Nanoscale Triboelectric-Effect-Enabled Energy Harvest for Polyaniline (PANI) Thin Film: Studied by AFM

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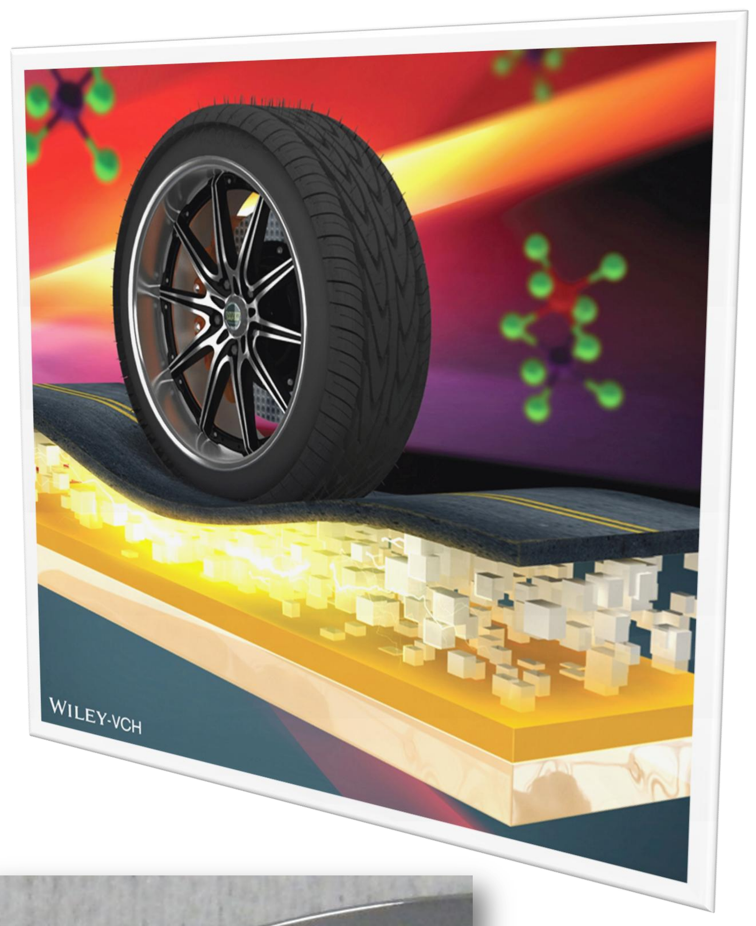
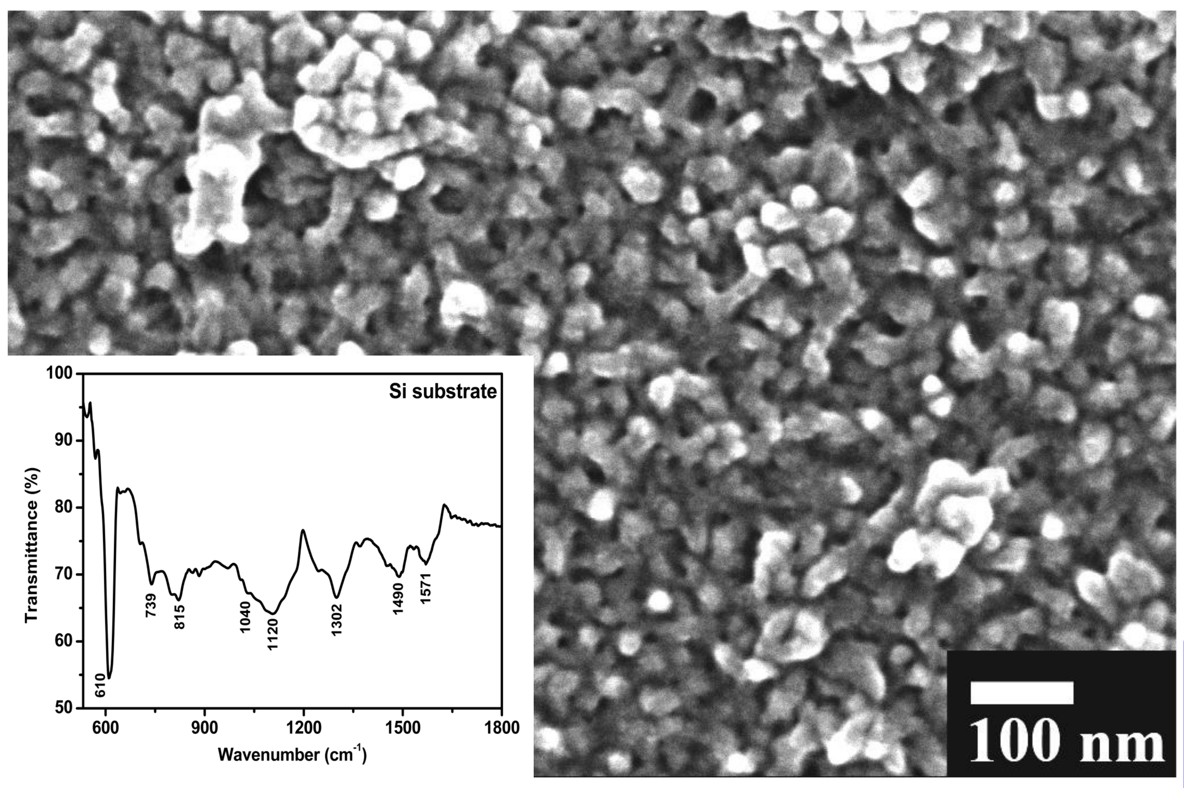
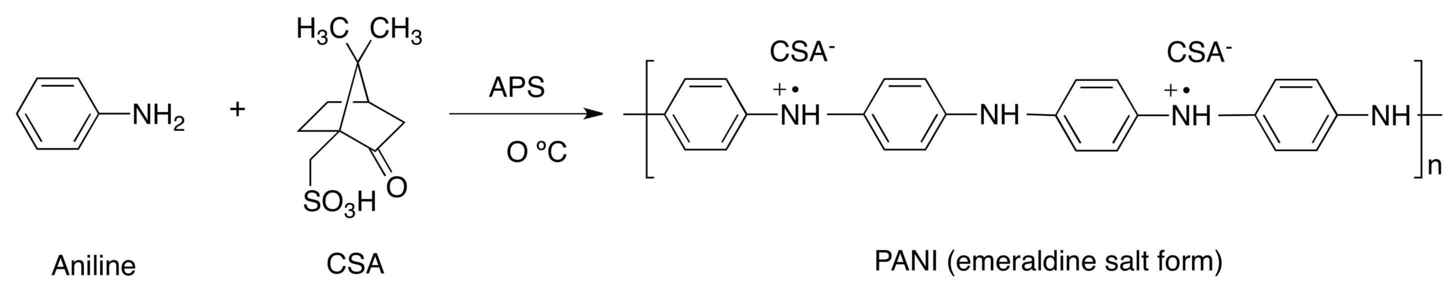
Triboelectric Effect – is a kind of contact electrification in which a material becomes electrically charged after it is contacted with a different material through friction. Triboelectrification is about the charge transfer between the surfaces of two materials in a contact separation process. This effect has been widely utilized in particle separation and energy harvesting for powering micro/nanosystems, where the charge transfer is preferred to be maximized.

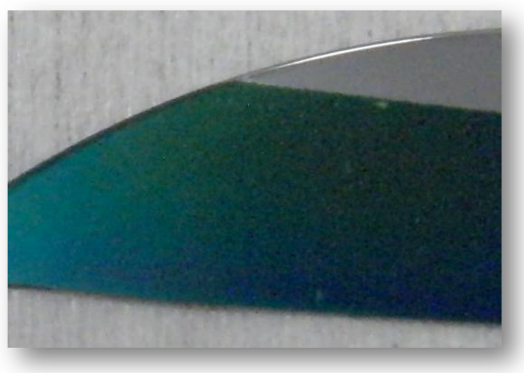




FESEM image of the emeraldine salt polyaniline (ES-PANI) thin film with corresponding FTIR spectra (Inset).

Film Preparation

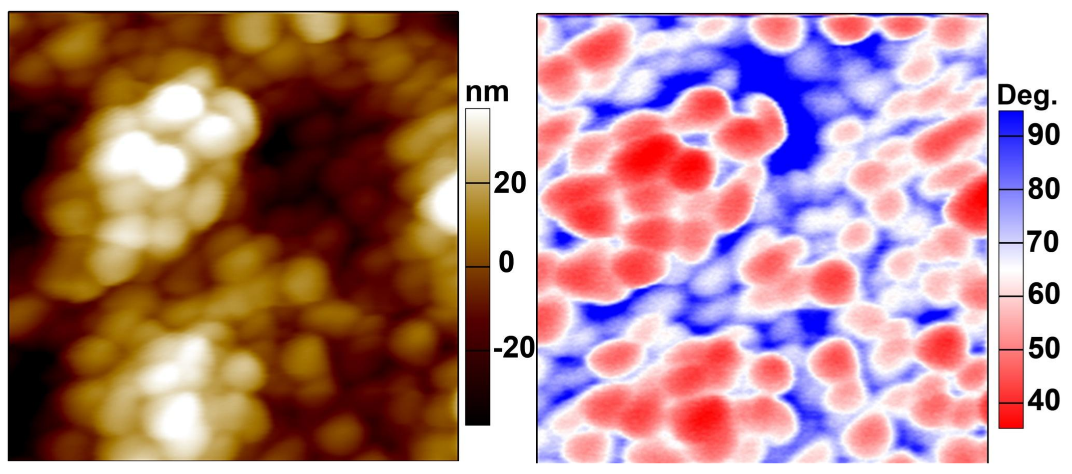




Thin films of well-connected PANI-β-CSA nanoparticles (~10-20 nm) on different substrates (ITO coated glass, silicon, gold coated silicon) were prepared by oxidative polymerization of aniline monomer (An) at 0ºC (ice bath) using ammonium persulfate ($(NH_4)_2S_2O_8$, APS) as the oxidant in the presence of D-10-camphorsulfonic acid (β-CSA).

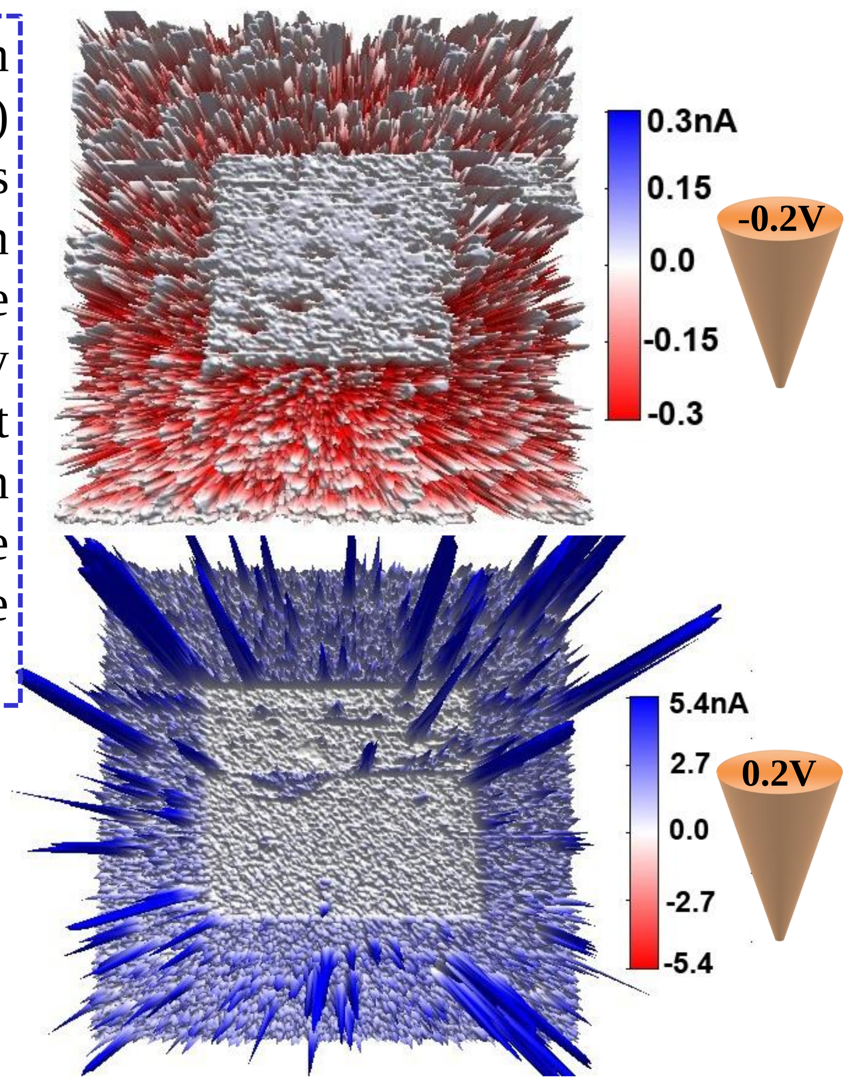
Metal-Molecule-Metal Interface: Triboelectrification

An in-situ method for quantitative characterization of the triboelectrification process at the Metal-Molecule-Metal (MMM) nanoscale interface has been demonstrated in the present work. The triboelectric charge distribution and multi-friction effect on charge transfer, as well as subsequent localized electric field diffusion on the polymer interface layer have been systematically characterized.

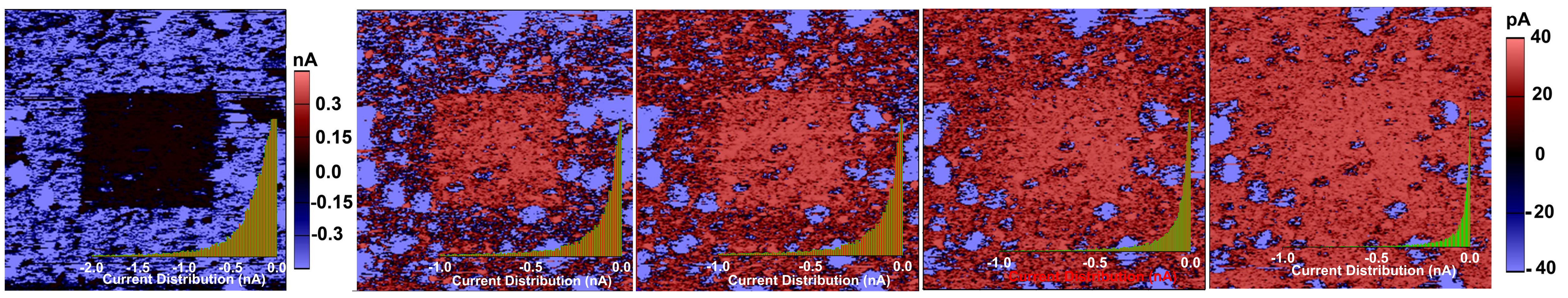


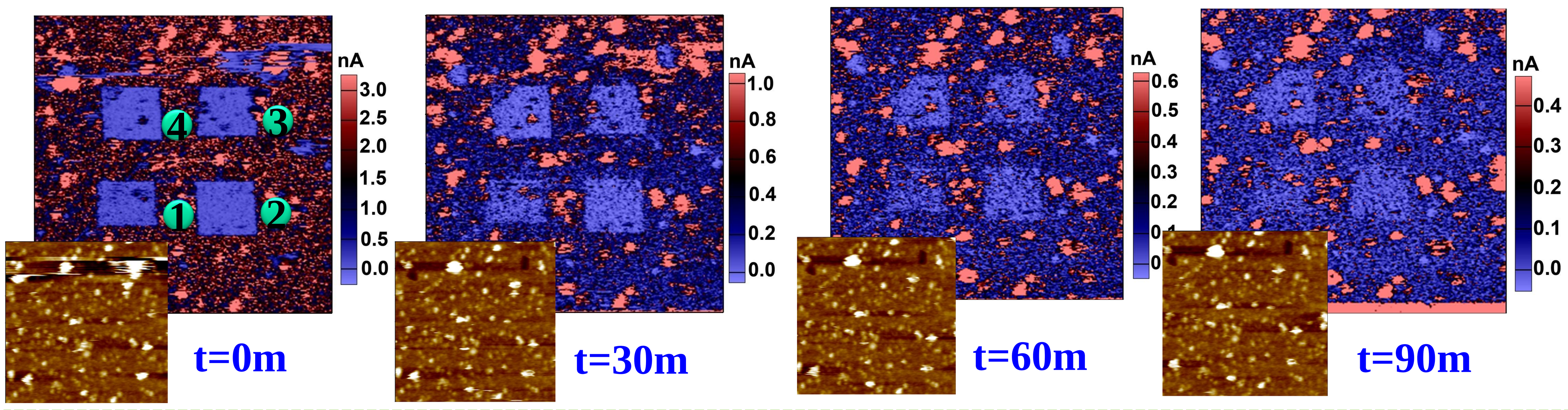
Sample topography with localized electric field mapping (500 x 500 nm) showing non-homogeneous field distribution on the polymer surface.

The accumulation of positive and negative charges on the ES-PANI film (on ITO substrate) were also investigated by the conducting AFM (c-AFM) method. During the experiment, AFM probe with Pt coating (AC240 TM) was firstly scanned consecutively over a 2×2 μm area of the polymer surface in contact mode with -0.2 V and 0.2 V tip bias respectively to induce the triboelectric charges. The current distribution pattern was then monitored by c-AFM without applying any tip voltage. A different direction of current distribution has been displayed according to the ploughing potential. In both cases, ploughed area does not harvesting any current whereas the rest of the area generating. Consequently, this phenomenon can be utilized for nanoscale **Triboelectric-Effect-Enabled (TEE) Energy Harvest Generator.**



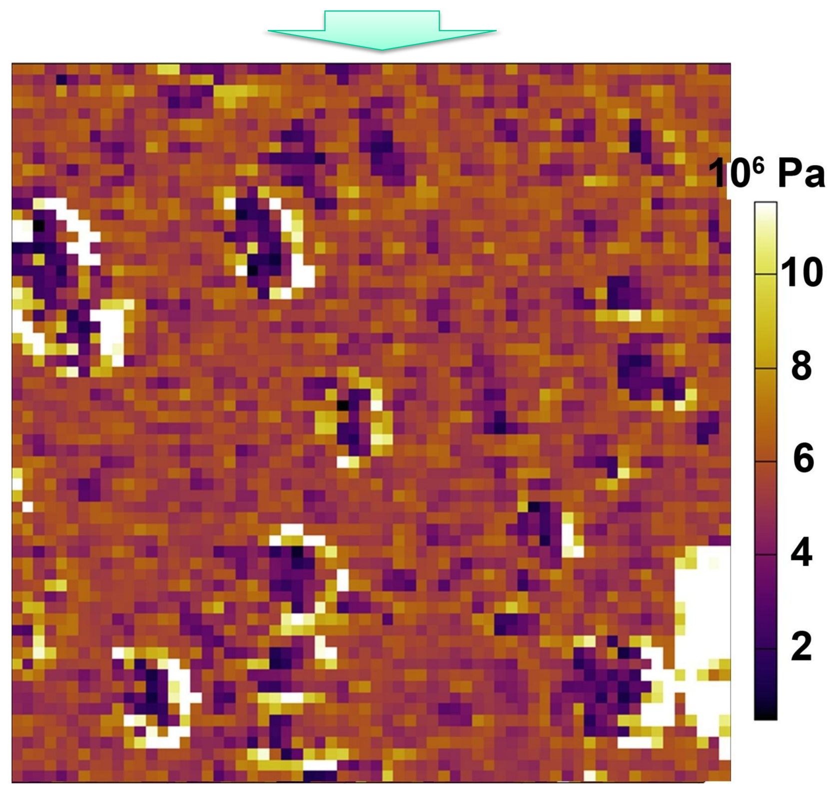
Time varying current distribution effect (5×5 μm) for -0.2V ploughed surface (2×2 μm)





AFM probe was operated under different contact forces, gradually increasing from 1 to 4 displaying different current pattern in 6×6μm scanning area. Indicates charge accumulation variation due different mechanical agitations on 1×1μm area.

The following method has been performed to analyze the surface nanomechanical properties of the sample such as Young´s modulus and adhesive energy.



References

Z. Lin Wang, ACS Nano 7(11) (2013) 9533–9557
G. Qin, J. Gu, K. Liu, Z. Xiao, C. Ming Yam and C. Cai, Langmuir. 27 (11) 2011 6987–6994

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