Tracing Structural Phase Transitions and Phase Ordering at Surfaces with Ultrafast LEED

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Solid state surface systems are particularly attractive because of their modified electronic, lattice and spin structures, resulting in strongly altered physical and chemical properties compared with the bulk [1]. We have recently developed ultrafast low-energy electron diffraction (ULEED) in a laser-pump/electron-probe scheme (Fig. 1a) to explore optically-induced structural dynamics at surfaces on their intrinsic time scales [2,3].

Here, we present the observation of phase-ordering mechanisms in the incommensurate (IC) charge density wave (CDW) phase of 1T-TaS_2 [2]. Utilizing the high momentum resolution of the ULEED setup, we perform a thorough spot profile analysis of the appearing IC CDW diffraction peaks and observe a coarsening behavior in the newly created IC phase (Fig. 1b). This growth of the IC CDW coherence length is attributed to the annihilation of dislocation-type topological defects.

We further use the high surface sensitivity of our ULEED apparatus to study the surface-specific structural phase transition of self-assembled Indium wires on Silicon (Fig. 1c). The sample is prepared by *in situ* evaporation of one monolayer of Indium on a clean Si(111) surface followed by subsequent annealing and cooling down to 60 K. At low temperatures, the system undergoes a Peierls-type transition from a metallic high-symmetry (4x1) to an insulating low-symmetry (8x2) phase [4]. This transition can be reversibly driven by ultrafast optical excitation. We will report on the first findings regarding the underlying structural dynamics and the emerging metastable (4x1) superstructure probed by ultrafast LEED.

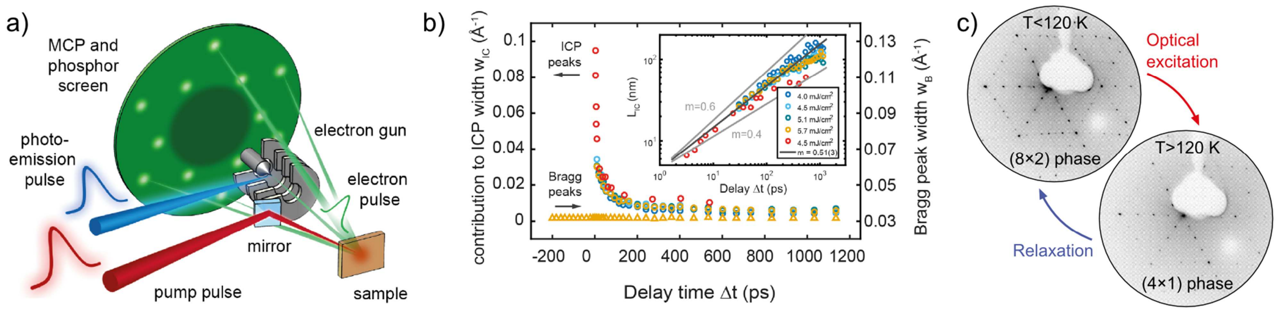

Fig. 1: a, Sketch of the optical-pump electron-probe scheme of the ULEED experiment. b, Time-dependent contribution to the width (FWHM) of the ICP diffraction peaks and width of lattice diffraction peaks for a range of optical-pump fluences. c, Diffraction images of the low-temperature (8x2) and the high-temperature (4x1) phase of Indium atomic wires on a Si(111) surface recorded with 130eV electron pulses in our ULEED setup.

References:
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