Experimental Report

Proposal: **7-01-379** **Council:** 10/2012

Title: Phonon confinement in Si-nanowires

This proposal is a new proposal

Researh Area: Materials

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Samples: Si

Instrument	Req. Days	All. Days	From	To
IN6	0	6	22/03/2013	28/03/2013

Abstract:

Nanowires can be used for devices based on thermoelectrics and to convert the heat into electrical current. The material design challenge here is to create the materials where the conduction of heat would be kept low, and the electrical conductivity will be high. It was reported that the thermal conductivity, which is related to the phonon propagation, can be strongly reduced in rough Si nanowires that are 20-300 nm in diameter [1]. The goal of this proposal is the investigation of the phonon propagation and the effects of the confinement in Si nanowires using IN5 TOF spectrometer. The results will help to understand the mechanism of the thermal transport in nanostructures, which in addition to the fundamental interest has practical implications in the design and performance of modern microelectronic devices

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Phonon propagation in Silicon Nanowires

The goal of the experimental study was the investigation of the phonons in Si nanowires.

All experiments were based on geometry using momentum transfer Q being aligned either along or across the nanowires. Si nanowires were prepared by the chemical etching method from n-type silicon with phosphor doping. The samples were packed into the thin Al sample holder 30 x 50 x2 mm, the thickness of the aluminum foil was 0.3 mm

In the proposal we have requested IN5 pointing at the capability of position sensitive detectors and short wavelength neutrons. However, accordingly to the decision of scientific panel we were awarded the beam time on IN6. Since IN6 does not have position sensitive detectors, it is not well optimized to measure phonons. In addition the shortest wavelength is 4.3 Å, which is too long to see the desired 400 reflection. However, to use the beam time in the best way we decided to measure VDOS as a function of sample position. For this purpose NW and bulk Si were measure at 4 positions: 45° and 135° for energy transfer ω=0 meV and 22° and 112° for energy transfer about ω=10 meV. The spectra were collected in 80-100° range. The results can be seen on the figure 1. The bulks Si shows clearly the same structure. The intensity is not always the same; probably due to not perfect vanadium normalization (sample position was not exactly the same as of vanadium). However, the peaks position is still the same. In the case of NW enhanced additional intensity can be seen at the low energy range < 10 meV for “along” configuration. It is important to mention that the construction of the sample holder allowed the reproducibility of the sample position with quite high degree. The collected results confirm that the confinement of the phonons in NW shall exist and should be studied further in details on suitable instrument.

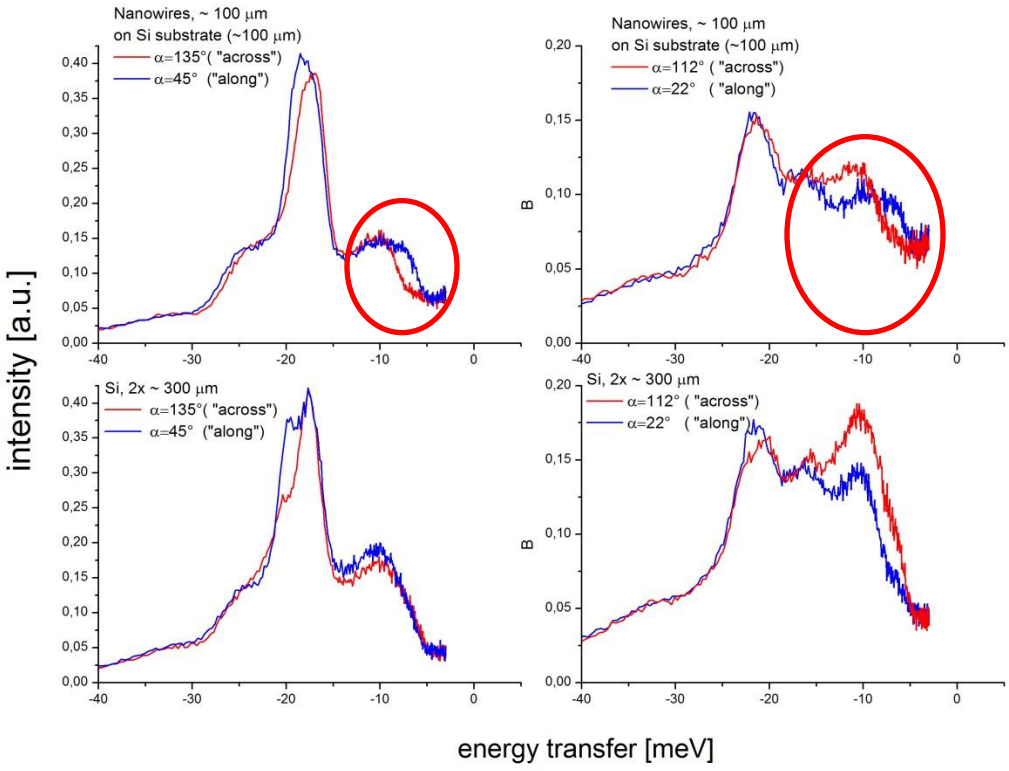

Figure 1. The data measured on IN6 for Si NW sample and Si bulk.