Dynamic AFM in Liquids

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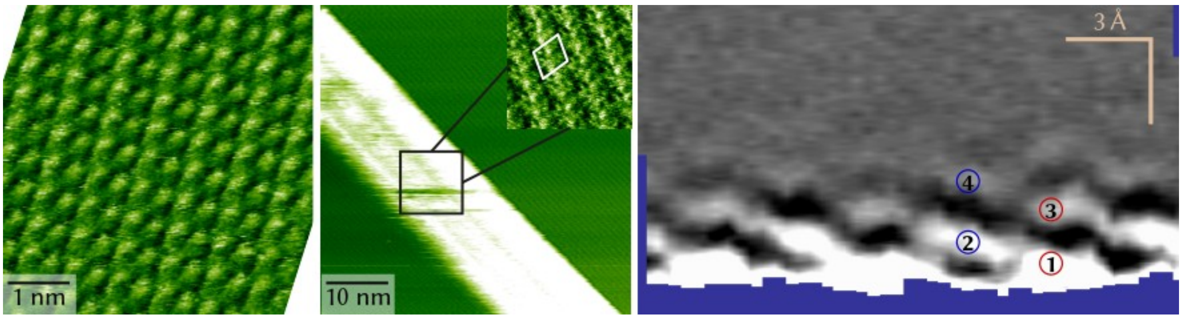
Solid-liquid interfaces play a decisive role in a wide range of natural and technological processes. For example, mineral dissolution, growth and weathering are pivotal within geochemistry and environmental science [1]. Molecularly controlled nucleation and growth at the solid-water interface govern biomineralisation and biomimetic crystallisation; processes that are known to result in highly sophisticated, tailor-made materials [2]. Moreover, interfacial reactions are at the heart of many industrial fields such as catalysis and corrosion protection [3].

For understanding, controlling and predicting processes at the solid-liquid interface, a detailed knowledge of the atomic structure, potential surface rearrangements and the solvation structure is mandatory. In the last decade, dynamic atomic force microscopy (AFM) has been developed into a most powerful tool for investigating the interfacial structure and reactivity in real space and at the atomic level.

In this lecture, main challenges of dynamic AFM in liquids and their technical solutions will be presented. Besides increasing the signal-to-noise ratio [4], a direct excitation of the cantilever is needed to avoid the "forest of peaks" [5]. Nowadays, dynamic AFM provides atomic-resolution imaging at the solid-liquid interface on a routine basis, which is used for investigating molecular self-assembly and molecule-induced surface restructuring [6, 7]. State-of-the-art applications include three-dimensional solvation layer mapping [8, 9], revealing the solvent structure at the interface. Finally, an outlook will be given addressing promising solutions for Kelvin probe force microscopy measurements in electrolyte solutions.



Examples for dynamic AFM in liquids: (*left*) Atomic resolution imaging on the dolomite (10.4) surface in water, (*middle*) a self-assembled stripe of Congo Red molecules on calcite with molecular-scale resolution as inset and (*right*) a vertical slice of a 3D hydration layer map acquired at the calcite-water interface.

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