Center for Micro Engineered Materials

Fernando Garzon
Director
Professor: Chemical and Biological Engineering

Adrian Brearley
Associate Director
Distinguished Professor: Earth and Planetary Sciences

2020 Annual Review Of Category 3 Research Centers/Institutes
Membership of Advisory Committee 2020-21

Christos Christodoulou, Dean of Engineering and Computing
Mark Peceny, Dean of Arts and Sciences
Sang M. Han, Associate Chair of Chemical and Biological Engineering
Jeremy Edwards, Chair of Chemistry and Chemical Biology
Yu-Lin Shen, Chair of Mechanical Engineering
Arash Mafi, Director of UNM Center for High Technology Materials
Elizabeth (Lisa) Kuuttila, President and CEO of STC.UNM

• Last Review: April 21st 2020 Spring Review Meeting
CMEM Located In the Advanced Materials Laboratory UNM/Sandia

- Building completed in 1992
  - Originally UNM, Sandia, LANL, Facility
  - Bonds payment completed
  - Partial HVAC renovation 2020

- New South Campus Facility under design at Shields and Bradbury location

- Occupancy: UNM, AFRL, Sandia

- Design by DPS architects to meet security needs of DOE and DOD operations

- Old AML building future usage?
Advanced Materials Laboratory
First Floor ~20,000 Square Feet total

- CMEM usage:
- Faculty and Staff Offices
- Classroom
- Conference room
- Instrumental facilities:
  - SEM-EDS
  - microRaman microscope
  - AFM/STM
- Electrochem Teaching Laboratory
Advanced Materials Laboratory
Second Floor~20,000 Square Feet total

CMEM Usage:
- Laboratories:
  - Electrochemistry
  - BSL-2
  - Materials Synthesis- 7 fume Hoods
- PD, RF and Student office space
- Instrumental facilities:
  - XPS
  - microXRF
  - Thermal Analysis
  - Gas adsorption/Surface Area Analysis
- Grey area is Sandia 1815 Org.
Rental space

<table>
<thead>
<tr>
<th>Staff Space</th>
<th>1411</th>
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<tbody>
<tr>
<td>Office Space</td>
<td>2585</td>
</tr>
<tr>
<td>Laboratory Space</td>
<td>5730</td>
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<tr>
<td>Classroom</td>
<td>741</td>
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<tr>
<td>Storage</td>
<td>539</td>
</tr>
<tr>
<td>Conference</td>
<td>387</td>
</tr>
<tr>
<td>Kitchen</td>
<td>210</td>
</tr>
<tr>
<td>Bathroom</td>
<td>328</td>
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<tr>
<td>Hallway space</td>
<td>2800</td>
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**Total Space Usage** 14731
Mission

The primary mission of the UNM Center for Micro-Engineered Materials (CMEM) is to serve as a focal point for collaborative, interdisciplinary, micro-engineered materials research, development and education.
CMEM Faculty & Staff

• Theory, Modeling & Analysis:
  • Ivana Gonzales CBE/LANL
  • Jamie Gomez CBE
  • D. Petsev CBE
  • F. Van Swol CBE
  • Randy Schunk SNL/CBE
  • Kristianto Tjiptowidjojo CBE

• Experimental
  • Adrian Brearley EPS
  • Ying-Bing Jiang EPS/left UNM 9/20
  • Abhaya Datye CBE
  • Fernando Garzon CBE/SNL
  • Jose Cerrato CCE
  • Jeff Brinker CBE
  • Osman Anderoglu NE
  • Tom Peng AFRL
  • Lok-Kun Tsui CMEM
  • Tim Boyle SNL/Chem
  • Bernie Hernandez-Sanchez SNL/Chem
  • Hongyou Fan SNL/CBE
  • Chris Apblett SNL/CBE
  • Shuya Wei, CBE
  • Nick Carroll, CBE
  • Rodney Borup LANL
  • Rangachary Mukundan LANL
  • Eric Coker SNL

• Advanced Characterization Research Staff:
  • Eric Peterson EPS
  • Elena Dobrica EPS
  • Angelica Benavidez CMEM
  • Geoffrey Courtin CBE
  • Chris Anderson EPS

• Center Support Staff:
  • Estelle Zamora (Retired 1/29)
  • Svetlana Shevkun
  • Rosalina Preciado

• Experimental
  • Adrian Brearley EPS
  • Ying-Bing Jiang EPS/left UNM 9/20
  • Abhaya Datye CBE
  • Fernando Garzon CBE/SNL
  • Jose Cerrato CCE
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  • Tim Boyle SNL/Chem
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  • Chris Apblett SNL/CBE
  • Shuya Wei, CBE
  • Nick Carroll, CBE
  • Rodney Borup LANL
  • Rangachary Mukundan LANL
  • Eric Coker SNL
# Active National Laboratory & Defense Lab Collaborations with CMEM

<table>
<thead>
<tr>
<th></th>
<th>Sandia National Laboratory:</th>
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</thead>
<tbody>
<tr>
<td>AFRL:</td>
<td>Randy Schunk: Additive Manufacturing</td>
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<tr>
<td>Tom Peng:</td>
<td>Judi Lavin: Additive Manufacturing</td>
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<tr>
<td></td>
<td>Adam Cook: Additive Manufacturing</td>
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<tr>
<td></td>
<td>Bryan Kaehr: Additive Manufacturing</td>
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<tr>
<td></td>
<td>Nelson Bell: Additive Manufacturing</td>
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<tr>
<td></td>
<td>Rebecca Schaller: Corrosion &amp; Electrochemistry</td>
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<tr>
<td></td>
<td>Rico Treadwell: Nanotechnology</td>
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<tr>
<td></td>
<td>Timothy Boyle: Metalorganic Chemistry, Nanotechnology</td>
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<tr>
<td>LANL:</td>
<td>Rod Borup, LANL: Fuel Cells</td>
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<tr>
<td>Rangachary Mukundan: Fuel Cells</td>
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<tr>
<td>Cortney Kreller: Electrosynthesis</td>
<td></td>
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<tr>
<td>Yue Sueng Kim, Polymers</td>
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<tr>
<td>Mahlon Wilson, Fuel Cells</td>
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<tr>
<td>Piotr Zelenay, Fuel Cells</td>
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<td>Ulises Martinez, Fuel Cells</td>
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<tr>
<td>Eric Brosha, Sensors</td>
<td></td>
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<tr>
<td>NRL:</td>
<td>Huyen Dinh: Hydrogen economy</td>
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<tr>
<td></td>
<td>Mike Ulsh: Additive manufacturing</td>
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<tr>
<td></td>
<td>Scott Mauger: Additive manufacturing</td>
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<tr>
<td>Oak Ridge Nat. Lab.</td>
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<tr>
<td></td>
<td>David Wood: Additive manufacturing</td>
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<tr>
<td></td>
<td>Karren More: Electron Microscopy</td>
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<tr>
<td>NRL:</td>
<td>Nancy Swider-Lyons: Fuel Cells</td>
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<tr>
<td></td>
<td>Joshua Lamb: Batteries</td>
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<td>Eric Allcorn: Batteries</td>
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<td>Lorraine Castro: Batteries</td>
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<td></td>
<td>Christine Roberts: Battery modeling</td>
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<td>Kyle Fenton: Power Sources</td>
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<td>Mohan Karulkar: Power Sources</td>
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<td>Kyle Fenton: Power Sources</td>
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<tr>
<td></td>
<td>Mohan Karulkar: Power Sources</td>
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**AFRL:**
- Tom Peng:
  - Electrochemistry
  - Additive manufacturing
- Robert Walters: Fuel Cells, Additive manufacturing
- Joseph Fellner: Fuel Cells
- Ben Urioste: Fuel Cells
- Doug Dudis: Fuel Cells

**LANL:**
- Rod Borup, LANL: Fuel Cells
- Rangachary Mukundan: Fuel Cells
- Cortney Kreller: Electrosynthesis
- Yue Sueng Kim, Polymers
- Mahlon Wilson, Fuel Cells
- Piotr Zelenay, Fuel Cells
- Ulises Martinez, Fuel Cells
- Eric Brosha, Sensors

**NRL:**
- Karen Swider-Lyons: Fuel Cells
CMEM focuses on “Bottom-up” Materials Engineering

- Nano Materials Synthesis, Characterization And Incorporation into Device Structures:
- Catalysts for Green Synthesis: NSF-CISTAR
- Printed Electronics, Flexible Conductors and Ionic Switches: AFRL
- Energy Conversion Devices: Li Batteries and Fuel Cells for Transportation and Space, DOE-EERE & AFRL
- Sensors for Environmental Protection, As and U in groundwater NSF, Methane emissions, DOE-FE
- Advanced Manufacturing Development: DOE AMO
- Corrosion at the Nanoscale: DOE-Sandia
CY 2020 Goals And Status

CMEM’s main goals are:

• To serve as a catalyst for the development of nano and micro-engineered technologies to make NM and the US more competitive.

• To collaborate with NM Universities, Sandia, LANL and AFRL in high quality materials R&D.

• To engage with UNM.STC to transfer these technologies to industry fostering the development of competitive businesses within the State of New Mexico.

• To support campus-wide nanomaterials research by maintaining high performance characterization facilities.

• To engage the UNM undergraduate and graduate STEM students in nanomaterials & geologic materials research and development.

• To support interdisciplinary academic programs, such as Nanoscience and Microsystems Engineering and course offerings in CBE, CCB, EPS, ME and CCE

CMEM’s current Status

• All CMEM user facilities are operational with research faculty supervision under UNM-COVID-19 regulations

• COVID-19 restrictions limit student participation to funded programs and limit laboratory occupancy

• CMEM Faculty losses: Dr. Ying-Bing Jiang, new hire approved, with support from A&S
CY 2020 Highlights

• Associate Director Adrian Brearley wins $1M+ awards for EELS spectroscopy system from NASA
• Professor Shuya Wei was selected to receive a competitive ORAU Ralph E. Powe Junior Faculty Enhancement Award,
• CMEM Researchers published over 100 papers in Nature, Science, ACS, APS, ECS, Geophysical Society, and other peer-reviewed Journals
• CMEM Research Associate Professor, Kristianto Tjiptowidjojo awarded the I.E. Scriven Young Investigator Award
• CMEM Assistant Professor Nick Carroll wins NSF-CAREER award
• CMEM Distinguished Professor C. Jeffery Brinker Keynote 17th Annual Conference on Foundations of Nanoscience: Self-assembled Architectures and Devices (fnano20)
• Prof. Sang Han named AVS fellow and highlighted on Nanovision science podcast. His company, Osazda Energy wins 1.25M DOE contract
• Associate Prof. Jose Cerrato wins Fulbright scholarship to Spain
CMEM/EPS Analytical Facilities

Invests in the future by acquisition of new instrumentation that stimulates and enables new research activities, enhancing UNM’s flagship status and competitiveness in research:

New PAIS Facility, JEOL NeoARM installed, JEOL 2010 gift transfer to UNM from Sandia in process, Helios FIB/SEM to be added to PAIS EM facility

CMEM/EPS facilities act as core characterization facilities for UNM, NM academic institutions, as well as users from SNL, LLNL, CINT, AFRL and local business.

For many instruments, UNM is the core facility for the State of New Mexico.

Staff teach key characterization classes for undergraduate and graduate students.

Provide hands on instrument training to develop skilled graduates with excellent high-level analytical skills that are in high demand in academia and the workforce.
CMEM/EPS TEM/FIB-SEM Laboratory
Diverse user base from across UNM campus and externally:

**College of Arts and Sciences:** EPS, P&A, Biology, CCB, IOM

**School of Engineering:** CBE, ME, CCE, ECE, NE

**College of Fine Arts:** Tamarind Institute

**UNM Centers:** CMEM, CHTM, CBME, CWE (NSF-CREST)

**HSC:** Pharmacy, Pathology, Community Health, Core Microscopy Facility

**External Health Facilities:** VA Hospital, Lovelace Respiratory Institute

**National & DOD Laboratories:** SNL, LANL, CINT, AFRL

**External Universities:** Highland, NMT, ENMU, Missouri, U. Hawaii, Wash. U.

**Companies:** Pajarito Powders, Sasol, Fairchild Semiconductor, NanoNMR, BioDirection, EWII Fuel Cells, MicroExact, Oncothyreon, Soladigm, World Minerals, Zircoa, NanoCool
Return on Investment: Graduate and Undergraduate Training

- Faculty and laboratory staff contribute to core mission of UNM through teaching materials characterization classes for graduate and undergraduate students:
  - NSMS 512/CHEM 469,569/ CBE412,512: Characterization Methods for Nanostructures ~45 students/year
  - EPS 538L - Analytical Electron Microscopy – taught every Spring semester – 144 graduate students since 2009
  - EPS 400/500: Introduction to X-ray diffraction – 60 undergraduate and graduate since 2009.
  - CBE477,577 Electrochemistry & Electrochemical Engineering ~25 students/year
  - CBE371, Introduction to Materials Engineering, ~50 students/year
  - Laboratory training and mentorship of undergraduate students. ~30/yr at AML (limited by COVID-19 in 2020)

Return on Investment: Publications, Patents, Presentations 2020

- Current CMEM Researchers published over 100 papers in Nature, Science, ACS, APS, ECS, MRS, Geophysical Society, and other Journals
- Current CMEM members made web-based presentations at Major International Society Conferences, ACS, AICHE, APS, MRS, ECS, TMS, AGU
- Active CMEM members have over 120,000 citations total. Junior and Mid-Career members citation rates continue to increase
- 10 patents granted or applied for
Proposals & Awards

Proposals

Awards
Research Expenditures and F&A

Research Expenditures

F&A

<table>
<thead>
<tr>
<th>Year</th>
<th>Research Expenditures</th>
<th>F&amp;A</th>
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<tbody>
<tr>
<td>FY18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FY19</td>
<td></td>
<td></td>
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<tr>
<td>FY20</td>
<td></td>
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**FY20 Sources of Revenue**

<table>
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<tr>
<th>Source</th>
<th>Amount</th>
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<tr>
<td>F&amp;A Return</td>
<td>$219,417</td>
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<tr>
<td>VPR Pullback</td>
<td>$(10,784)</td>
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<tr>
<td>PI F&amp;A Return</td>
<td>$(12,831)</td>
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<tr>
<td>Service Centers</td>
<td>$127,765</td>
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<tr>
<td>Support from OVPR</td>
<td>$380,149</td>
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<tr>
<td>FY20 Reserves</td>
<td>$527,321</td>
</tr>
<tr>
<td><strong>Total Revenue</strong></td>
<td>$1,231,037</td>
</tr>
</tbody>
</table>

**CMEM EXPENDITURE DETAILS**

- **Salaries**: $247,531, 39%
- **Fringe Benefits**: $91,595, 15%
- **Materials & Supplies**: $286,570, 46%
**STRENGTHS**

- CMEM Continues to bring world-class capabilities in micro and nanoscience and engineering - best in NM
- CMEM combines solution and colloid chemistry and physics with advanced manufacturing engineering to provide innovation
- CMEM provides multi-disciplinary theoretical, computational and experimental capabilities to solve complex problems
- Strong collaborations with Federal Labs

**OPPORTUNITIES**

- Increased DOE & AFRL connections
- New CMEM-Sandia-AFRL Facility in planning stage
- Benefactor for PAIS microscopy facility?
- CHEM, EPS, ME, CBE, CCE recruiting new faculty
- Soft Materials Research

**WEAKNESSES**

- CMEM AML facility is aging and costly to maintain
- Salaries are below Nat. Labs
- NM provides minimal State support
- CMEM tools are aging
- CMEM does not have any endowments
- South Campus rental costs

**THREATS**

- COVID-19 severely curtailed many training operations
- Declining Basic Science and Engineering Federal support
- Aging CMEM Facility
- Recruitment of top graduate students more difficult-foreign student visa barriers and more job opportunities
- Retention of early/mid career faculty
Looking Ahead to 2021

• CMEM will pursue adding new state of the art Electron Microscopy and X-ray Metrology tools to support the UNM STEM community

• CMEM will continue reevaluation of instrumental user fees to ensure access while keeping facilities operational with trained supervisory personnel.

• EPS and CMEM will support a new EM facility manager and develop an External Advisory group for the Facility

• CMEM will continue to participate in the design of the new South Campus Research Facility

• CMEM will aggressively pursue large multi-disciplinary & multi-researcher grants and contracts from NSF, NIH, DOE, EERE Grand Scale Energy Storage, FE, ARPA, BES, AMO, AFRL, AO, ONR, AFRL and Private funding sources.

• CMEM will continue to work with the Senior Vice President, Provost, Deans & VPR to help eliminate the rent burden, since the building loans have been paid off.
Summary

- CMEM has a strong national presence with multi-investigator participation in NSF, NIH, DOE and DOD programs, and international visibility through the professional service and visibility of its faculty and organization of major learned society events.
- CMEM is relocating capabilities from aging Northrop Hall to new PAIS Facility.
- CMEM at the AML is a vibrant site at UNM Science & Technology Park and continues being a “human bridge” to SNL & AFRL supporting collaborations in materials research with real collaborations between UNM and Federal partners.
- CMEM continues to win high dollar Federal support and foster the development of Tenure Track, Tenured and Research Faculty.
- CMEM provides a major educational resource for UNM students, engaging many undergraduate and graduate STEM students in NSF, DOE and DOD research projects.
- CMEM is a technology incubator for many UNM businesses and continues to have strong ties with the UNM Rainforest Innovation Center.