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ADVANCED MULTI-FUNCTIONAL MATERIALS: TACKLING MULTI-SCALE AND MULTI-FIELD CHALLENGES

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The demands of a sustainable society can only be met through significant technological advancements, particularly in the development of new materials designed with a multi-functional perspective. Multi-functionality is indeed a key requirement for engineering breakthroughs across various applications, such as more efficient devices for energy harvesting (e.g., conversion systems, batteries), memory storage (e.g., high-tech magnets), and the Internet of Things (e.g., biomedical sensors, mechanical actuators). In these contexts, promising and fascinating developments are also expected from the advent of responsive systems for soft robotics and metamaterials with functional programmed instabilities.

Multi-functional materials often rely on the coupling of different physical fields-such as thermal, electrical, magnetic, chemical, and mechanical. The efficiency of energy conversion mechanisms between these phenomena and energy transfer across vastly different time and length scales is crucial to their development. This presents significant challenges in the design process, requiring substantial efforts from the scientific community. Many underlying mechanisms remain experimentally unstudied, and predictive theoretical and numerical models are still under development worldwide.

This session aims to bring together leading experts in the field to foster a debate on the current challenges and future directions. Key topics of interest include constitutive modeling of coupled responses; numerical approaches for multi-field problems; homogenization of complex microstructures and multi-field phenomena; efficient data-driven virtual material testing strategies; soft robotics and metamaterials; and the analysis and design of novel technologies and devices based on multi-functional materials.