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Fabrication, characterization, and modeling of silicon-on-insulator field-effect-transistor nano-ribbon biosensors

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Abstract

For over 30 years, field effect transistors (FETs) have been used as sensors. In the past, Ion-Sensitive-FETs (ISFET) were based on bulk Metal-Oxide-Semiconductor FET designs and the device was gated by biasing the electrolyte through the reference electrode. Recently, functionalized silicon nanowires and silicon-on-insulator (SOI) devices have been introduced for their greater sensitivity in detecting proteins, DNA and even single viruses. This work focuses on a variety of issues that impact the properties of SOI FET-based sensor devices. Biological solutions consist of protein or DNA in an electrolytic solution containing salt ions. Some of these ions, such as Na, have long been known to cause instabilities in MOS devices. The effect of mobile ions on SOI-based sensors will be presented. The ability to stabilize and control the attachment of cells on the sensor surface is critical. The reliability and reproducibility of self-assembled-monolayers such as aminosilanes will be presented. The SOI-based sensor structure results in the electrolyte voltage being capacitively coupled to the back gate voltage. The impact of this coupling on sensor response will be described. Physically realistic SPICE models were developed and illustrate the response of both pH and biosensors with a multi-gate model. The model demonstrates good agreement to experimental data including the impact of Debye screening and site binding charge.

Biography

Eric M. Vogel is currently Professor of Materials Science and Engineering at the Georgia Institute of Technology (GIT). Prior to joining GIT in August 2011, he was Associate Professor of Materials Science and Engineering and Electrical Engineering at the University of Texas at Dallas (UTD) where he was also Associate Director of the Texas Analog Center of Excellence and led UTD's portion of the Southwest Academy for Nanoelectronics. Prior to joining UTD in August of 2006, he was leader of the CMOS and Novel Devices Group and founded the Nanofab at the National Institute of Standards and Technology. He received the Ph. D. degree in 1998 in electrical engineering from North Carolina State University and the B. S. degree in 1994 in electrical engineering from Penn State University. Dr. Vogel's research interests relate to devices and materials for future electronics including advanced MOS devices and materials and nanoelectronics devices. He has published over 110 journal publications and proceedings, written 4 book chapters and given over 50 invited talks and tutorials.