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Fundamental limits of detection with nanowire FET chem/bio sensors in subthreshold and linear regimes XUAN GAO, Harvard University, GENGFENG ZHENG, CHARLES LIEBER — Nanowire field effect transistors (NW-FETs) have been demonstrated to be powerful sensors for the detection of biological and chemical species, and thus understanding and pushing their intrinsic sensitivity limits could have a significant impact on a broad-range of applications of these devices. We report studies of the response of silicon-NW-FET sensors as the devices are tuned from linear to subthreshold regimes by electrochemical gating. Conductance versus solution pH data show that operation in the subthreshold regime can increase both the percentage change in conductance and the signal to noise ratio of the device by over ten times compared to the linear regime. We also demonstrate that operating in the subthreshold regime yields improvement in the detection limit for the cancer marker protein PSA with detection down to $\sim$1.5 fM for a device with $\sim$0.75 pM detection limit in the linear regime. Analysis of these results shows that the sensitivity improvement is due to the more effective surface charge gating resulting from the reduced screening by carriers. In addition, the effect of NW diameters and the intrinsic charge detection limit for using NW-FET devices will be described. Our work shows that optimization of NW-FET structure and operating conditions can provide a significant enhancement as well as a fundamental understanding of the sensitivity limits for nano-FET sensors.

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