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Study of Heat Conduction in Corrugated Si Nanowires Using Raman mapping

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Thermal properties of nanostructures have attracted growing interest, especially, in application in thermoelectrics. Due to size limitation in nanostructures, phonon mean free path (MFP) reduction takes place due to boundary scattering and, therefore, thermal conductivity decreases. However, recently, even stronger reduction of MFP was obtained in corrugated nanowires (NWs) at low temperatures [1]. Nearly one order reduction of thermal conductivity *k* of corrugated NWs compared to straight NW was demonstrated. The effect was attributed to multiple phonon scattering on corrugated surfaces. Further studies of this effect, especially, at room and higher temperatures are required for its mechanism clarification and practical application.

In this work, we study heat conduction in a variety of corrugated Si NWs using Raman mapping. 5 and 10 micron long NWs were made from silicon-on-insulator (SOI) structure with ~1 micron thick buried oxide (BOX) layer using electron beam lithography with subsequent removal of BOX material under NWs in HF. As a result, sets of parallel suspended NWs connecting two SOI islands were fabricated. Figure 1 shows 55 nm thick corrugated NW with minimal width ~ 60 nm and maximal width ~ 150 nm. Raman measurement was done using Nanofinder 30 confocal Raman system (Tokyo Instruments Inc.) equipped with a scanner and a 561 nm wavelength laser. Lens with 100x magnification and 0.95 numerical aperture focusing laser light into ~350 nm spot was utilized. Figure 2 shows dependence of temperature increase ΔT determined from temperature-induced NW Raman band downshift in laser-illuminated NW area on position along NW. Parabolic fitting of the dependence reveals a parameter proportional to *k*. Obtained data suggest that corrugations cause ~ 50% *k* reduction in the 300 – 400 K temperature range. This reduction is less pronounced than that reported in Ref. [1] for low temperatures but, nevertheless, our data suggest that NW corrugation is a promising technique for thermoelectrics fabrication.

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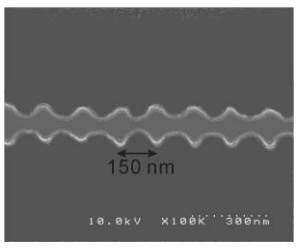

Fig.1. SEM image of corrugated NW

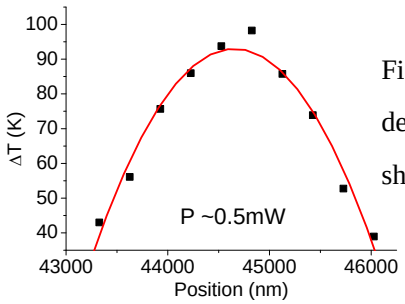

Fig.2. ΔT vs. position dependence for NW shown in Fig. 1.

References

[1] C. Blanc, A. Rajabpour, S. Volz, T. Fournier and O. Bourgeois, Appl.Phys.Lett. 103, 043109 (2013)