Engineering Functionality Through Dynamic Visualization and Control of Atomic Motions

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Advances in energy, computing, and medicine rely on the discovery of dynamic materials, whose properties can be tuned in real time via external stimuli – this is key to engineering "smart" systems that can respond rapidly to changing environments. This paradigm necessitates a microscopic understanding of how materials respond transiently to external perturbations, which can ultimately drive useful changes in macroscale properties. In this seminar, I will present three examples of functionalities arising from the modulation of atomic structure on timescales spanning twelve orders of magnitude. On the timescale of seconds, I will show how electrochemical ion insertion into a van der Waals layered material can drive large (~10x) reversible tuning of heat transport, for applications in dynamic thermal management. On the microsecond timescale, I will demonstrate how electrical excitation of a phase-changing oxide can trigger the formation of a non-equilibrium intermediate state, with implications for low-energy neuromorphic computing. Finally, on the picosecond timescale, I will discuss how ultrafast optical excitation can induce giant (>100x) enhancement of energy transfer rates across a 2D atomic junction, a finding that is important for engineering next-generation optoelectronic devices. These results illustrate the power of dynamic control as a tool for on-demand programming of materials, with applications in various areas of energy and computing.

Dr. Aditya Sood is a Research Scientist at the Stanford Institute for Materials and Energy Sciences (SIMES) at Stanford University & SLAC National Laboratory, working with Prof. Aaron Lindenberg and Prof. William Chueh. He earned his B.Tech. from the Indian Institute of Technology (IIT) Kanpur and Ph.D. from Stanford University, both in Materials Science and Engineering. His Ph.D. research was done under the supervision of Prof. Kenneth Goodson in the Department of Mechanical Engineering at Stanford, in close collaboration with the group of Prof. Eric Pop in Electrical Engineering. His interests lie at the intersection of thermal transport, nanoelectronics, and ultrafast physics, with a focus on visualizing and controlling atomistic dynamics across a range of technologically-relevant timescales. He has received the Batra Gold Medal from IIT for outstanding undergraduate performance (2011), the Gold Graduate Student Award from the Materials Research Society for his Ph.D. research (2017), and the LCLS Young Investigator Award from SLAC National Laboratory for his postdoctoral work (2021). For more information, see https://sites.google.com/view/adityasood

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