Engineered, two-phase moderators
- matrix phase: good moderation
  structural integrity
- entrained phase: high moderation

Radiation stable, lifetime components operating at > 600°C.

A practical route to reducing cost lies in simplification and ultimate safety.
Technologies enabling this include:
- Zero release fuel form (FCM-SiC/TRISO)
- Core conduction to ambient under LOCA
- Compact, lifetime SMR.
- Replace core graphite with high performance moderator

**Goal**

- To develop and mature high-temperature, highly moderating materials for SMR application.

**What is the technology?**

- **Team members**
  - Professor Nick Brown and Caen Ang, UTK
  - Drs Xunxiang Hu and Yutai Katoh, ORNL
  - Professor David Sprouster, Stony Brook

- **Engineered, two-phase moderators**
  - matrix phase: good moderation
    structural integrity
  - entrained phase: high moderation

- **Radiation stable, lifetime components operating at > 600°C.**

- **A practical route to reducing cost lies in simplification and ultimate safety.**
  Technologies enabling this include:
  - Zero release fuel form (FCM-SiC/TRISO)
  - Core conduction to ambient under LOCA
  - Compact, lifetime SMR.
  - Replace core graphite with high performance moderator
Mitigation of Significant Off-Site Radiological Release

Control and Prevention of Beyond Design Basis Accidents

Control of Accident Within the Design Basis

Control of Abnormal Operation & Failure Detection

Prevention of Abnormal Operation and Failures

Conservative Design and High Quality In Construction and Operation

Control, limiting and protective systems. Surveillance.

Engineered Safety Features and Accident Procedures

Complementary Measures and Accident Management

Off-Site Emergency Response

Beyond Design Basis Accidents

Normal Operation
Motivation for utilizing new high-performance advanced materials in nuclear energy systems

S.J. Zinkle\textsuperscript{a,b,}* K.A. Terrani\textsuperscript{b}, L.L. Snead\textsuperscript{c}

\textbf{COSSMS 2016}
How is your system transformational?

- AdMod Sys. 1: Be\(^{2}\)nd Phase Materials
- AdMod Sys. 2: ZrH\(^{2}\)nd Phase Materials
- Advanced moderator will allow more compact and safer core. Direct economic benefit from size and enhanced portability. Significant advantage gained if technology augments argument for reduced EPZ.
- Advanced manufacturing (i.e. Direct Current Sintering) is now allowing engineered structures (amalgams) of vastly different melting temperatures by “getting in under the kinetics.”

<table>
<thead>
<tr>
<th></th>
<th>Slowing Down Power (\zeta \Sigma)</th>
<th>(T_{\text{melt}}) (T$_{\text{recomp}}$) (\degree\text{C})</th>
<th>Irradiate Perf. ((\sim 500\degree\text{C, &gt;20 dpa}))</th>
<th>Therm. Cond. ((650\degree\text{C})) (\text{W/m-K})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graphite</td>
<td>0.077</td>
<td>(3000)</td>
<td>Poor</td>
<td>~20</td>
</tr>
<tr>
<td>CVD SiC</td>
<td>0.044</td>
<td>(2860)</td>
<td>Excellent</td>
<td>~80</td>
</tr>
<tr>
<td>ZrH</td>
<td>0.859</td>
<td>(&gt;850)</td>
<td>unknown</td>
<td>~17</td>
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<tr>
<td>MgO</td>
<td>0.060</td>
<td>2853</td>
<td>Excellent</td>
<td>~50</td>
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<tr>
<td>Be(_{2})C</td>
<td>0.125</td>
<td>(~2100)</td>
<td>unknown</td>
<td>~22</td>
</tr>
<tr>
<td>ZrBe(_{13})</td>
<td>0.129</td>
<td>1525</td>
<td>unknown</td>
<td>~40</td>
</tr>
<tr>
<td>TiBe(_{12})</td>
<td>0.138</td>
<td>1925</td>
<td>unknown</td>
<td></td>
</tr>
<tr>
<td>BeO</td>
<td>0.124</td>
<td>2507</td>
<td>V. Bad, anisotropic</td>
<td>~30</td>
</tr>
<tr>
<td>Be</td>
<td>0.16</td>
<td>1287</td>
<td>Bad</td>
<td>~60</td>
</tr>
</tbody>
</table>
The MEITNER team applied an advanced manufacturing approach to patent the fundamental methods and mass production of FCM fuel. The team will apply a similar approach to AdMod.
What challenges do you anticipate?

- Ad-Mod System 1: ZrH
  - Loading and Control of ZrH
  - Loss of H at Temperature/Irradiation
  - Ability to and Stability of Cladding

- Ad-Mod System 2: Be-based systems
  - Suppressing matrix sintering temp.
  - Entraining toxic material
  - Thermal stability

- Robust and viable materials systems
  - Viable neutronics and safe reactor core
  - Economics from fabrication to system

- TEA