

# ATOMIC SCALE TECHNOLOGIES BASED ON DYNAMIC SCANNING FORCE MICROSCOPY

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The dynamic scanning force microscope (SFM) operated in the so-called non-contact mode (NC-AFM) is today a universal tool for investigating the topography, atomic structure as well as chemical and a variety of other properties of surfaces and nanostructures. Since the first evidence for atomic resolution SFM imaging [1], the technique has been developed into a mighty tool for atomic scale investigation with unique capabilities in research on structures, defects and functions on dielectric surfaces. Here, the impact and potential of dynamic SFM is discussed in the context of applications in molecular electronics, atomic manipulation and surface chemistry.

In **molecular electronics**, the problem of a leakage current from a molecule to its support is a severe limitation. One concept facilitating the controlled contact of a molecule to a metallic support while avoiding leakage current is to decouple the conducting molecule from the substrate by weakly conducting spacer legs [2], [3]. However, a design with molecular structures on a non-conducting support is more desirable especially for optoelectronics where an optically transparent support is of advantage (Fig. 1). The quest for suitable combinations of functional conducting molecules and electrically insulating substrates is one of the central issues in the FP6 IP PicoInside [4]. There, dynamic SFM is used to investigate molecular layers on dielectric substrates; Fig. 1 shows a result of PTCDI on mica. In future, low temperature dynamic SFM will be able to probe and manipulate the conformation of molecules and to precisely structure molecular layers.

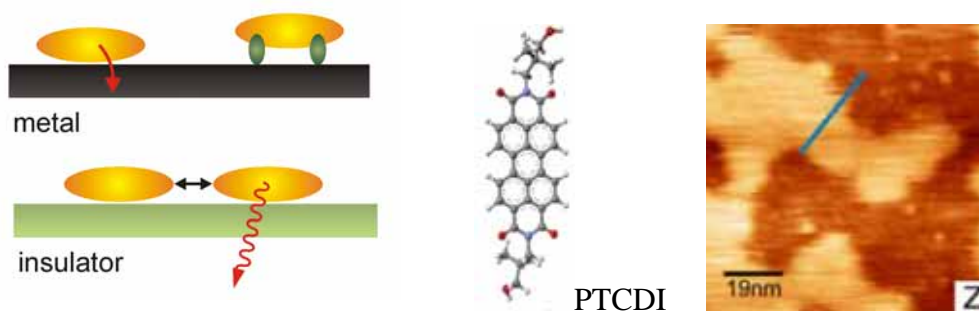


Fig. 1

Among the insulators, fluorite was one of the first materials where atomic resolution SFM imaging could be achieved [5] and where atomic contrast formation could be fully explained by theoretical modelling [6]. Already in first studies, the degradation of the fluorite surface by incorporation of hydroxide groups from water dissociated at surface defects was apparent [5]. When exposing the surface to a large amount of water, defect sites may be saturated with hydroxides and additionally water molecules adsorb. It was found that these molecules may be manipulated by the action of a scanning SFM tip in close proximity to the surface [7]. Figure 2 is an illustration for such a process of **force controlled molecular manipulation** performed at room temperature. The water molecule encircled in red is pushed downwards in three steps by 10, another 10 and 27 ionic spacings while the hydroxide encircled in green is unaffected by the scanning tip. In future work, this concept of molecular manipulation with the dynamic SFM will be applied to larger organic molecules to precisely position them for

the manufacture of functional molecular structures. This will involve the development of sophisticated manipulation protocols and the implementation of an effective drift correction.

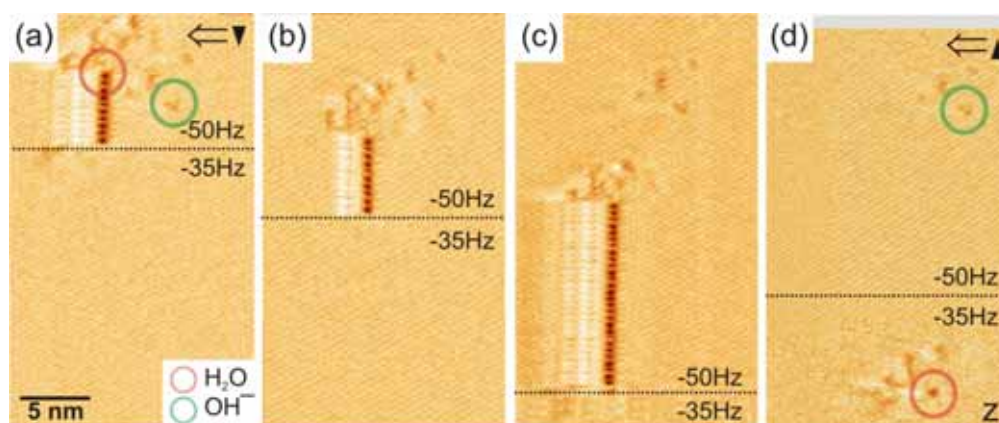


Fig. 2

The dynamic force microscope has been most successful in the identification of surface structures [8] and defects [9] on bulk insulating oxides. Recent advances in the study of materials relevant to catalysis [10] have opened the door to SFM studies of **surface chemistry at the atomic scale**. Figure 3 is a series of four images consecutively taken on a ceria surface demonstrating the conversion of a surface triple oxygen vacancy into a triple hydroxide by the interaction of the surface with water. In future, techniques of molecular SFM manipulation, imaging and spectroscopy combined with electronic (optical) excitation could be developed into an atomic scale chemical laboratory.

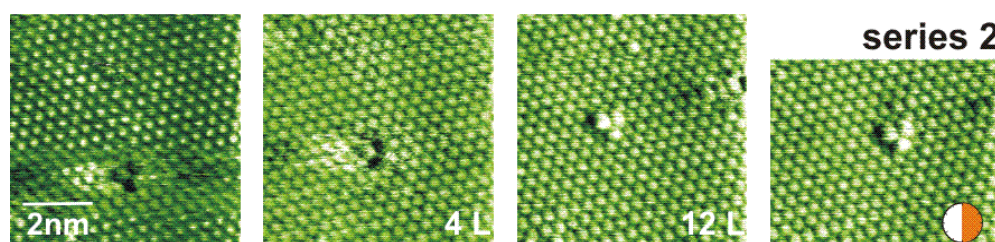


Fig. 3

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