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Charge Transport in Silicon Nanomembranes[1]

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Charge transport in very thin semiconductor sheets, ribbons, or nanowires is dominated by surface and interface effects as a consequence of the absence of an extended bulk. In silicon, a model system for exploring these effects, factors can include interface states and fixed oxide charges if the Si nanomembrane is oxidized, surface states in chemically modified surfaces, reconstruction if the surface is clean, or a combination of these factors if the surfaces are not equivalent (e.g., one oxidized, the other clean). Additionally, in membranes or wires thin enough that quantum size effects are observable, surface roughness may influence conduction. For conventionally doped Si, effects become noticeable at nanomembrane thicknesses below ∼200 nm (depending on doping). We describe experiments on a platform based on (001) oriented silicon-on-insulator (SOI), using van der Pauw, Hall effect, and I-V measurements, along with scanning tunneling microscopy and diffraction, and theoretical analysis of several situations that shed light on the interplay of these factors. Measurements are compared on oxidixed membranes, clean and chemically modified surfaces on membranes, and attached and freestanding nanowires with well-defined surfaces, patterned from SOI. Most importantly, large changes in conductivity are possible with small changes in surface condition, making nanomembranes (well defined in surface orientation, thickness, and surface quality) an ideal vehicle for establishing a framework for understanding charge transport in nanostructured semiconductors. With W. Peng, S. Scott, F. Chen, J. Endres, I, Knezevic, D. Savage, M. Eriksson, C.-H. Lee, C. Ritz, M.-H. Huang, M. Ziwisky, and R. Blise

[1] P.P. Zhang et al., *Nature* **439** 703 2006
[2] S. Scott et al., *ACS Nano* **3** 1683 2009
[3] C-H. Lee et al., submitted

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