



International Energy Agency (IEA) *Energy in Buildings and Communities (EBC) Executive Committee Meeting*

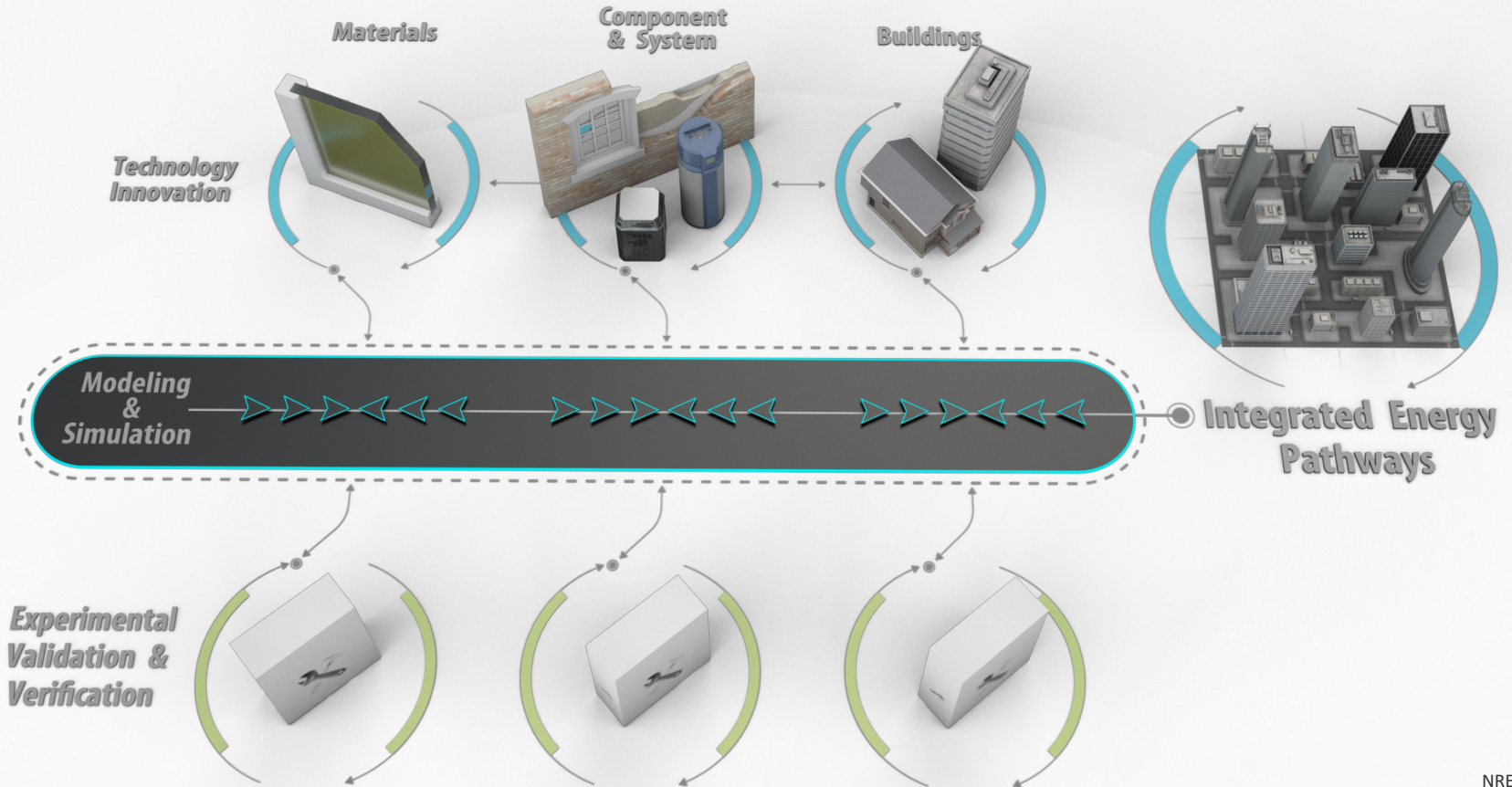
Judith Vidal, Ph.D.
Manager, NREL Building Energy Science Group
November 12, 2019



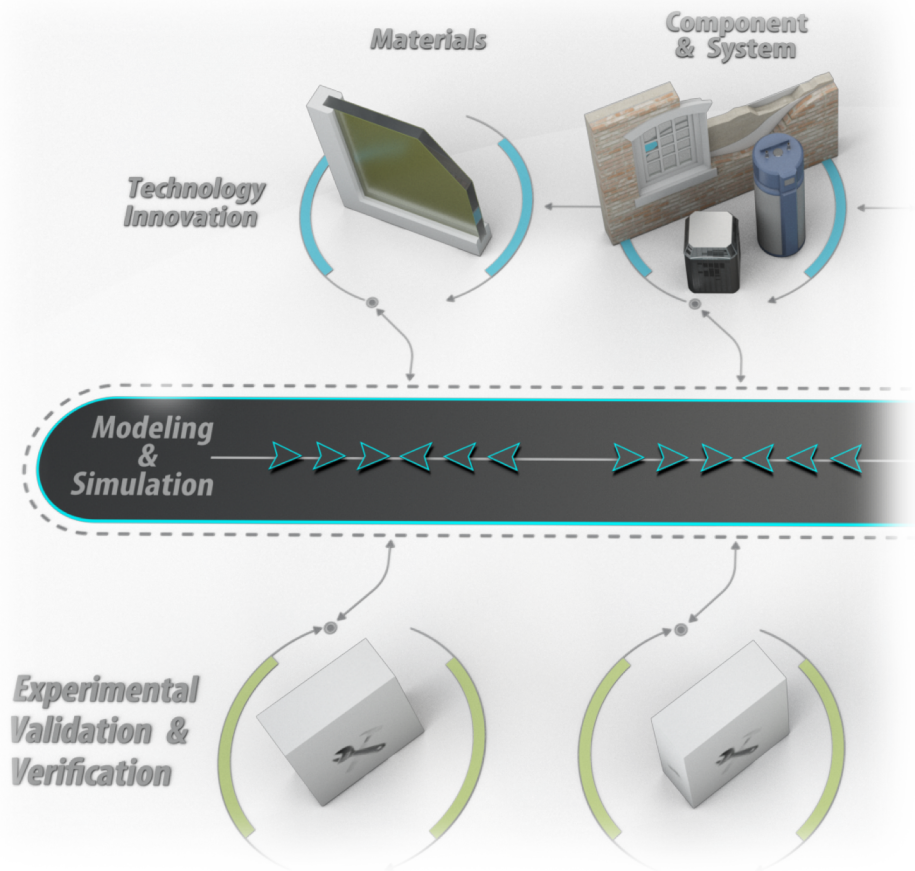
Thermal Energy Storage (TES)

Buildings Applications

Integrated Strategy Enables Impactful Innovation



Materials to Components & Systems for Thermal Energy Storage in Buildings



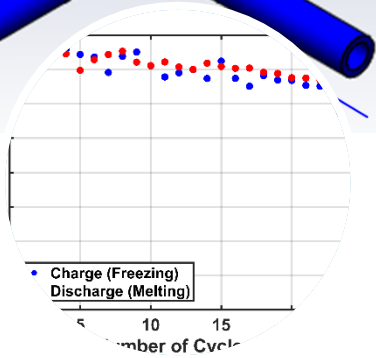
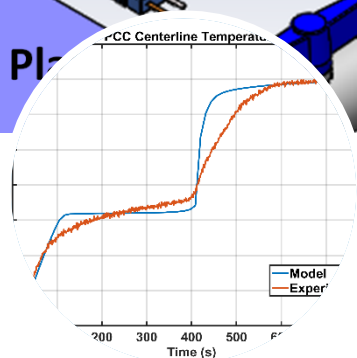
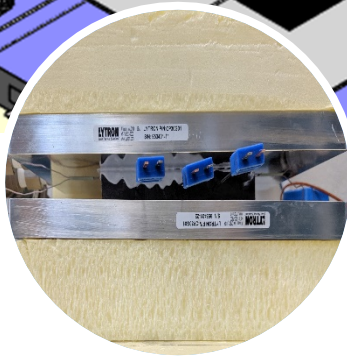
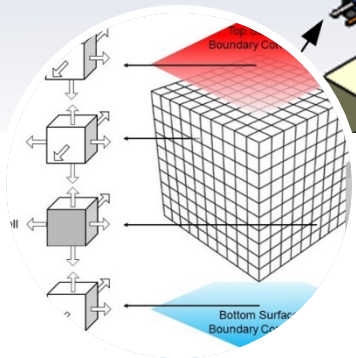
TES Materials: Thermal Characterization

Hot Fluid Outlet

Hot Plate

Sample

Cold Plate



Model

3-D transient model to predict the performance of the material

Experiments

New experimental facility to characterize the performance of bulk TES materials

Validation

Validated model predicts the response accurately

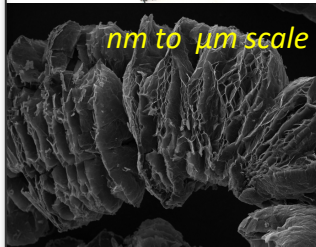
Thermal Cycling

Specific energy throughput calculated over cycles

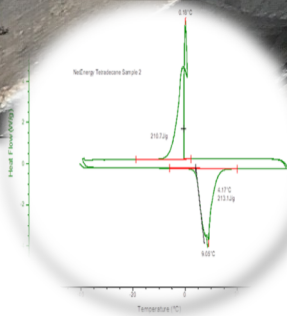
HVAC-Integrated Composite Phase-Change Material (PCM)



nm to μm scale

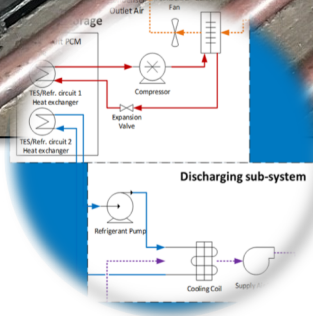


Expanded graphite



Materials characterization

Develop and characterize high-conductivity composite phase-change materials



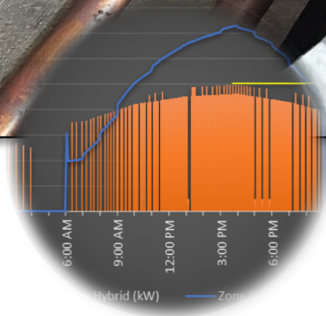
Heat exchanger and HVAC system design

Model and design thermal storage heat exchangers and systems



Prototype characterization

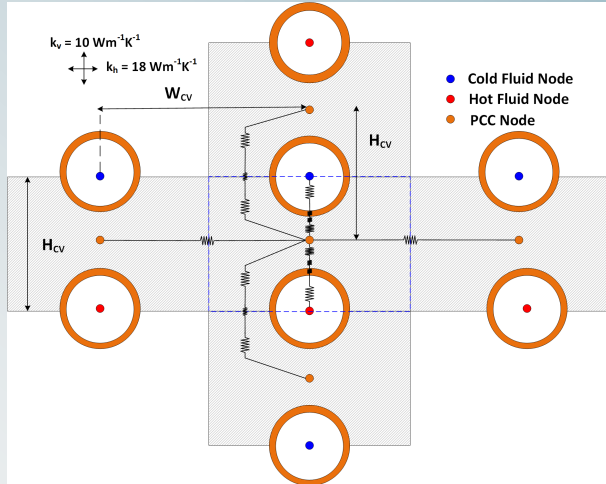
Build and characterize HVAC-integrated thermal storage



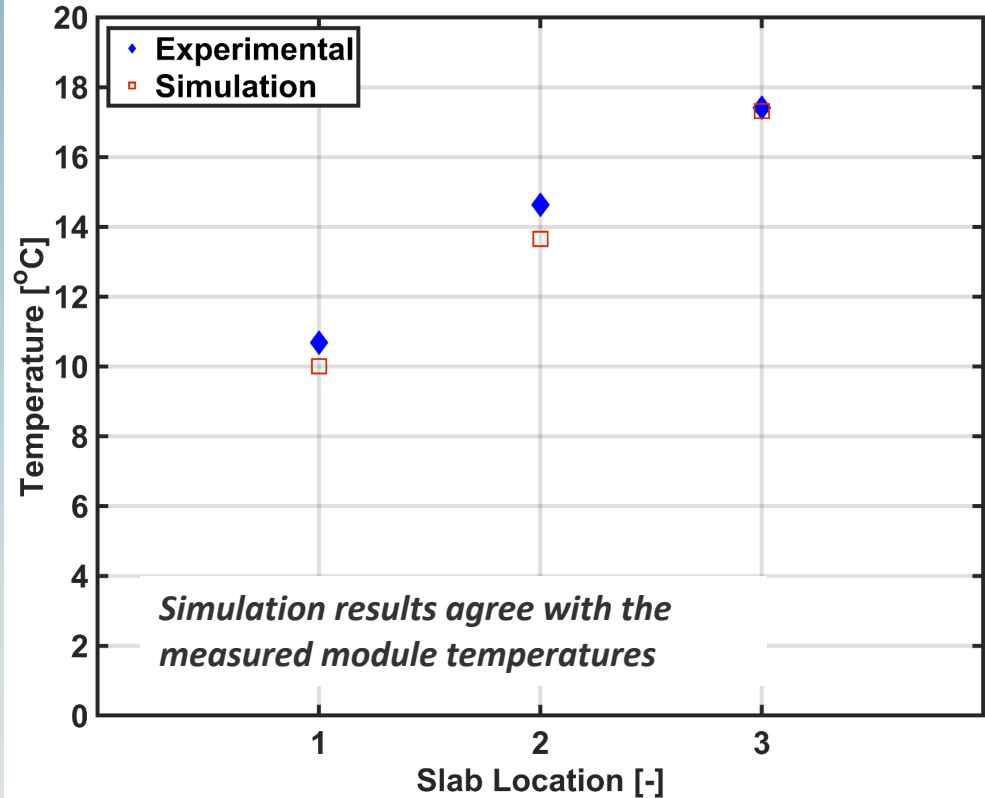
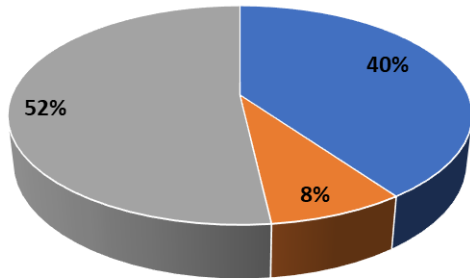
Energy and demand analysis

Evaluate new thermal storage using HVAC system and building modeling

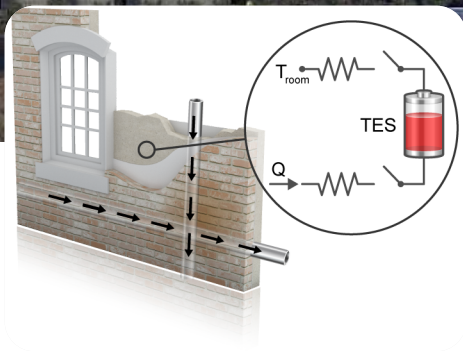
Thermal Resistances and Model Comparison



■ Conductive ■ Convective ■ Contact

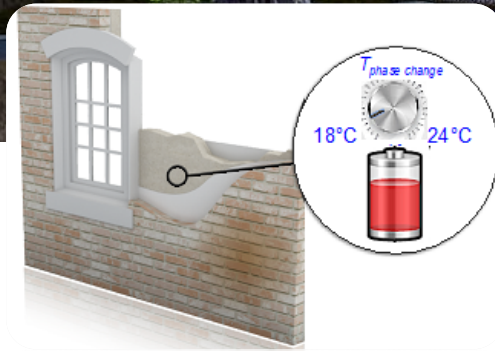


Tunable TES & Thermal Switch for Smart Building Envelopes



Controlled thermal switch

To vary thermal resistance



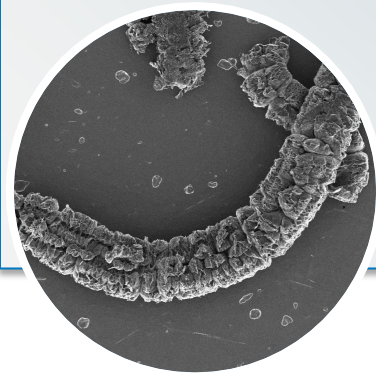
Dynamic tunability in solid-state PCM

Comb-branch Micro block Polymer

Multi-physics multi-scale modeling

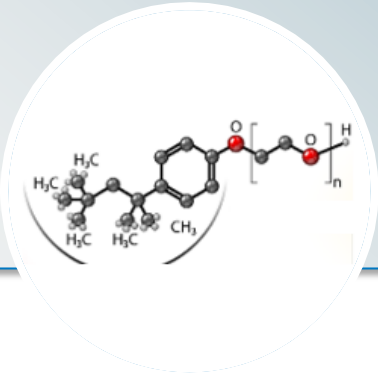
Demonstrate maximum potential of using tunable thermal energy storage and thermal switch to support grid flexibility

Salt Hydrate/ Graphite PCM Matrices



Porous Expanded Graphite

Host matrix for PCM with high specific area and nano/micro porosity



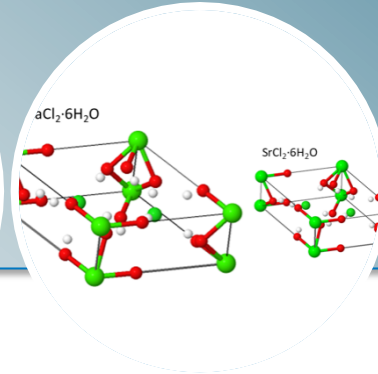
Hydrophilic Surface Modification

Surface modification to enable loading of hydrophilic PCM into hydrophobic graphite



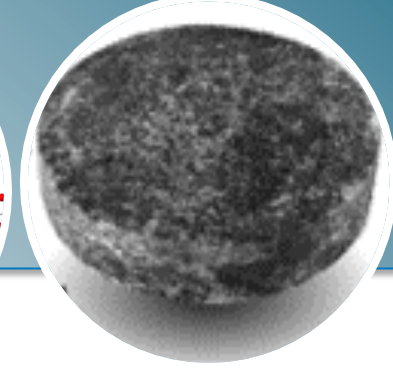
Improved Wetting

Improved wetting and low contact angle of PCM on porous graphite surfaces



Lattice Matched Nucleating Agents

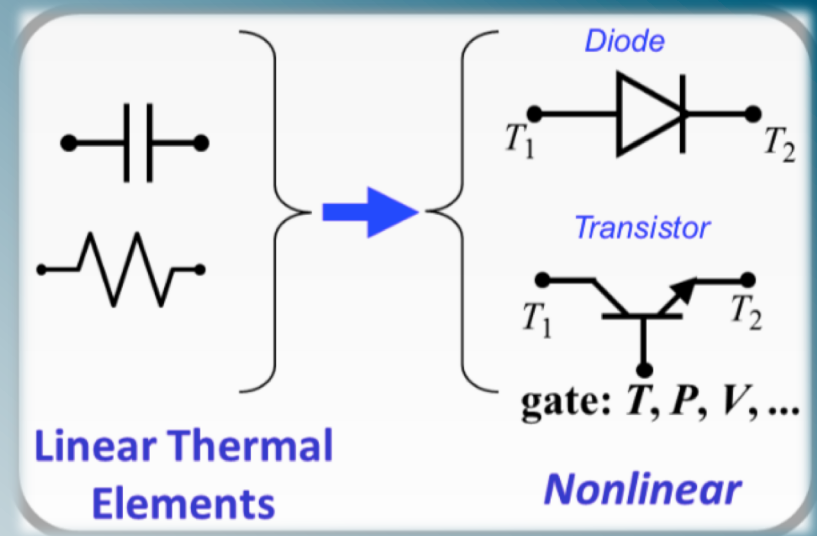
Incorporation of lattice matched nucleating agents for supercooling reduction



PCM phase change composite

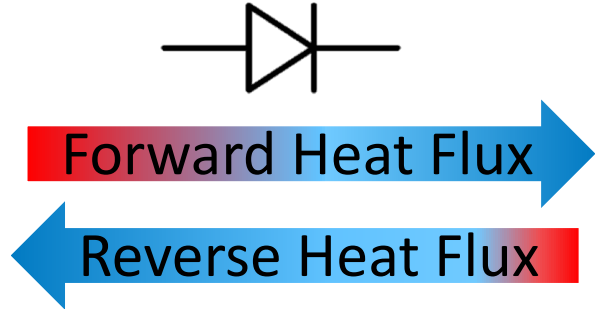
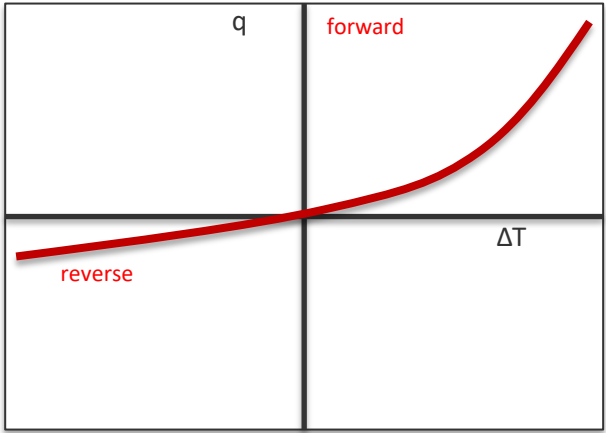
High thermal conductivity, high energy density PCM composite

Taken from HEATER Big Idea Presentation.
Ravi Prashant LBNL

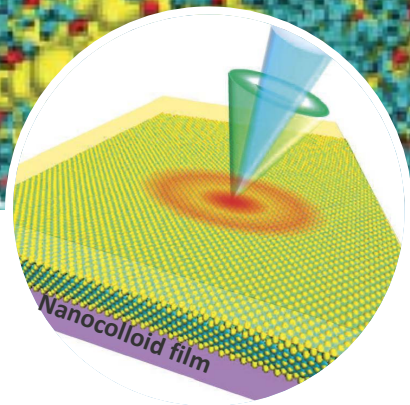
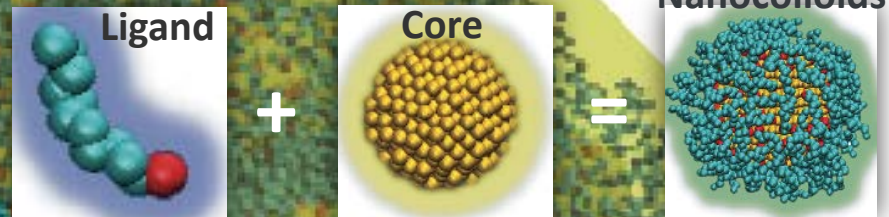


Thermal Diode for Buildings

Thermal Diodes:
Directional Heat Transfer and Thermal Management System

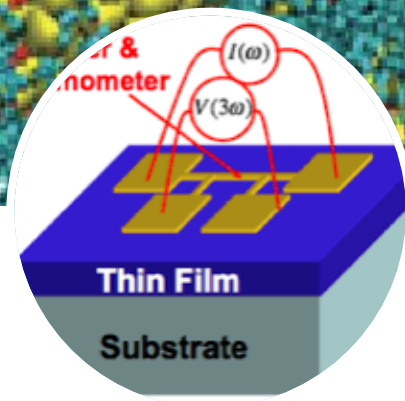


Switchable/Tunable Thermal Conductivity of Colloidal Nanocrystals



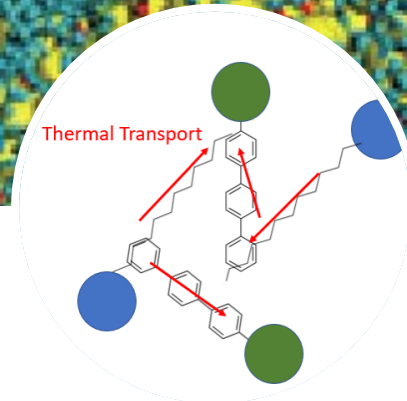
Time Domain Thermal Reflectance

Thermal conductivity measurement for colloidal nanocrystal thin films



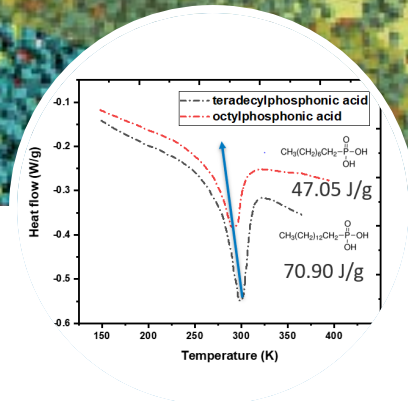
3-Omega Method

Thermal conductivity measurement for bulk, thin film and powder



Switchable Thermal Conductivity

Study the influence of different type of ligands and Cores on thermal conductivity



Tunable solid-solid Phase Change

Study the influence of core+ligand+bonding on phase change behavior



Thank You

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