Drift-insensitive distributed calibration of probe microscope scanner in nanometer range: Virtual mode

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Key ideas of distributed calibration

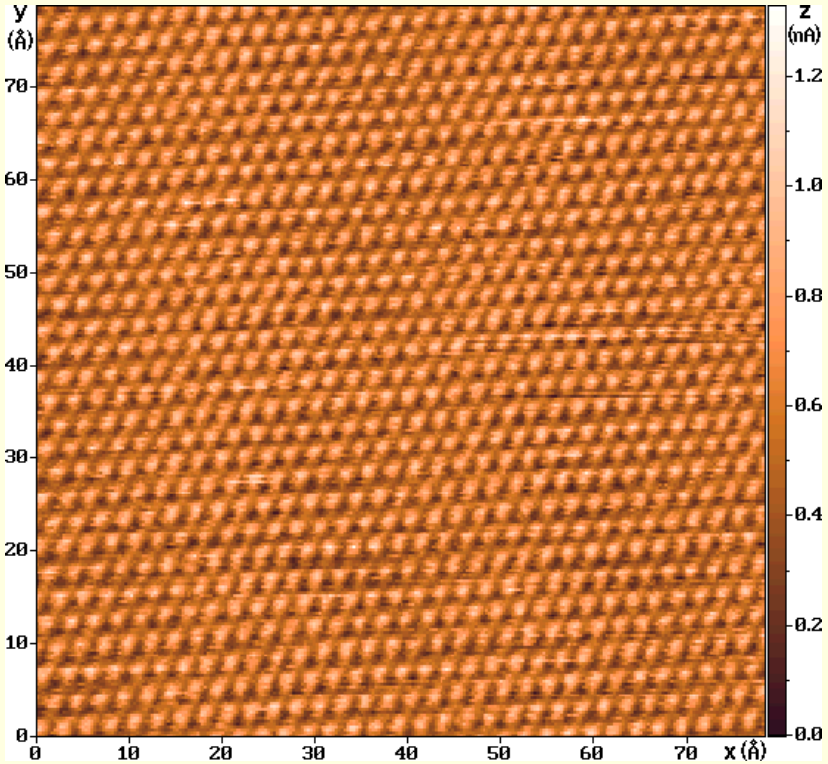
The method of distributed calibration of a probe microscope scanner consists in a search for a net of local calibration coefficients (LCCs) $K_x(x, y, z)$, $K_y(x, y, z)$, $K_z(x, y, z)$ in the process of automatic measurement of a standard surface, whereby each point of the movement space of the scanner can be defined by a unique set of scale factors. To eliminate the negative influence of noises, thermal drifts and creeps upon the distributed calibration results, the methods of feature-oriented scanning (FOS), feature-oriented positioning (FOP), counter-scanned images (CSIs) are used

Positioning the virtual mode in the context of the study

The full description of the distributed calibration approach is available in a series of three papers. In paper one, a general description is given, the paper has been published in the December, 2015 issue of Applied Surface Science. The paper under consideration, which is the second in the series, is devoted to the virtual calibration mode. In this mode, instead of measuring the real surface of a standard, the calibration program performs a “measurement” of surface image of the standard, which was obtained earlier by a conventional raster scanning. The virtual mode is used for simulating the process of calibration and validating the analytical solutions found in the first paper. In the third paper of the series, which is to be published later, the real calibration mode is described and experimental proofs are given of the practical feasibility of the method and its high precision

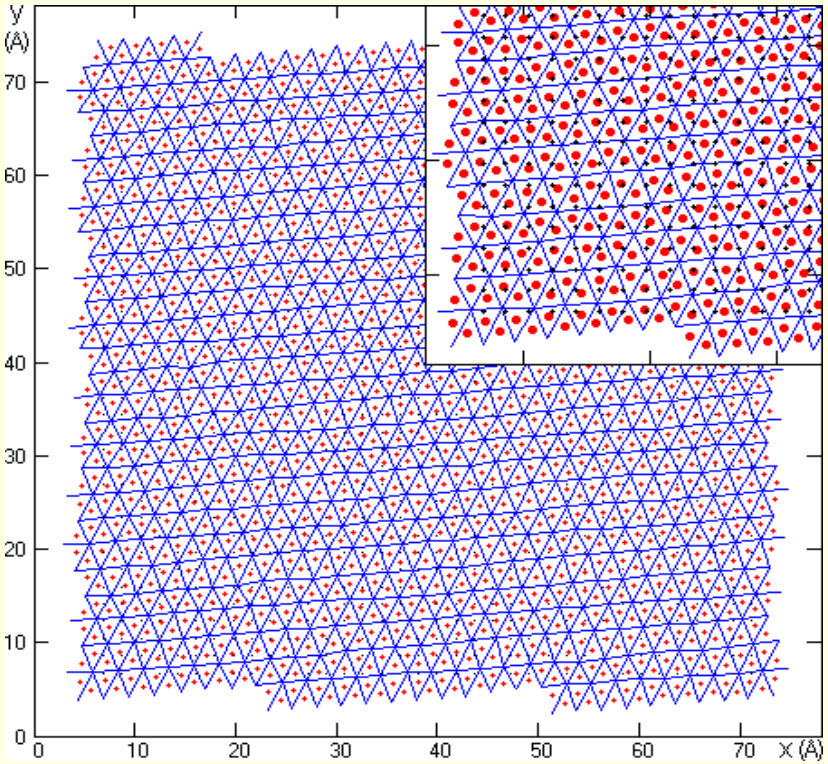
Virtual calibration by graphite lattice

STM scan of highly oriented pyrolytic graphite (HOPG)



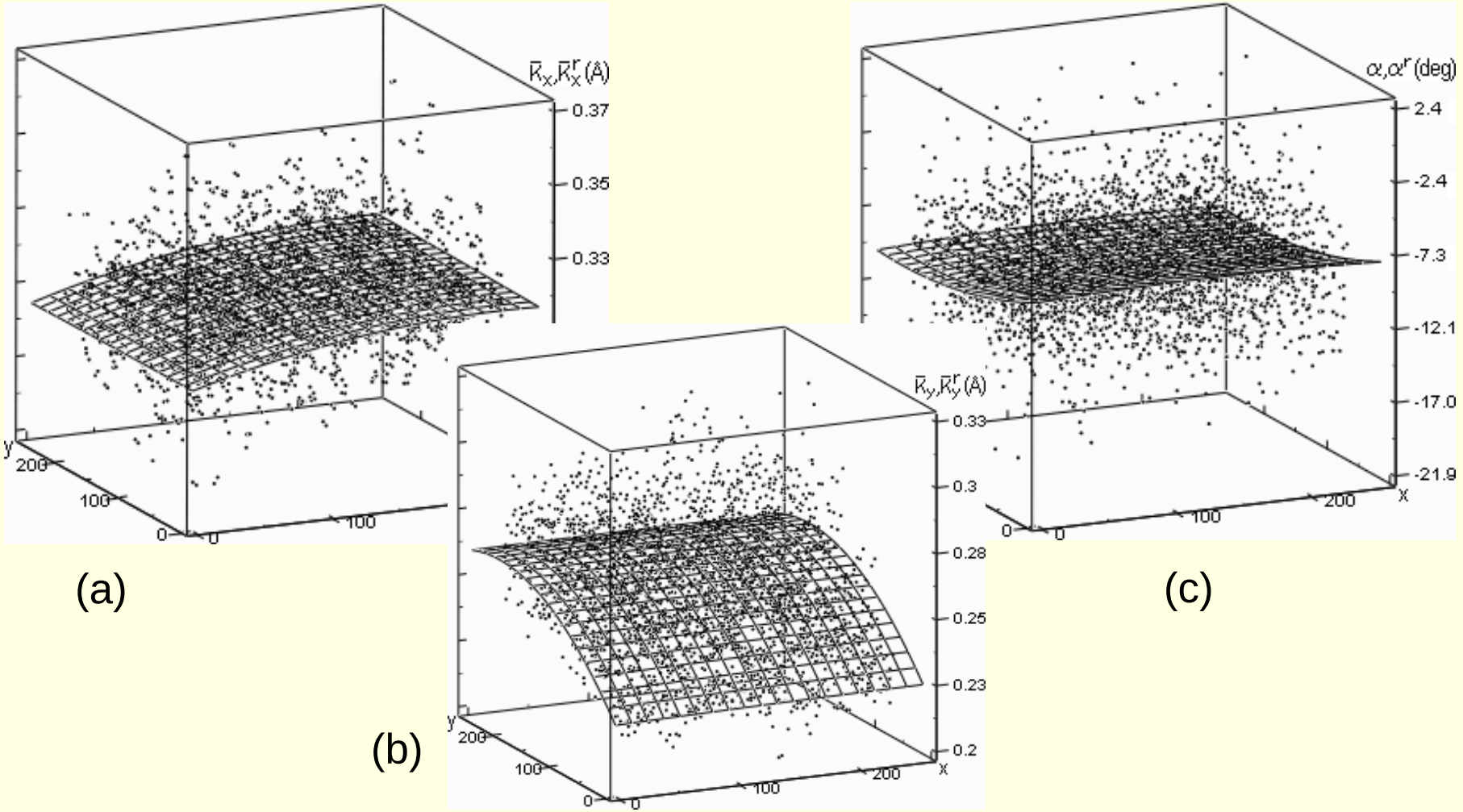
Constant-height mode, U_{tun}=85 mV, I_{tun}=750 pA, raster 256×256 points. Mean lattice constant 2.7 Å (error 11%)

Net of detected local calibration structures (LCSs)



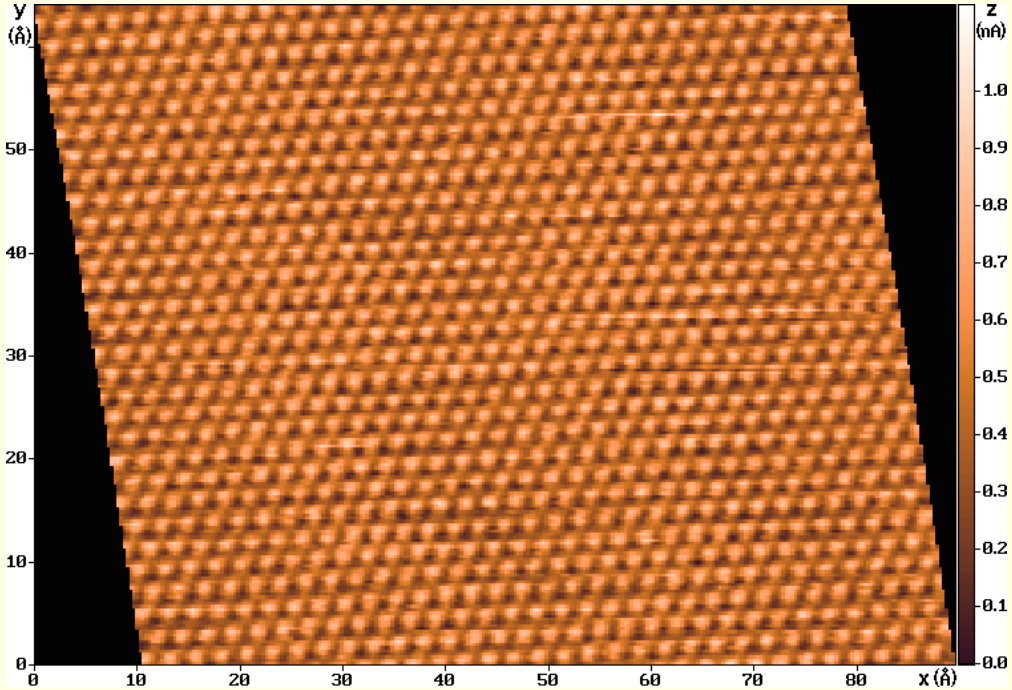
Initial net of 36×36 nodes. Carbon atoms are used as features. Number of LCSs: 1503

Calibration database



The searched for regression surfaces drawn through LCCs (a) K_x, (b) K_y, and (c) local nonorthogonality α accumulated in calibration database

Corrected image of graphite surface



Mean lattice constant 2.464 Å (error 0.002%)

Research summary

- Simulation of the process of distributed calibration has been performed, validity of the previously suggested analytical solutions has been confirmed
- Operation of the probe microscope scanner has been analyzed in detail, the values and the character of raster distortions for both regular and counter types of scanning have been determined
- A possibility of estimating the values of thermal drift and creep acting during a raster scanning has been demonstrated
- Applicability of the distributed calibration for surface characterization in automatic mode has been proved

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