Based on the thermal measurement results, an actual GeTe switching heater device is designed with 8-unit heater layout covering the phase change region of 25×12.5 μm^2. A finite element model is established for the heater device to predict the steady state and transient thermal responses. To validate the thermal measurement results and the finite element model, the heater device is also fabricated and experimentally tested. The steady state thermal response is measured through a thermal mapping system; the transient response is reflected through a phase change test with pulse voltage input. Both the steady state temperature profile and the amorphized GeTe region under pulse input show high agreement between simulation and experiment, proving the accuracy of the thermal measurement and the finite element model. This work extends the thermal understanding of the GeTe based reconfigurable devices, and provides a general workflow on comprehensive thermal modelling of nanofabricated heater structures.

SESSION EN07.17: Energy Conversion and Storage
Session Chairs: Hyungyu Jin and Dongyan Xu
Friday Afternoon, April 26, 2024
Room 327, Level 3, Summit

1:45 PM *EN07.17.01
Triboelectrics and Tribovoltaics for Energy Harvesting Sang-Woo Kim; Yonsei University, Korea (the Republic of)

Energy harvesting systems based on triboelectric nanomaterials are in great demand, as they can provide routes for the development of self-powered devices which are highly flexible, stretchable, mechanically durable, and can be used in a wide range of applications. Ultrasound was used to deliver mechanical energy through skin and liquids and demonstrated that a thin inplantable vibrating triboelectric nanogenerator is able to effectively harvest it. Secondly the presenter is going to introduce a two-dimensional (2D) materials-based tribotronics for possible future application toward tactile sensors, robots, security, human-machine interfaces, etc. The triboelectric charging behaviors of vaious 2D layered materials including graphene, MoS_2, WS_2, etc were investigated in order to decide the triboelectric position of each 2D material using the concept of a triboelectric nanogenerator, which provides new insights to utilize 2D materials in triboelectric devices, allowing thin and flexible device fabrication. Finally I will introduce a novel tribovoltaic effect, which can generate DC power output through the coupling of tribo exciton and drift by built-in electric field to overcome the limitations of conventional AC power-generating triboelectric nanogenerators. It was found that DC power can be generated at dynamic perovskite/CTL heterojunctions by electrical carrier generation from triboelectrification between two layers, which is different from the electric energy generation by photon excitation in solar cells. The tribovoltaic effect enables a paradigm shift in energy harvesting by enhancing battery charging efficiency based on an innovative working mechanism.

2:15 PM EN07.17.02
Dynamically Tunable Solid-State Thermal Energy Storage Shuang Cui[1,2] and Judith Vidal, Ph.D[2]; [1]The University of Texas at Dallas, United States; [2]National Renewable Energy Laboratory, United States

Thermal energy storage (TES) utilizing phase-change materials (PCMs) holds substantial promise in various applications, such as climate control in buildings and thermal management for batteries and electronics. A critical challenge in PCM-based TES applications is the limited tunability of the operating temperature, especially for the near-ambient applications, as the PCM has a fixed transition temperature as designed. or instance, within buildings, the required operating temperature can significantly fluctuate between summer and winter, and even exhibit notable diurnal variations. This results in suboptimal PCM utilization, often leading to incomplete melting or no phase transition at all. Recent efforts have aimed to enhance the tunability of thermal materials and devices, enabling dynamic changes in their properties and performance. However, most of these endeavors have primarily concentrated on modifying thermal transport properties, such as thermal conductivity, while neglecting thermodynamic characteristics, specifically the transition temperature of materials. Changing the transition temperature using external stimuli like pressure, electric fields, or magnetic fields presents a non-trivial task, as the required magnitude of the stimulus to achieve a sizable change in Tm is typically large, and the enthalpy change at Tm is only moderate for thermal storage applications. Additionally, handling the liquid phase of PCMs during phase transitions (melting) has hindered practical TES implementation. To address these challenges, this work reports a solid-state, tunable TES utilizing shape stabilized PCMs. This innovative tunable TES achieves an impressive dynamic transition temperature tunability of up to 10°C and enables outstanding shape stability over a month without leakage during melting. Such advancements offer the potential for simplified and safer TES device and system designs. Furthermore, the tunable TES exhibits exceptional cyclability, maintaining TES capacity across more than 100 cycles, thus presenting a promising avenue for practical applications.

2:30 PM EN07.17.04
Physics-Based Prediction and Design of Absorption Properties of Moisture-Capturing Hydrogels Carlos D. Diaz, Lorenzo Masetti, Miles Roper, Kezia Hector, Yang Zhong, Zhengmao Lu, Gustav Graeber, Jeffrey C. Grossman and Gang Chen; Massachusetts Institute of Technology, United States

Moisture-capturing hydrogels have emerged as promising low-cost sorbent materials for applications including thermal management, thermal energy storage, and atmospheric water harvesting. Despite extensive efforts in the synthesis of novel hydrogels, there is a major knowledge gap between the synthesis variables and the material properties, which hinders the design of properties and system-level optimization. In this work, we develop physics-based models to predict the properties of moisture-capturing hydrogels from their composition. We develop and experimentally validate thermodynamic models that accurately predict the water uptake and absorption enthalpy as a function of humidity as relevant hydrogel synthesis variables are changed. We also develop mass transport models, using a convection-limited transport description, that accurately predict experimental absorption and desorption speeds. This work represents a major step in the design of moisture-capturing hydrogels, enabling application optimization for high performance thermal management of electronics, buildings, and people, heat storage, and atmospheric water production.

2:45 PM EN07.17.05
Hydrogel-Salt Hydrate Composite for Highly Stable Heat Energy Storage with Reduced Supercooling Sung Bum Kang, Youngmun Lee, Wonsik Eom, Wuchen Fu, Mayur S. Prabhudesai, Daniel Hsieh, Sameh Tawfick, Nenad Miljkovic, Sanjiv Sinha and Paul V. Braun; University of Illinois at Urbana-Champaign, United States

Phase change materials (PCM) have potential for use in thermal energy storage in buildings, medical devices, and water heat pumps. Sodium sulfate hydrate (SSD) is appealing due to its high energy storage capability and affordability. However, SSD has issues including high supercooling (> 15°C) and low thermal cyclic stability. In this study, we introduced an ionic molecular nucleating agent that decreases the supercooling temperature to under 2°C. When this SSD was combined with a hydrogel, it maintained its thermal energy storage capacity for over 100 cycles without any decline. The success is attributed to the polymer confining the SSD crystals, preventing large-scale phase separation and the nucleating agent which resulted in nucleation of many small SSD crystals at small undercoolings rather than a small number of larger crystals. As a proof-of-application, we synthesized this composite at a kg