Industrial Partnership for Research in Interfacial & Materials Engineering
IPRIME History

• 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

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

"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

- 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

**China (1)**
Wanhua Chemical

**Japan (4)**
Dai Nippon Printing
Mitsui
Toray
Zeon

**France (1)**
Total

**Netherlands (1)**
DSM

**Germany (3)**
BASF, Evonik, Henkel
IPRIME Member Companies
Industrial Support

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 research program, no Industrial Fellow

• **Small company option**
  - $7,500 minimum or
  - 0.03% of sales per year, up to $48,000
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
<table>
<thead>
<tr>
<th>Company</th>
<th>Employee</th>
<th>Research Topic</th>
<th>Faculty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbott</td>
<td>Sarah Hankins</td>
<td>Thickness Characterization of Thin Coatings Commonly Used in Medical Devices</td>
<td>Lorraine Francis/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Greg Haugstad</td>
</tr>
<tr>
<td>Boston Scientific</td>
<td>Greg Sherwood</td>
<td>High sensitivity alpha-particle detectors</td>
<td>Steve Koester</td>
</tr>
<tr>
<td>Dai Nippon Printing</td>
<td>Koichi Nakano</td>
<td>Coating flow of non-Newtonian liquid in tensioned-web-over-slot die coating</td>
<td>Lorraine Francis/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Satish Kumar</td>
</tr>
<tr>
<td>Ecolab</td>
<td>Stephan Hubig</td>
<td>Evaluation of Nano Coatings for Surface Modification: Development of a tool kit</td>
<td>Alon McCormick</td>
</tr>
<tr>
<td>Mitsui</td>
<td>Ryohei Ogawa</td>
<td>Synthesis of cross-linkable aliphatic polyester elastomers derived from castor oil</td>
<td>Mark Hillmyer</td>
</tr>
<tr>
<td>Sherwin Williams</td>
<td>Gunnar Duner</td>
<td>New Methods for Adhesion of Coatings using AFM</td>
<td>Greg Haugstad</td>
</tr>
<tr>
<td>Toray</td>
<td>Kei Nomura</td>
<td>Multiblock compatibilizers for reuse/recycling of multilayer film</td>
<td>Chris Ellison</td>
</tr>
<tr>
<td>Wanhua Chemical</td>
<td>Shao-Jie Wang</td>
<td>Post polymerization modification</td>
<td>Mark Hillmyer</td>
</tr>
<tr>
<td>Wanhua Chemical</td>
<td>Xueshun Ji</td>
<td>Cryo-SEM observation of Dispersions by Pre-polymer Synthesis Method</td>
<td>Lorraine Francis</td>
</tr>
<tr>
<td>Zeon Corporation</td>
<td>Kousuke Isobe</td>
<td>TBD</td>
<td>Lorraine Francis/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Satish Kumar</td>
</tr>
</tbody>
</table>
Future Employees

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

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

Annual Meeting Poster Session
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

*Discount for IPRIME members
University of Minnesota Characterization Facility

- >$20 million of equipment (replacement value)
  - Electron microscopes: 6 TEM, 5 SEM/FIB, cryogenic/analytical
  - X-ray scattering: 8 wide-, 2 small-angle, 2 micro, variable Temp
  - Proximal nanoprobes: 4 AFM, STM, profilom., 4 indentors
  - Surface analytical: XPS/UPS/Auger, sputter, microtensiom.
  - Chemical spectro/microscopy: confocal Raman, FTIR/ATR
  - Thin film analysis: RBS w/PIXE/FReS, spectrosc. ellipsom.

- 11 FTE scientific staff (permanent)
- ~600 research users/yr, ~100 external
- ~135 faculty users from ~35 UMN departments/units
- ~250 students/yr in curricular classes & short courses
- ~50 companies per year
- ~20 external academic institutions per year

www.charfac.umn.edu

Other pertinent facilities on campus:
State-of-the-art light microscopy (superresolution, etc.) ➔ University Imaging Center
Rheology/DSC/TGA, NMR, Mass spectrom., X-ray tomography/electron microprobe
Micro-/Nano-fabrication, Bioprocessing (fermentation, etc.)

Clientele: “Like a national lab”

Newest systems

XPS, UPS, cluster beam
Dual-beam FIB/SEM
Small-angle X-ray scattering
CharFac instruments: data-generating systems (38)

**Scanning & Transmission Electron Microscopes & FIB (11)**
- 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)
- FEI Helios NanoLab G4 dual-beam FIB/FE-SEM (just added)
- JEOL 1200 EX Bio-TEM (LaB₆)
- FEI Tecnai G2 Spirit Bio-Twin (cryo/bio) (LaB₆)
- FEI T12 TEM (LaB₆ with EDS)
- FEI Tecnai G2 F30 FEG-TEM (EF-TEM, cryo/bio, 2-axis tilt for tomog.)
- FEI Tecnai G2 F30 FEG-TEM (EELS, EDS, STEM, HAADF)
- FEI Titan aberration-corrected FEG-TEM (EDX, EELS, STEM, HAADF)
- Two full suites of specimen prep tools (for SEM/TEM + AFM/Raman): hard and soft materials, biological; two cryo-microtomes

**Proximal nanoprobes: AFM, nanoindentors & related (10)**
- Omicron ultrahigh vacuum STM/STS LT system (coming soon)
- Two Bruker Nanoscope V Multimode 8 SPMs (with PeakForce QNM, EFM, MFM, KPFM, FMM, fast force volume)
- Intermodulation Products add-on to Bruker SPMs (just added)
- Two Keysight 5500’s (closed loop scanners, current sensing, T/RH control, easy fluid cells, multifrequency); inverted light microscope
- WITec digital pulsed force mode add-on to Keysight 5500
- Anasys nanoTA2 + SThM add-on (heated tip) to Keysight 5500s.
- LabView / custom methods (setpoint ramping, FT shear modulation)
- Hysitron Triboindentor (mapping)
- Hysitron Picoindentor (in situ indentation, inside TEM)
- Keysight Nanoindentor XP (AC loading, storage/loss modulus)
- Custom-built micromechanical tester (IBM MMT)
- Tencor stylus profilometer (up to 14” wide, 2” thick samples)

**X-ray Diffraction & Scattering (8)**
- Bruker AXS (Siemens) D5005 XRD
- Panalytical X’pert Pro high-angular resolution XRD (reflectivity, in-plane diffraction, rocking curves, reciprocal space maps)
- Bruker AXS micro-XRD (2D detector, 2-axis sample tilt)
- Bruker D8 Discover micro-XRD (2D detector, 2-axis sample tilt)
- Bruker D8 Advance XRD with temperature and humidity control
- Laue diffractometer (crystal orientation)
- Xenocs/SAXSLAB Ganesha SAXS/WAXS/GISAXS (coming soon)

**Ion Beam Analysis (elemental composition, depth profiles)**
- Rutherford backscattering (RBS); FReS, PIXE/PIGE, NRA
- NEC 5.1 MeV accelerator, He⁺, He⁺⁺ and H⁺ beams
- Goniometer, channeling: depth/element-specific crystallinity

**Surface analytical (elemental, chemical, sputter-profiling)**
- Phi versaProbe III XPS/ESCA with UPS: monochromated, small spot, angle resolved; cluster beam sputter profiling (just added)
- SSI XPS (monochromated)
- Auger spectroscopy (AES; scanning microscope, 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⁻¹ vibrations

**Visible light based analysis &imaging (also see U Imaging Ctr)**
- Woollam spectroscopic ellipsometer (film thickness and optical constant characterization over λ=200-1100 nm)
- Nikon light microscope - bright/dark field, polarization, phase, fluorescence, differential interference contrast (DIC)

Details at www.charfac.umn.edu

Not listed: ~30 ancillaries (mainly specimen prep tools)

---

CharFac instruments: data-generating systems (38)

**Scanning & Transmission Electron Microscopes & FIB (11)**
- 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)
- FEI Helios NanoLab G4 dual-beam FIB/FE-SEM (just added)
- JEOL 1200 EX Bio-TEM (LaB₆)
- FEI Tecnai G2 Spirit Bio-Twin (cryo/bio) (LaB₆)
- FEI T12 TEM (LaB₆ with EDS)
- FEI Tecnai G2 F30 FEG-TEM (EF-TEM, cryo/bio, 2-axis tilt for tomog.)
- FEI Tecnai G2 F30 FEG-TEM (EELS, EDS, STEM, HAADF)
- FEI Titan aberration-corrected FEG-TEM (EDX, EELS, STEM, HAADF)
- Two full suites of specimen prep tools (for SEM/TEM + AFM/Raman): hard and soft materials, biological; two cryo-microtomes

**Proximal nanoprobes: AFM, nanoindentors & related (10)**
- Omicron ultrahigh vacuum STM/STS LT system (coming soon)
- Two Bruker Nanoscope V Multimode 8 SPMs (with PeakForce QNM, EFM, MFM, KPFM, FMM, fast force volume)
- Intermodulation Products add-on to Bruker SPMs (just added)
- Two Keysight 5500’s (closed loop scanners, current sensing, T/RH control, easy fluid cells, multifrequency); inverted light microscope
- WITec digital pulsed force mode add-on to Keysight 5500
- Anasys nanoTA2 + SThM add-on (heated tip) to Keysight 5500s.
- LabView / custom methods (setpoint ramping, FT shear modulation)
- Hysitron Triboindentor (mapping)
- Hysitron Picoindentor (in situ indentation, inside TEM)
- Keysight Nanoindentor XP (AC loading, storage/loss modulus)
- Custom-built micromechanical tester (IBM MMT)
- Tencor stylus profilometer (up to 14” wide, 2” thick samples)

**X-ray Diffraction & Scattering (8)**
- Bruker AXS (Siemens) D5005 XRD
- Panalytical X’pert Pro high-angular resolution XRD (reflectivity, in-plane diffraction, rocking curves, reciprocal space maps)
- Bruker AXS micro-XRD (2D detector, 2-axis sample tilt)
- Bruker D8 Discover micro-XRD (2D detector, 2-axis sample tilt)
- Bruker D8 Advance XRD with temperature and humidity control
- Laue diffractometer (crystal orientation)
- Xenocs/SAXSLAB Ganesha SAXS/WAXS/GISAXS (coming soon)

**Ion Beam Analysis (elemental composition, depth profiles)**
- Rutherford backscattering (RBS); FReS, PIXE/PIGE, NRA
- NEC 5.1 MeV accelerator, He⁺, He⁺⁺ and H⁺ beams
- Goniometer, channeling: depth/element-specific crystallinity

**Surface analytical (elemental, chemical, sputter-profiling)**
- Phi versaProbe III XPS/ESCA with UPS: monochromated, small spot, angle resolved; cluster beam sputter profiling (just added)
- SSI XPS (monochromated)
- Auger spectroscopy (AES; scanning microscope, 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⁻¹ vibrations

**Visible light based analysis &imaging (also see U Imaging Ctr)**
- Woollam spectroscopic ellipsometer (film thickness and optical constant characterization over λ=200-1100 nm)
- Nikon light microscope - bright/dark field, polarization, phase, fluorescence, differential interference contrast (DIC)

Details at www.charfac.umn.edu

Not listed: ~30 ancillaries (mainly specimen prep tools)
### CharFac Technical Staff

13 professionals (11.15 FTE) manage 3-site capabilities. Includes expert analytical services, education/training, assistance/consultation, methods development, collaboration.

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

Contact Information at [www.charfac.umn.edu/staff](http://www.charfac.umn.edu/staff)
Analytical services (proprietary/commercial)
• Sample analysis by facility staff. (High commercial charge rates.)
• 1/3 discount on instrument time with IPRIME consortium membership.

Hands-on (proprietary/commercial)
• Obtain training for independent use of instruments (at high charge rates).

Sponsored projects (full overhead-bearing; well-defined contract)
• Fund grad student, postdoc and/or staff scientist(s) under University principal investigator. (Low internal charge rates.)

IPRIME consortium collaborations (no overhead, no contract or deliverables)
• Collaborate on publishable research with an IPRIME principal investigator and his/her colleagues, no hands-on usage of CharFac. (Low internal charge rates.)
• Become an industrial fellow in collaboration with IPRIME principal investigator on publishable research. May include hands-on usage at low internal charge rates.

Methods development collaboration (no UMN overhead, no contract or deliverables)
• Fund CharFac technical staff member(s) on publishable methods research (academic instrument rates, no hands-on). Modeled after IPRIME industrial fellow program.
Knowledge Transfer

**Annual Meeting** *(May 29 – 31, 2018)*
- Workshops
- Program Reviews
- Two-Night Poster Session
- Plenary Luncheon
- TAC & PPB Meetings

**Mid-Year Workshops** *
- January 9 - 10, 2018

**Website with members-only features** *
- Webcasts, Research Information, Exclusive Presentations

**Short Courses** *(member discounts)*
- Coating Process Fundamentals (May 22 -24, 2018)
- Rheological Measurements (August 12-17, 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
- “3D Printing of Polymers: Materials and Processes” (CPF & MP) Jan 9, 2018
- “Remote Imaging of Implanted Biomaterials and Theranostics” (BPM) Jan 10, 2018

Short Courses
• Coating Process Fundamentals Short Course (May 22-24, 2018)
• Rheology Short Course (August 12-17, 2018)
• CharFac Workshop (August 20-21, 2018)

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)
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.
7 Research Programs

- 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)

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

*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)

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Department</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ron Siegel*</td>
<td>Phm⁠¹/BME²</td>
<td>hydrogels, drug delivery systems, microfabrication</td>
</tr>
<tr>
<td>Effi Kokkoli</td>
<td>CEMS³</td>
<td>bioadhesion and drug targeting</td>
</tr>
<tr>
<td>Jayanth Panyam</td>
<td>Phm</td>
<td>multifunctional nanodelivery vehicles</td>
</tr>
<tr>
<td>Wei Shen</td>
<td>BME</td>
<td>bioactive materials</td>
</tr>
<tr>
<td>Calvin Sun</td>
<td>Phm</td>
<td>drug crystal and particle engineering</td>
</tr>
<tr>
<td>Raj Suryanarayanan</td>
<td>Phm</td>
<td>solid state properties of drugs, stability of drug/biomaterial formulations</td>
</tr>
<tr>
<td>Bob Tranquillo</td>
<td>BME/CEMS</td>
<td>fabrication and characterization of bioartificial cardiovascular replacement tissues</td>
</tr>
<tr>
<td>Chun Wang</td>
<td>BME</td>
<td>bio-molecular materials, polymer-based DNA and drug delivery, protein-based tissue scaffolds</td>
</tr>
</tbody>
</table>

*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

<table>
<thead>
<tr>
<th>Investigator</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lorraine F. Francis*</td>
<td>Solidification, stress development, microstructure, printing</td>
</tr>
<tr>
<td>Marcio S. Carvalho**</td>
<td>Fluid mechanics, rheology, numerical methods</td>
</tr>
<tr>
<td>Satish Kumar</td>
<td>Transport processes, interfacial phenomena, microfluidics</td>
</tr>
<tr>
<td>Alon V. McCormick</td>
<td>Curing, thermodynamics &amp; kinetics, NMR, stress development</td>
</tr>
<tr>
<td>C. Daniel Frisbie</td>
<td>Printing processes, printed electronics</td>
</tr>
<tr>
<td>Chris W. Macosko</td>
<td>Rheology, polymer processing</td>
</tr>
<tr>
<td>Xiang Cheng</td>
<td>Colloids, polymers, rheology, visualization</td>
</tr>
<tr>
<td>Michael Tsapatsis</td>
<td>Zeolite and particulate coatings, membranes, separations</td>
</tr>
<tr>
<td>Wieslaw Suszynski***</td>
<td>Coating process experiments, apparatus, flow visualization</td>
</tr>
</tbody>
</table>

*Program Leader

**Pontifica Universidade Catolica, Rio de Janeiro

***Research Engineer and Coating Process and Visualization Laboratory Manager
## Electronic Materials and Devices (EMD)

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

**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)

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

*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)

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

*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)

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

**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

* Program Leader