Charged and non-charged surface defects on NiO (001) investigated by dynamic mode SFM

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Transition-metal oxides like NiO have been subject of numerous studies in the past, especially because of their catalytic properties. Showing hardly any reactive behavior with a defect-free surface, the reactivity of the NiO (001) surface strongly depends on the number of point and line defects. Vacancies in ionic crystals can show different charge states due to a varying number of electrons or holes respectively, trapped in a vacancy (e.g. F^{2+}, F^{+} and F centers). Scanning Force Microscopy in the dynamic mode is a promising tool to visualize charged vacancies in the surface as it is possible with this method to perform atomic scale studies in real space on insulating surfaces and thereby detect individual point defects.

In our study we used a home-built SFM (*Hamburg-design*) in UHV to analyze the (001) surface of NiO. Using *in situ* cleaved single crystals we were able to obtain clean stoichiometric surfaces, which was confirmed by LEED and AES. SFM images show flat terraces with a typical width of 10 to 20 nm. The image quality strongly depends on the tip condition, which could be improved by repeatedly touching the surface with the tip. With such tips the detection of individual point defects and extended vacancy islands was obtained. The observed defects often, but not always, show an elevated circumference. In some cases elevated circular areas without the presence of a surface defect could be imaged. These observations can be interpreted as localized charges (color centers), i.e., electrons trapped by positively charged vacancies.

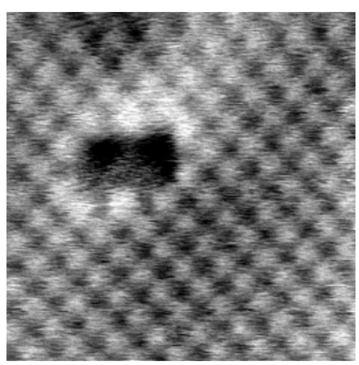

Fig.1: Atomic resolution around a small vacancy island on the (001) surface of NiO.