Low-voltage steep-subthreshold-swing transistors

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Abstract

A steep transistor is one that can turn on with a subthreshold swing (SS) of less than (kT/q)ln(10) = 60 mV/decade of current at room temperature. Over the last 15 years, steep transistors have been widely explored to enable power supply voltages to be reduced to noise-limited values. Tunnel field-effect transistors (TFETs) are the most well established steep transistor, however none of the experimental demonstrations are in a material system that translates readily into commercial foundries. Steep transistors have been reported with ferroelectric gates in foundry processes, and these are the subject of considerable attention and debate. This talk will outline the physics/technology of these transistors, current progress in the field, measurement/circuit pitfalls, and paths forward.

Biography

Alan Seabaugh is a Frank Freimann Chair Professor of Electrical Engineering at the University of Notre Dame and Director of the Notre Dame Center for Nano Science and Technology (https://nano.nd.edu/). He received the Ph.D. degree in electrical engineering from the University of Virginia, Charlottesville, in 1985. Before joining the faculty at Notre Dame he held engineering positions at the National Bureau of Standards (1979 to 1986), Texas Instruments (1986 to 1997), and Raytheon (1997 to 1999). He has authored or coauthored more than 300 papers and holds 24 U.S. patents. He was elected Senior Fellow at Raytheon in 1999 and IEEE Fellow in 2003. He received the International Symposium on Compound Semiconductor Quantum Devices Award in 2011 for seminal contributions and leadership in semiconductor devices and circuits based on quantum mechanical tunneling.

III-V Nanowire Tunnel Field Effect Transistors with SubThreshold Slopes down to 31 mV/dec

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Abstract

Tunnel Field Effect Transistors have the potential to reduce the power consumption in logic operating at very low off-state current levels and at moderate switching speed. The high transconductance efficiency will also open for low-power RF-applications operating at very low current levels. Transistor key metrics include a high on-state current with a high Ion/Ioff-ratio that needs to be combined with a low hysteresis. A low subthreshold slope combined with a high transconductance are needed to meet these requirements.

III-V nanowire Tunnel Field-Effect Transistors have demonstrated hysteresis-free operation of 48 mV dec with a Ion of 10 μA/μm for Vgs=0.3 V. Statistical analysis of a large number of transistors with subthermal operation show that the subthreshold slope mainly is limiting Ion for low Vds (0.1) while gm is limiting for higher Vds (0.3V). Enhancing the transistor performance is thus not only related to the subthreshold slope, but also the on-state performance is critical. Nanowire diameter scaling down to 10 nm improves electrostatics and reduces the subthreshold slope, although the increased access resistance and the increased band gap reduces the transconductance. III-V heterostructures offers an excellent opportunity based on the wide range of the combinations possible.

The understanding of how different defects contribute to the measured I-V characteristics is essential to identify routes to improve the performance. Bulk traps, interface states, and oxide defects all contribute in different ways, as well as the possible contribution from gap states formed around the band edges. The different contributions may be quantified by careful I-V spectroscopy, demonstrating that such defects can be controlled on a sufficient level for advantageous Tunnel Field-Effect operation.

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Biography

Lars-Erik Wernersson received the M.S degree the Ph.D. degree in Solid State Physics at Lund University in 1993 and 1998, respectively. Since 2005 he is Professor in Nanoelectronics at Lund University, following a position at University of Notre Dame 2002/2003. His main research topics include nanowire- and tunneling- based nanoelectronic devices and circuits for low-power electronics and wireless communication. He has authored/co-authored more than 200 scientific papers. He has been awarded two individual career grants and he served as Editor for IEEE Transaction on Nanotechnology. He is founder of Acconeer related to low-power radar technology. He is coordinator for the H2020 project INSIGHT.