Contact mode potentiometric measurements with an atomic force microscope on high resistive perovskite thin films

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Abstract

Ternary oxides with perovskite structure are getting more and more important for various applications especially high integrated circuits such as non-volatile memory cells. BaTiO3 has been well studied for many years and therefore widely used as model material for perovskite structures of ABO3 type. A detailed knowledge about the electrical transport mechanisms is important for their usability. Therefore the study of local electric potential distribution is of major interest for analysing the electrical properties of the interface between the electrodes and the thin film and the barrier height in between crystallites. Hitherto it is not possible to perform potentiometric measurements with an atomic force microscope (AFM) on these high insulating materials in contact mode due to the time constant of the sample resistance and the effective capacity of amplifier and set-up. With respect to drift phenomena it is necessary to accelerate the potentiometric scan. Therefore an optimised electrometer and AFM set-up with minimized overall capacitance has been developed, which allows to observe the surface potential simultaneous to the topography in AFM contact mode. Measurements are performed on thermally reduced BaTiO3 thin films manufactured by a CSD process on an insulating sapphire substrate. To apply an electrical field we used planar top-electrodes in a distance of 1 mum to 10 mum. The width of these electrodes is significantly larger than the gap in between to guarantee an equal field distribution. A conducting cantilever was used as probe to observe the localized surface potential. We observed no linear potential distribution in between the electrodes but plateaus of equal potential on single grains and groups of grains. We also found islands of higher potential which give a hint of some sub-surface conducting mechanisms.