

Abstract

Ultrafast electron crystallography (UEC), combining the ultrafast time resolution with femtosecond lasers and the atomic spatial resolution with electron crystallography, is developed and applied to elucidate the structural dynamics in solids, surfaces and macromolecular systems. The UEC experiments for surface studies were first demonstrated on semiconductor surfaces. Coherent nonthermal motions of atoms following ultrafast laser irradiation were shown with the timescales in picoseconds, and the amplitude of the motions was determined in picometer. Using Langmuir-Blodgett films, two-dimensional crystalline monolayer, bilayers and multilayers of fatty acids and phospholipids were also studied by UEC. The atomic structures under different preparation conditions were determined. The structural dynamics following a temperature jump induced by femtosecond laser on the substrates were obtained and compared to the equilibrium temperature dependence. It was observed that a coherent anisotropic expansion solely along the aliphatic chains happens at picosecond timescale, followed by nonequilibrium contraction and restructuring at longer times. The effects of different molecules, layer thickness and substrate on the dynamics were examined. Unlike monotonic disordering in the equilibrium heating, a transient structural ordering was revealed on the picosecond timescale.