Smart Correction of SPM Time Series: Can Data Analytics Help Us Extract Correlations?

I. Gaponenko[1*], P. Tückmantel[1], B. Ziegler[2], G. Rapin[1], M. Chhikara[1], and P. Paruch[1]
[1]Department of Quantum Matter Physics, University of Geneva, 1211 Geneva, Switzerland
[2]Combine AB, 413 04 Gothenburg, Sweden
*Iaroslav Gaponenko: iaroslav.gaponenko@unige.ch

Since its inception, scanning probe microscopy (SPM) has established itself as the tool of choice for probing surfaces and functionalities at the nanoscale. In its variety of functional modes, SPM is currently ubiquitously used in material and life sciences. Although recent developments in the instrumentation have greatly improved the metrological aspects of SPM, these techniques are still plagued by the drifts and nonlinearities of the piezoelectric actuators underlying the precise nanoscale motion.

In this work, we demonstrate the development of a novel computer-vision-based distortion correction algorithm for offline processing of functional SPM images. The topography of images acquired on overlapping areas is compared, and pairs of matching points are generated. From the difference in vertical and horizontal position of the latter, a new set of coordinates that can be applied to auxiliary channels such as current or piezoresponse phase is produced. This allows two images to be directly overlaid with minimal error – correlating the position with time evolution and local functionality.

The versatility of this algorithm is demonstrated by its application to two very different systems. First, the characteristics of surface folds and wrinkles in CVD graphene deposited on a polyethylene substrate are probed as a function of applied strain, showing the disappearance of wrinkles perpendicular to the strain direction. A second example demonstrates the tracking of polarization switching in an epitaxial $Pb(Zr_{0.2}Ti_{0.8})O_3$ thin film during high-speed continuous scanning under applied tip bias. Thanks to the precise time-location-polarization correlation we can extract the regions of domain nucleation and track the motion of domain walls until the merging of the latter in avalanche-like events.