Thermo-Mechanical Nanometry of Self-Assembled InAs Nanowires

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III-V semiconductor nanowire (NWs) [1] are attracting great attention in view of thermoelectric application due to their excellent electrical transport properties, the possibility to exploit gate-tunability [2] and to control the thermal properties thanks to a suitable choice of nanostructure geometry, dimensions, and semiconductor material [3]. In this context, a full thermomechanical characterization of the nanostructures is desirable for the determination of the behavior and stability of NW-based devices including thermoelectric generators. In this work, we investigate the mechanical properties of InAs NW assemblies exploiting ultrafast photoacoustic spectroscopy [5] and finite element modelling. In particular, we retrieve the InAs NWs elastic tensor. Furthermore, we extract the thermal conductivity, \( k \), of individual nanostructures thermally decoupled from the substrate, using an all-electrical method that exploits the 3\( \omega \)-technique [6,7] applied to suspended NW-based devices. In our devices, suspended heaters as well as local metallic gates can additionally allow for the measurement of the Seebeck coefficient and the field effect control of the band filling in the semiconductor nanostructure. Our device architectures open new routes to the full all-electrical investigation of gate-controlled electrical and thermal parameters in nanoscale semiconductor devices. The present results bear great relevance for applications – not even limited to thermoelectrics - involving InAs NW assemblies or individual nanostructures, since the thermo-mechanical properties affect any device operation.

References: