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Transport imaging in 1D structures: from nanowires to nanotubes

S.V. Kalinin,[1] J.S. Shin,[1,2] A.P. Baddorf,[1] R. J. Harrison[3] and V. Meunier,[3]

[1]*Condensed Matter Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831*

[2]*Department of Physics and Astronomy, The University of Tennessee, Knoxville, TN 37996*

[3]*Computer Science and Mathematics Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831*

Electronic transport in low dimensional systems including carbon nanotubes and oxide nanowires is determined by a small number of electroactive elements, including contacts, junctions and atomic defects. Incorporation of these materials into functional devices requires an understanding of the origins of field effect and frequency-dependent transport properties on the level of individual defects. We illustrate the use of recently developed Scanning Impedance Microscopy (SIM) and Scanning Frequency Mixing Microscopy (SFMM) to real space imaging of frequency dependent electronic transport in low-dimensional systems and illustrate measurements of the current-voltage curve of individual defect in oxide nanowires and carbon nanotube networks. Local field effect in carbon nanotube circuits is addressed using Scanning Gate Microscopy. We present a new approach to quantitatively interpret SPM which treats the interaction between the probe and the system using a combination of first principles density functional calculations and continuum electrostatics modeling. An approach for experimental measurement of the tip radius of curvature from the electrostatic SPM data is developed. Within this approach, we can quantitatively describe, for the first time, the capacitive tip-surface interactions and predict the magnitude of the tip gate effect in nanoscale systems, such as carbon nanotubes, oxide nanobelts and semiconductor nanowires, permitting quantitative determination of electronic properties of atomic defects in these systems.

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