zhou	Bio EM specimen prep, (cryo)microtomy, TEM (bio, soft material)

# Knowledge Transfer

## Annual Meeting<sup>\*</sup> (May 29 – 31, 2018)

- Workshops
- Program Reviews
- Two-Night Poster Session
- Plenary Luncheon
- TAC & PPB Meetings



<sup>\*</sup> Free to members

## Mid-Year Workshops<sup>\*</sup>

- January 9 - 10, 2018

## Website with members-only features<sup>\*</sup>

- Webcasts, Research Information, Exclusive Presentations

## Short Courses (member discounts)

- Coating Process Fundamentals (May 22 -24, 2018)
- Rheological Measurements (June, 2018)
- CharFac Workshop and Demonstrations (August 28-29, 2017)

## Industrial Fellows (non-proprietary) & Special Projects (proprietary research)



## **2018 Annual Meeting**

**May 29-31, 2018**

- Featuring workshops and presentations from our 7 research programs
- Two night poster session with current research from our grad students
- Plenary Luncheon with a featured speaker
- Industry/Faculty Meet & Greet reception

### **Mid-Year Workshops**

**January 9-10, 2018**

- Two days of workshops presented by our research programs

### **Short Courses**

- Coating Process Fundamentals Short Course (May 22- 24, 2018)
- Rheology Short Course (Summer 2018)
- CharFac Workshop (August 28-29, 2017)

## **2017 Annual Meeting**

**May 30-June 1, 2017**

### **Featuring presentations on:**

- Characterization of Coatings: Needs & Opportunities
- Polymers at Surfaces & Interfaces
- Innovations in Organic & Flexible Electronics for Display, Sensing & Energy Conversion Devices
- Unsolved Problems in Biomedical Materials
- Enzyme Technology for Cleanup

### **Mid-Year Workshops**

**January 10-11, 2017**

- “Color and Appearance of Coatings” CPF
- “Nanomaterials for Protein, Genetic Material, and Small Molecule Delivery to Cells” NMP/BPM

### **Short Courses**

- Coating Process Fundamentals Short Course (May 23- 25, 2017)
- CharFac Workshop (August 28-29, 2017)



# [www.iprime.umn.edu](http://www.iprime.umn.edu)

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 Driven to Discover™

**IPRIME**  
 Industrial Partnership for Research in Interfacial & Materials Engineering

Home About ▾ Membership ▾ Research ▾ Who's Involved ▾ News | Events | More ▾

## Home

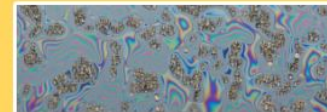
### [Learn About IPRIME](#)



### Welcome to IPRIME

IPRIME focuses on creating opportunities for professionals in industry to collaborate with students and researchers at the University of Minnesota. This exchange provides a productive environment for addressing key areas in interfacial and materials science.

### Research Programs



Coating Process  
Fundamentals (CPF)



### IPRIME Overview



### News & More



### Upcoming Events

Save the Date!

# 7 Research Programs

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- Biocatalysis and Biotechnology (BB)
- Biomaterials and Pharmaceutical Materials (BPM)
- Coating Process Fundamentals (CPF)
- Electronic Materials and Devices (EMD)
- Flexible Electronics and Photovoltaics (FEP)
- Microstructured Polymers (MP)
- Nanostructural Materials and Processes (NMP)

# Biocatalysis and Biotechnology (BB)

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<u>Investigator</u>	<u>Department</u>	<u>Expertise</u>
Ping Wang*	BBE	Enzymology and biocatalysis, bioconversion and biosynthesis, biomaterials and functional coatings, bioelectrochemical processing, biosensors.
Mark Distefano	Chem	Organic and biochem., protein conjugates for therapeutic and biotechnology applications.
Mikael Elias	Biochem	Protein engineering and evolution, molecular modelling and recognition, bioremediation and quorum quenching strategies.
Wei-Shou Hu	CEMS	Systems biotechnology, biochemical engineering, cell culture bioprocessing, stem cell technology
Romas Kazlauskas	Biochem	Biocatalytic synthesis of chemical intermediates and biofuels, enzyme modification for new reactions.
Lawrence Wackett	Biochem	Enzymes in biotechnology, immobilization technology, bioremediation, computer prediction tools for biocatalysis
Kechun Zhang	CEMS	Synthetic biology, metabolic engineering, protein engineering, biofuels, renewable chemicals.

*\*Program Leader (Email: ping@umn.edu; Phone: 612-624-4792)*

Chemical and fuel bioprocessing; Biocatalyst engineering; Biotransformation and Bioremediation; Enzyme evolution; Bio-based polymers and biocoatings; Pathway engineering; Synthetic biology; Systems biotechnology; Cell culture bioprocessing

# Biomedical and Pharmaceutical Materials (BPM)

<u>Investigator</u>	<u>Department</u>	<u>Expertise</u>
<b>Ron Siegel*</b>	Phm <sup>1</sup> /BME <sup>2</sup>	hydrogels, drug delivery systems, microfabrication
<b>Effi Kokkoli</b>	<b>CEMS<sup>3</sup></b>	bioadhesion and drug targeting
<b>Jayanth Panyam</b>	Phm	multifunctional nanodelivery vehicles
<b>Wei Shen</b>	BME	bioactive materials
<b>Calvin Sun</b>	Phm	drug crystal and particle engineering
<b>Raj Suryanarayanan</b>	Phm	solid state properties of drugs, stability of drug/biomaterial formulations
<b>Bob Tranquillo</b>	BME/CEMS	fabrication and characterization of bioartificial cardiovascular replacement tissues
<b>Chun Wang</b>	BME	bio-molecular materials, polymer-based DNA and drug delivery, protein-based tissue scaffolds

*\*Program Leader (Email:siege017@umn.edu)*

**Affiliated Investigators:** *Chris Macosko, Marc Hillmyer, Theresa Reineke, Tom Hoye,*

**Pharmaceutics; Biomedical Engineering; Chemical Engineering and Materials Science, Chemistry**

- **Biomaterials for drug delivery, medical device coatings, and tissue engineering**
- **Drug/medical device combinations, characterization of drug/materials interactions**
- **Cell-based fabrication of bioartificial tissues**
- **Novel tissue mechanical testing and analysis methods**

# Coating Process Fundamentals — CPF

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## Investigator

## Expertise

Lorraine F. Francis\*

Solidification, stress development, microstructure, printing

Satish Kumar\*

Transport processes, interfacial phenomena, microfluidics

Marcio S. Carvalho\*\*

Fluid mechanics, rheology, numerical methods

Alon V. McCormick

Curing, thermodynamics & kinetics, NMR, stress development

C. Daniel Frisbie

Printing processes, printed electronics

Chris W. Macosko

Rheology, polymer processing

Xiang Cheng

Colloids, polymers, rheology, visualization

Michael Tsapatsis

Zeolite and particulate coatings, membranes, separations

Wieslaw Suszynski\*\*\*

Coating process experiments, apparatus, flow visualization

*\*Program Co-Leaders*

*\*\*Pontifica Universidade Catolica, Rio de Janeiro*

*\*\*\*Research Engineer and Coating Process and Visualization Laboratory Manager*

# Electronic Materials and Devices (EMD)

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<b>Investigator</b>	<b>Department</b>	<b>Expertise</b>
Steven Koester*	ECE	<i>Electronic devices, semiconductors</i>
Bharat Jalan*	CEMS	<i>Complex oxides, molecular beam epitaxy</i>
Steve Campbell	ECE	Thin-film photovoltaics, 2D materials
Paul Crowell	Physics	<i>Magnetism, transport, ultra-fast spectroscopy</i>
Dan Frisbie	CEMS	Organic electronics, electrolyte gating
Chris Leighton	CEMS	<i>Electronic/magnetic properties, film/layer growth</i>

## **Collaborators**

Andre Mkhoyan (CEMS), Xiaodong Xu (U. Washington), Ludwig Bartels (UCR), Chris Palmstrøm (UCSB), Chris Kim (ECE)

\* Co-Program Directors

Synthesis, structural and chemical characterization of materials relevant for a wide range of electronic, optical and magnetic devices. Particular emphasis is placed on the understanding of the fundamentals of electronic structure and transport in electronic and magnetic materials, in addition to the materials science, physics and chemistry of the interfaces and nanostructures that play a vital role in device operation.

# Flexible Electronics and Photovoltaics (FEP)

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<b>Investigator</b>	<b>Department</b>	<b>Expertise</b>
Russell Holmes*	CEMS	Thin films, LEDs, solar cells
David Blank	CHEM	Ultrafast optical spectroscopy
Chris Douglas	CHEM	Molecular synthesis
C. Daniel Frisbie	CEMS	TFTs and printed electronics
Paul Ruden	ECE	Device modeling, transport theory

\*Program Leader

Interested in the design of materials, device architectures, and processes  
For the realization of flexible electronics and optoelectronics  
based on organic and hybrid organic-inorganic materials



# Microstructured Polymers (MP)

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Investigator	Department	Expertise
Chris Ellison *	CEMS	Composites, thin films, lithography fibers, photopolymerization, & polymer processing
Frank S. Bates	CEMS	Thermodynamics, scattering, synthesis
Kevin Dorfman	CEMS	Modeling, confined polymers, DNA
Marc A. Hillmyer	CHEM	Polymer synthesis and characterization (Director: Polymer Synthesis Facility)
Timothy P. Lodge	CHEM/CEMS	Polymer dynamics, solutions, scattering
Chris Macosko	CEMS	Rheology, processing
Mahesh Mahanthappa	CEMS	Polymer Science and Engineering
David C. Morse	CEMS	Theory and modeling
Theresa Reineke	CHEM	Biomedicine, Diagnostics, Targeted Delivery

\*Program leader

## Collaborators include:

Lorraine Francis (CEMS), Dan Frisbie (CEMS), Tom Hoye (CHEM), Chris Leighton (CEMS), Ron Siegel (PHRM), Bill Tolman (CHEM)

**Synthesis, characterization, dynamics, processing, properties, and theory**

# Nanostructural Materials & Processes (NMP)

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<b>Investigator</b>	<b>Dept</b>	<b>Expertise</b>
Alon McCormick*	CEMS	Reaction Engineering of Materials Synthesis; Spectroscopy; Molecular Simulation
C. Daniel Frisbie	CEMS	Molecular Materials and Interfaces; Molecular Electronics
Wayne Gladfelter	CHEM	Materials Chemistry; Inorganic Chemistry; Scanning Probe Microscopy
Greg Haugstad	CHAR FAC	AFM Scanning Probe Microscopy (Director, Characterization Facility)
Christy Haynes	CHEM	Porous and plasmonic nanomaterials, nanoparticle toxicity
R. Lee Penn	CEMS	Environmental Solid State Chemistry
Andreas Stein	CHEM	Solid State Chemistry of Porous Materials
Michael Tsapatsis	CEMS	Materials Synthesis, Structure Elucidation and Modification
Joe Zasadzinski	CEMS	Molecular Fluids, Optical/Electron/Scanning Probe Microscopy

## **Associated Investigators:**

Frank Bates – Lorraine Francis – Bill Gerberich – David Norris – Wei Zhang – Christy Haynes

□

Synthesis, phase behavior, structure, and performance of surfactants and self-assembled molecular and colloid systems