# Structural Properties and Carrier Transport in Axial Silicon-Germanium Nanowire Heterojunctions

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Recent advances in forming semiconductor heterojunctions within spatially confined nanoscale objects, including nanowires (NWs), show that the traditional limitations in the lattice-mismatched hetero-growth can be challenged. In various III-V semiconductor NWs, abrupt heterojunctions have been successfully demonstrated using the vapor-liquid-solid (VLS) growth for GaAs/InAs (7% mismatch) and InAs/InP (3% mismatch) heterojunctions. In group IV semiconductors, the approach is complicated not only by the 4.2% lattice mismatch between Si and Ge but also because Si and Ge both have a quite high solubility in the Au-Si catalyst. During chemical vapor deposition (CVD) based VLS growth using $SiH_4$ and $GeH_4$ (or similar gases), a supply of Si remains effectively "on" in the catalyst, and Si effectively intermixes with the arriving Ge even if the $SiH_4$ flow is already switched "off". One way to address this problem is to choose a catalyst with a lower Si solubility, e.g. $AlAu_2$ and AgAu. Another possibility is to significantly reduce growth temperature before turning a $GeH_4$ source "on". Using the latter technique, we demonstrated Si-Ge heterojunction NWs with nearly ideal interface (Fig. 1) and only an 8 nm thick SiGe transition layer between straight and nearly micron-long Si and Ge NW segments [1].

In this work, we analyzed structural and electrical properties of axial Si-Ge heterojunction nanowires (NWs). The observed non-linear and rectifying current-voltage characteristics, strong flicker noise and damped current oscillations with frequencies of 20-30 MHz are explained using the proposed SiGe heterojunction NW energy band diagram including the energy states associated with the NW surface (and near-surface) structural imperfections revealed by transmission electron microscopy.

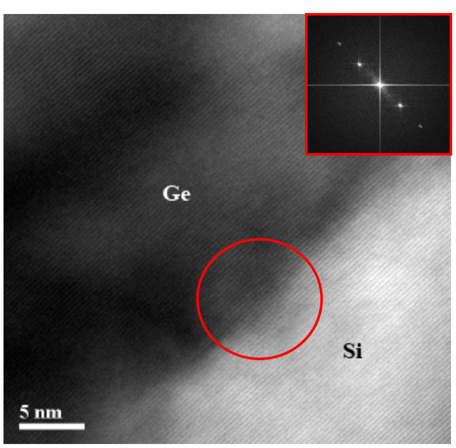


Figure 1. High-resolution TEM micrographs of the SiGe NW heterojunctions at the NW center. The insert is FFT of the lattice fringes showing nearly ideal periodicity.

[1] Wang, X., et al. *Journal of Applied Physics* 118.23 (2015): 234301.

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