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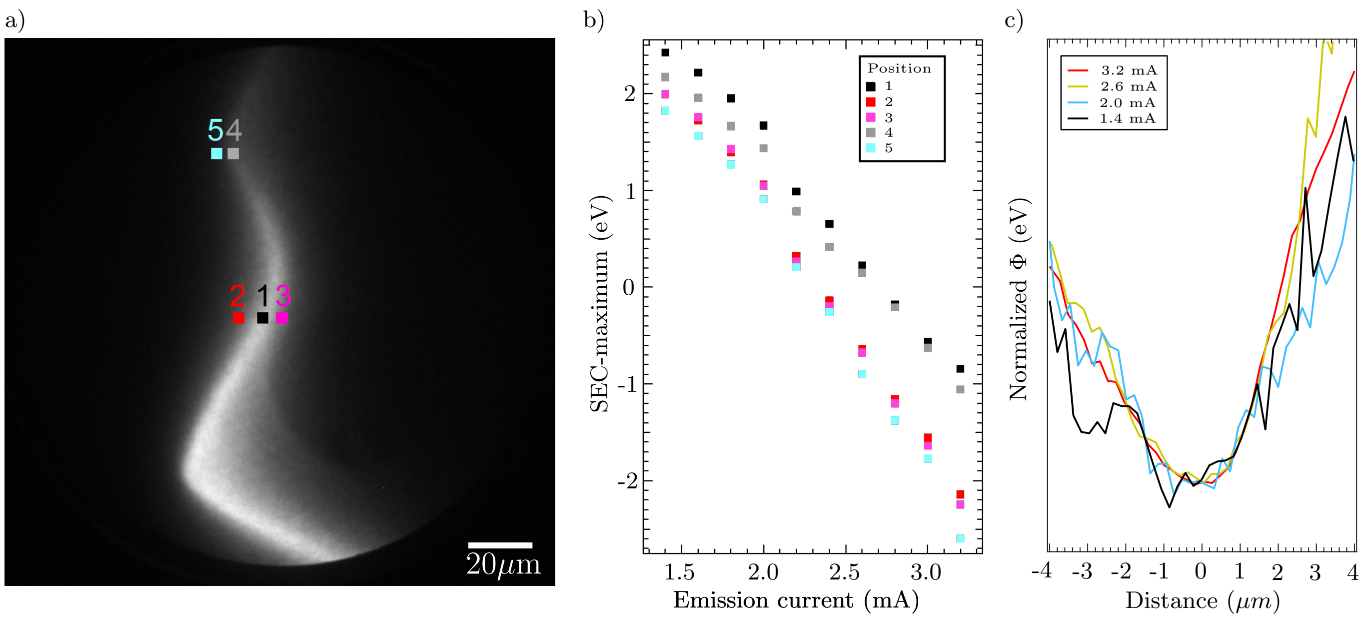
Supplemental Material: Polarization driven conductance variations at charged ferroelectric domain walls

A.-S. Pawlik[1], T. Kämpfe[2,3], A. Haußmann[2,3], T. Woike[4], U. Treske[1], M. Knupfer[1], B. Büchner[1,5], E.Soergel[6], R. Streubel[7], A. Koitzsch[1] and L. M. Eng[2,3,5]
[1] *IFW-Dresden, P.O.Box 270116, D-01171 Dresden, Germany*
[2] *Institute of Applied Photophysics, TU Dresden, George-Bähr-Str. 1, 01062 Dresden, Germany*
[3] *Center for Advancing Electronics Dresden (cfaed), 01062 Dresden, Germany*
[4] *Institute of Structural Physics of Condensed Matter, TU Dresden, George-Bähr-Str. 1, 01062 Dresden, Germany*
[5] *Center for Transport and Devices (CTD), Helmholtzstrasse 20, 01069 Dresden, Germany*
[6] *Institute of Physics, University of Bonn, Wegelerstrasse 8, 53115 Bonn, Germany*
[7] *Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley CA 94720, USA*

I. DEPENDENCE OF THE SURFACE POTENTIAL ON PHOTON INTENSITY

SFig. 1(a) shows a DW region and several points at and near the DW center labelled 1 – 5. SFig. 1(b) presents the emission current dependence of the secondary electron cutoff (SEC) maximum position for these points. The emission current of the x-ray tube is directly proportional to the photon flux. The SEC maxima shift approximately linearly with the emission current. Note, that points 1 and 4, directly at the DW have a different slope than points 2, 3, 5 reflecting their lower resistance, consistent with the discussion in the main text. SFig. 1(c) shows the potential perpendicular to the DW as a function of emission current. The principal line shape and width remains similar but for low emission current the noise level increases.

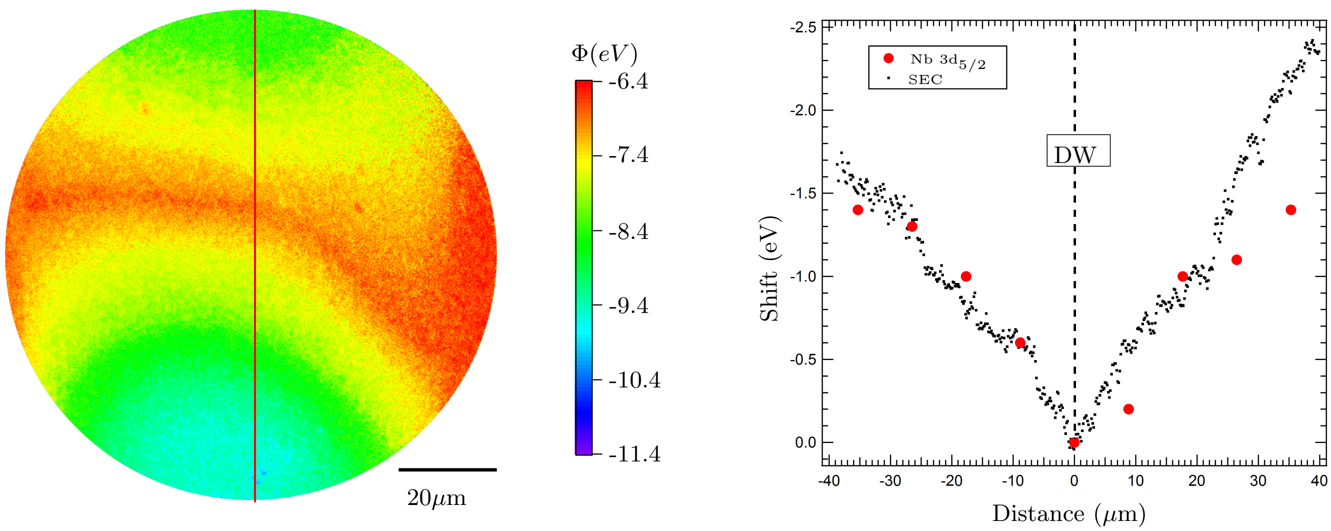


SFig. 1. a) PEEM image of a DW region. b) Position of the secondary electron maximum vs emission current of the x-ray tube for point 1 –5 shown in (a). c) Representative SPCs across the DW as a function of the emission current.

The field of view in SFig. 1a is not homogenously illuminated but varies smoothly from the lower side (maximum) to the upper side (minimum), which is seen by the intensity of the SEC. However, the apparent photon intensity difference between, e.g. point 1 and 4 does not change the surface potential significantly. This is because the lateral conductance of the DW compensates the different rate of photoinduced charge carrier generation at point 1 and 4.

II. DEPENDENCE OF THE ENERGY SHIFT ON THE KINETIC ENERGY OF THE PHOTOELECTRONS

Our interpretation of Fig. 1 neglects possible image distortions due to lateral electric fields which must be present for inhomogeneously charged sample surfaces.[1] These lateral electric fields would deflect the trajectories from photoelectrons emitted at a given sample position towards more positively charged sample regions, thereby blurring the direct relationsship between the true local surface potential and the observed local energy shift of the SEC. This effect is most pronounced for slow, low-energy photoelectrons, which we have used here. SFig. 2 shows a comparison between the energy shift at the SEC and of the Nb $3d_{5/2}$ core level with E_{kin} = 1281 eV. They are in agreement, excluding large image distortions. Note, that the overall energy shift is smaller than in Fig. 1 of the main text because the conductance has been improved by metal contacts evaporated onto the surface.



SFig. 2. (left) SEC image of the DW. On the left and right hand side of the field of view metal contacts are visible. (right) Comparison of SEC and Nb $3d_{5/2}$ shift along the line indicated in the left panel.

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[1] M. Lavayssiere, M. Escher, O. Renault, D. Mariolle, and N. Barrett, “Electrical and physical topography in energy-filtered photoelectron emission microscopy of two-dimensional silicon pn junctions,” *Journal of Electron Spectroscopy and Related Phenomena*, vol. 186, pp. 30 – 38, 2013.