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Studying real materials in action: Time resolved measurements of local structure in materials at synchrotrons and XFELs

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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. Of particular interest is the study of nanomaterials and materials structure on different length-scales. In this talk I will describe various developments that leverage the latest data acquisition and analysis techniques, sometimes powered by artificial intelligence (AI) and machine learning (ML), that reveal how materials behave on ultra-fast (picosecond) time-scales after being hit with a laser. The material studied is a quantum material with a charge-density wave transition, but is a model system that demonstrates an approach that could be used to study chemical reaction coordinates for real processes in sustainable energy, environmental remediation, and health.

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