Optical and Electrical Properties of Ge Nanowire –Si substrate One-dimensional Heterojunctions - L. Tsybeskov, B. Kamenev, V. Sharma, E.K. Lee (New Jersey Institute of Technology), P. Fosh (Mscow State University), T. Kamins, and S. Williams (Hewlett-Packard Laboratories)

We report Raman scattering, photoluminescence (PL) and carrier transport measurements in Ge nanowires (NWs) grown by vapor-liquid-solid (VLS) technique using chemical vapor deposition of Ge with Au-nanoclusters as precursors. We study two types of samples with Ge NWs grown on silicon substrates with <100> and <111> crystallographic orientations. A sharp and narrow Raman peak at ~ 300 cm^{-1} indicates nearly single crystal quality of ~ 40 nm diameter and nearly a micrometer in length Ge NWs. The absence of Si-Ge vibrations in Raman spectra shows that for most of the NW volume, SiGe interdiffusion is insignificant. Low temperature PL spectra and PL intensity temperature dependence strongly indicate that the observed emission originates mostly at Ge NW – Si substrate interfaces (i.e., Ge NW –Si substrate heterojunctions) where Si-Ge intermixing has been detected. We found that such one-dimensional heterojunctions are formed differently for <111> and <100> oriented Si substrates due to strong <111> preferential orientation of Ge NWs. However, in both types of substrates electrical measurements show strong rectification, relatively low impedance and a high photosensitivity associated with nearly epitaxial quality of the studied heterojunctions. The device applications of these one-dimensional heterojunctions will be discussed.

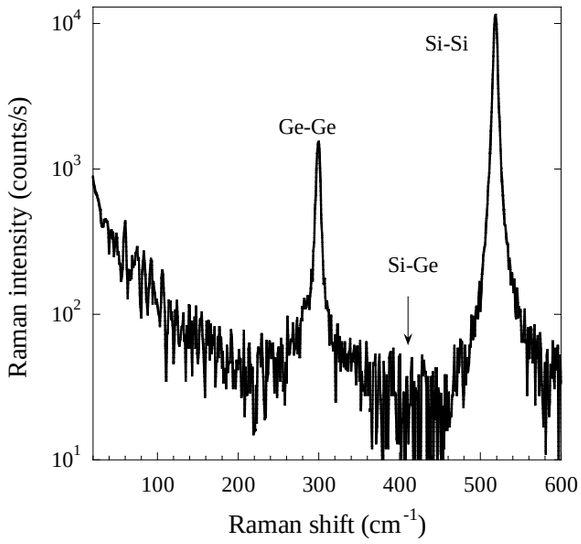

Figure 1. Raman spectra in the sample of Ge NWs grown on <111> Si substrate with estimated NW length of ~ 500 nm. The observed Si-Si and Ge-Ge vibration are indicated. Note logarithmic scale of Raman signal intensity.

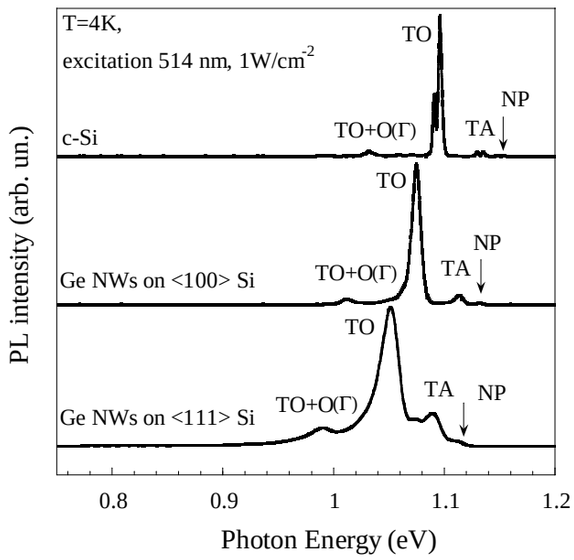

Figure 2. Low-temperature PL spectra in c-Si and samples of Ge NWs grown on <100> and <111> Si substrates respectively. No-phonon (NP) PL line and PL bands associated with characteristic phonon energies are shown.