Electron Diffraction at Surfaces: By now Ultrafast!

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The non-equilibrium structural dynamics of the (8×2) reconstruction on a Si(111) surface were observed by means of ultra-fast time-resolved electron diffraction. We use a combination of pulsed electron gun in reflection high energy electron diffraction (RHEED) geometry with a fs laser system (80 fs, 800 nm, 1 mJ, 5kHz) in a stroboscopic pump probe setup. Using a tilted pulse front scheme for the laser excitation the temporal resolution was improved to 350 fs. Upon excitation by the fs-laser pulse the (8x2) groundstate is driven in less than 400 fs to the (4×1) excited state as observed through the intensity rise and drop of the reconstruction spots. Transient heating of the In atoms from 30 K to 60K occurs time delayed only after 3 ps. Thus the surface is excited electronically, the Peierls distortion lifted by photo doping and not by thermal excitation. Surprisingly the surface remains for nanoseconds in this super cooled metastable (4×1) state, which is not accessible under equilibrium conditions. The relaxation into the (8×2) groundstate happens delayed through the nucleation of the (8×2) phase at pre-existing adsorbate induced defects which triggers a 1-dim. recrystallization front which propagates with 100 m/s as determined from a transient spot profile analysis of the diffraction spots.