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WATCHING REAL MATERIALS IN ACTION: EVERYTHING, EVERYWHERE, ALL AT ONCE

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At the heart of materials science studies for next generation materials is an idea that we want to be studying real materials doing real things, often in real devices. In practice, this presents a number of key data analysis and interpretation challenges because it implies we are studying ever more complicated samples, often in complex heterogeneous environments and in time-resolved operando setups, and we are interrogating our data for more and more subtle effects such as microstructures and evolving defects and local structures. Advanced data analysis algorithms and software are essential for the success of this enterprise. Of particular interest is the study of nanomaterials and materials structure on different lengthscales. In this talk I will describe various developments that leverage latest data acquisiont and analysis techniques, sometimes powered by artificial intelligence (AI) and machine learning (ML), that reveal how materials behave on different length-scales and sometimes also timescales. The materials studied include materials for sustainable energy, environmental remediation, and cultural heritage studies, and techniques range from spatially resolved x-ray and electron nanostructure studies and neutron diffraction and scattering.