

Correction of systematic errors in scanning force microscopy images with application to ion track micrographs

Müller C, Voss KO, Lang M, Neumann R

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION B-BEAM INTERACTIONS WITH MATERIALS AND ATOMS 212 (2003) 318-325

Scanning force microscopy (SFM) is capable of imaging surfaces with resolution on a nanometer scale. This method therefore plays an important role in characterizing radiation-induced defects in solids complementing methods like transmission electron microscopy, small-angle X-ray scattering and optical spectroscopy, to name a few. In particular, the SFM inspection of ionic single-crystals irradiated with energetic heavy ions revealed minute hillocks. The aim to determine the size and shape of these ion tracks as a function of parameters such as energy loss gives rise to critically analyze the interaction between SFM probe tip and sample in order to recognize and take into account systematic errors. Such errors originate especially from the finite size of the sensor tip.

This work presents both an uncomplicated model of the SFM imaging process and its experimental verification allowing one to quantify the influence of the tip geometry on the recorded micrographs and correct the resulting data accordingly. For this purpose, a computer program was developed, which is able firstly to determine the tip geometry by means of the known geometry of a calibration standard. Secondly, using this tip geometry, the program reproduces the original sample topography containing the radiation damage structures under study. This is illustrated representatively for artificially generated images and also for a sample micrograph recorded on the surface of U-irradiated CaF_2 to prove the efficiency of the suggested procedures.

Afterwards, an existing set of images showing the calibration standard 2D200 (NANOSENSORS) is used to classify the average tip shape. Due to the fact that no large variations in this shape occur, the procedure of imaging the calibration standard for each measurement can be replaced by using this average tip for reconstruction. The article concludes with the elimination of systematic errors in existing data sets of hillock diameters recorded on LiF , CaF_2 and LaF_3 after irradiation with swift heavy ions.