2D Silica Films - Structure, Properties and Transfer

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The surface structure of silicon dioxide is of particular interest, due to the diverse application of crystalline and amorphous silica in communications technology, catalysis and many other fields. However, studies of SiO_2 bulk samples are hampered by the insulating nature and the high surface roughness of the material.

Using a thin film approach, an atomically flat bilayer of SiO_2 supported on a Ru(0001) single crystal can be created, which allows imaging with scanning tunneling microscopy (STM) and atomic force microscopy (AFM). For the first time, the structure of an amorphous network is imaged in real space. Atomic positions of either oxygen or silicon can be visualized, as well as extended ring structures with their distributions and local neighborhoods. This allows for statistical analysis of the typical building units, comparing amorphous to crystalline regions, as well as experiment to theory.

Coexisting crystalline and amorphous areas provide the opportunity to image topological transitions. The understanding of glassy structures gained from these experiments is the starting point for more in-depth structural investigations, tracking the influence of composition and preparation history on the amorphous network.

A multitude of technologically relevant properties of silica bilayers have been established in the last years. Silica bilayers have been shown to have large band gaps of around 6.5 eV. Adsorption properties of the film were probed using single metal atoms which migrate through the film, exhibiting ring-size-selectivity. Silica bilayers can be employed as molecular sieves. Solvent exposure and hydroxylation studies show the chemical inertness of silica bilayers. SiO_2 films maintain their atomic structure outside the UHV environment, as evidenced by liquid AFM imaging.

The unique bilayer structure is coordinatively saturated, exhibiting weak interaction with the substrate. A mechanical transfer of an intact silica bilayer from the growth substrate to another support material has been demonstrated. The bilayer film stays intact on the mm-scale throughout the transfer, which is promising for applications as insulating layers in 2D-heterostacks.