Kink as a new freedom to tune the thermal conductivity of nanowires

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Various kinds of nanowires of kinked morphology have been prepared in a controlled manner and demonstrated for novel applications. However, the effects of kinks on thermal transport have not been well studied. We show that for materials of elastic anisotropy, kinks can pose remarkable resistance to thermal transport. For example, for single-crystalline boron carbide nanowires, a single kink can pose a thermal resistance up to ~30 times that of a straight wire segment of equivalent length. The pronounced kink resistance can cause significant thermal conductivity change. In fact, a single kink in 80 nanometer diameter boron carbide nanowires can lead to 36% thermal conductivity drop for a nanowire of 4.3 um long. As such, in addition to the wire diameter, surface roughness, and acoustic softening, kink can be a new freedom to effectively tune thermal transport in nanowires. The pronounced kink resistance in boron carbide nanowires is attributed to the combined effects of backscattering of highly focused phonons and mandatory mode conversion at the kink. Interestingly, we found that instead of posing resistance, structural defects in the kink can actually assist phonon transport through the kink and reduce its resistance. In addition to boron carbide nanowires, we have also studied how kinks can affect thermal transport in silicon nanoribbons and characterized the thermal conductivity of kinked silicon nanoribbons as a function of kink period. Given the common kinked line morphology in nanoelectronic devices and the promise of nanowires for thermoelectrics, the finding of how kinks can alter thermal transport in nanowires should have important implications in precise device thermal management and thermoelectrics.