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Surface trap mediated electronic transport in biofunctionalized silicon nanowires

F Puppo[1,3], F L Traversa[2], M Di Ventra[2], G De Micheli[1] and S Carrara[1]

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francesca.puppo@epfl.ch
ftraversa@physics.ucsd.edu
diventra@physics.ucsd.edu
giovanni.demicheli@epfl.ch
sandro.carrara@epfl.ch

[1] Integrated Systems Laboratory, École Polytechnique Fédérale de Lausanne, Lausanne 1015, Switzerland

[2] Department of Physics, University of California, San Diego, La Jolla, CA 92093, USA

[3] Author to whom any correspondence should be addressed.

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Abstract

Silicon nanowires (SiNWs), fabricated via a top-down approach and then functionalized with biological probes, are used for electrically-based sensing of breast tumor markers. The SiNWs, featuring memristive-like behavior in bare conditions, show, in the presence of biomarkers, modified hysteresis and, more importantly, a voltage memory component, namely a voltage gap. The voltage gap is demonstrated to be a novel and powerful parameter of detection thanks to its high-resolution dependence on charges in proximity of the wire. This unique approach of sensing has never been studied and adopted before. Here, we propose a physical model of the surface electronic transport in Schottky barrier SiNW biosensors, aiming at reproducing and understanding the voltage gap based behavior. The implemented model describes well the experimental I–V characteristics of the device. It also links the modification of the voltage gap to the changing concentration of antigens by showing the decrease of this parameter in response to increasing concentrations of the molecules that are detected with femtomolar resolution in real human samples. Both experiments and simulations highlight the predominant role of the dynamic recombination of the nanowire surface states, with the incoming external charges from bio-species, in the appearance and modification of the voltage gap. Finally, thanks to its compactness, and strict correlation with the physics of the nanodevice, this model can be used to describe and predict the I–V characteristics in other nanostructured devices, for different than antibody-based sensing as well as electronic applications.

+ 1. Introduction

+ 2. Experiments

+ 3. Model

+ 4. Results and discussion

+ 5. Conclusions

+ Acknowledgments

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