Structural Dynamics Probed with Ultrafast & Coherent X-Rays

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Structural heterogeneity and dynamics underlie the properties of the materials and performance of the devices. The recent advent of hard x-ray free electron lasers (XFELs) opens new areas of science due to their exceptional brightness, coherence, and time structure. In principle, such sources enable studies of dynamics of condensed matter systems over times ranging from femtoseconds to seconds. In this talk, I will present two examples of recent research on the ultrafast and nanoscale structural dynamics. The first part of my talk will be the time-resolved *in situ* visualization of internal deformations in nanoporous ZSM-5 zeolite crystals during the catalytic reactions. The results show that the interactions between the reactants and the active sites lead to the unusual strain distribution observed during the reaction, as confirmed by density functional theory simulations. These observations provide insights into the role of structural inhomogeneity in the activities of zeolites and should assist in the future design of catalysts. In the second, I will show the ultrafast atomic scale structural response of Bi2Se3 induced by laser pump and probed by femtosecond XFEL pulses. The initial strain induced by interaction with the carriers and the lattice vibrations directly measured in the time domain will be discussed.