Abstract Submitted
for the MAR13 Meeting of
The American Physical Society

On/off-current Ratio and Ambipolar Behavior of Narrow Bandgap III-V Nanowire FETs YANJIE ZHAO, Department of Physics, Purdue University, DREW CANDEBAT, COLLIN DELKER, School of Electrical and Computer Engineering, Purdue University, YUNLONG ZI, Department of Physics, Purdue University, DAVID JANES, JOERG APPENZELLER, School of Electrical and Computer Engineering, Purdue University, CHEN YANG, Department of Physics, Purdue University — III-V nanowires (NW) are promising candidates for future device applications due to the high bulk mobility. Yet the small bandgap may result in undesirable high off-current. Here we establish a simple but reliable model that quantitatively explains how channel bandgap and Schottky barriers at metal contacts affect the ambipolar characteristics and the achievable on/off-current ratios of NW-FETs. Thus one can gain insights of the expected transfer characteristics of a given channel material with certain device structure, and the optimal choice of materials for different device applications in ultimately scaled cases. The physics of electron transport in both ideal case (no Schottky barrier) and practical case (with Schottky barrier) is studied. The impact of Schottky barriers is evaluated by numerical calculation of the tunneling current, and is found to play a critical role for the different characteristics observed. A universal plot of on/off ratio vs. bandgap is presented. The excellent agreement between our simulation predictions and experiment results from InAs, InSb, Ge NWs and CNTs highlights the potential of our approach for understanding narrow bandgap NW-FETs, bridging material development and device applications, and guiding future transistor design.

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Date submitted: 26 Nov 2012 Electronic form version 1.4