Materials Research

Bill Fahrenholtz and Jenny Liu
Missouri University of Science and Technology
Rolla, MO USA
billf@mst.edu, jennyliu@mst.edu

Let’s Talk Research, 26 February 2021
Materials Research

• Materials science
  - Built on the principles of chemistry and physics

• Major technology areas
  - Electronics and semiconductors
  - Nanotechnology
  - Biotechnology and medicine
  - Civil infrastructure
  - Energy
  - Aerospace
  - Manufacturing

Heat shield for Mars Perseverance lander

Image from NASA.gov
### NAE Grand Challenges

- 14 game-changing goals for improving the quality of life in the 21st century defined by the National Academy of Engineering

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Advance personal learning</td>
<td>- Secure cyberspace</td>
</tr>
<tr>
<td>- Affordable solar energy</td>
<td>- Provide access to clean water</td>
</tr>
<tr>
<td>- Enhance virtual reality</td>
<td>- Provide energy from fusion</td>
</tr>
<tr>
<td>- Reverse-engineer the brain</td>
<td>- Prevent nuclear terror</td>
</tr>
<tr>
<td>- Engineer better medicines</td>
<td>- Manage the nitrogen cycle</td>
</tr>
<tr>
<td>- Advance health informatics</td>
<td>- Develop carbon sequestration methods</td>
</tr>
<tr>
<td>- Restore/improve urban infrastructure</td>
<td>- Engineer the tools of modern discovery</td>
</tr>
</tbody>
</table>
NAE Grand Challenges

• 14 game-changing goals for improving the quality of life in the 21st century defined by the National Academy of Engineering

- Advance personal learning
- Affordable solar energy
- Enhance virtual reality
- Reverse-engineer the brain
- Engineer better medicines
- Advance health informatics
- Restore/improve urban infrastructure
- Secure cyberspace
- Provide access to clean water
- Provide energy from fusion
- Prevent nuclear terror
- Manage the nitrogen cycle
- Develop carbon sequestration methods
- Engineer the tools of modern discovery

More than half directly depend on new materials!
Materials Research

• Traditional paradigm
  - Composition, structure, properties, and performance

• All natural and manufactured substances
  - Metals, ceramics, polymers
  - Combinations
  - Solid, liquid, gas, plasma

• Focus of the planning exercise
  - Chemistry, physics, and engineering of materials

From: Wikipedia, Materials Science
Historic Context

• Materials activity has been part of Missouri S&T from the start
  - Founded 1870 as Missouri School of Mines and Metallurgy
  - Ceramic engineering added in 1926

• U.S. Bureau of Mines
  - Research center
  - Metallurgy
  - 1920-1995

From: preservemo.org
Materials Research Center

• Started in 1964, renovated 2012
• Funding directly from the state of Missouri
• Missions
  - Promote interdisciplinary materials research
  - Operate and maintain major research instrumentation
  - Advocate for materials research
• Resources
  - Straumanis-James Hall
  - Technical/administrative staff
  - Senior investigators
  - Equipment
Connections Among Constellations

• Materials research is highly interdisciplinary
  - Involves majority of departments on campus
  - Research problems are at the intersections

• Leverage and more fully utilize resources

• Examples of connections
  - Bio-materials
  - Infrastructure materials
  - Workforce development
  - Data science
  - Resources
Current Strengths

• Infrastructure
  - Analytical equipment, specialized labs, MRC

• Licensing revenue
  - Majority of campus royalty income is from materials patents

• Entrepreneurship
  - MO-Sci and Brewer Science started by MRC faculty

• Ubiquity
  - Materials research performed in a majority of campus departments

• Scholarship
  - Several high impact scholars in materials area

• Funded research projects
Materials Research Areas

- Materials for extreme environments
- Computational materials science
- Materials informatics
- Materials workforce development
- Low dimensional materials
- Photonic materials
- Topological materials
- Metal additive manufacturing
- Ceramic additive manufacturing
- Glass
- Infrastructure materials
- Steel production
- Metal casting
- Biomaterials
- Cement chemistry
- Raw materials supply
- Nuclear materials
- High pressure-high temperature synthesis
- Environmentally-friendly corrosion inhibitors
- Materials for energy and environment
Resource Needs

• Human resources
  - Qualified graduate students, skilled staff, expert faculty

• Faculty time
  - Minimize administrative burden, support from OSP
  - Teaching support (GTAs, release time, fair workload policies)

• Research expertise
  - Awareness of capabilities of colleagues
  - Coordinated or cluster hires across departments/colleges
  - Research faculty

• Research infrastructure
  - Centralized lab space for cluster areas, modern labs
  - State-of-the-art research equipment with support staff
Roadmap for the Future

• Continue to aggressively pursue single investigator grants
  - Fundamental academic activity, builds scholarly reputation

• Align priorities with Kummer Institute
  - Leverage resources, establish new collaborations, etc.

• Explore emerging areas
  - Sustain high level of activity by increasing scope and breadth

• Utilize national user facilities
  - Leverage funding with additional resources for basic research

• Establish new consortia
  - Enables larger research efforts (e.g., EMC lab, PSMRC, CAMT)

• Increase external collaborations
  - Enhance research and raise visibility

• Pursue large grant opportunities