Phonon Engineering for Heat Transport Control

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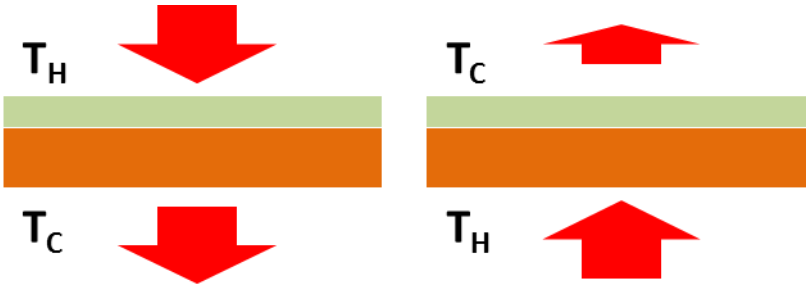
In the quest for alternative state variables, interest in phonon device concepts has been growing continuously over the last years [1]. Although somewhat far away from practical realisations, phonon engineering is perceived as a possible avenue for future information processing [2]. In fact, phonon engineering for thermal management in nanoelectronics, is considered by the semiconductor research communities in the USA and Asia as paramount for progress in the control of heat dissipation [3] and in the generation of thermoelectricity. Progress has been made in these fields enabled by advances in nanoscale materials, nanofabrication, theory and simulations methods and the increasing ability to measure nanoscale thermal properties, especially thermal conductivity and thermal conductance, which has greatly increased our understanding of phonon transport in the nanoscale while still leaving a huge number of research questions unanswered. The latter are a condition sine qua non for further progress in the physics and applications of phonons.

In this talk we will describe the possibility of engineering the nanoscale thermal properties in nanometer sized plates for a directionality control of the heat transport, as in thermal rectification. For this purpose, we will show that the classical thermal rectification arising in certain cases from the contact of two dissimilar bulk materials with different temperature dependence of the thermal conductivity can be extended to the Si/Ge system when thickness effects are taken into account. Moreover, the directionality of the in-plane heat flow in a Si plate can be achieved by tuning the thickness and the impurity concentration along the cross section of the plate. We have designed several potential structures with this function in mind and we will discuss the physics behind them as well as possible practical proposals for their realisation.



References

[1] See, e.g., C. Dames, “Solid state thermal rectification with existing bulk materials”, ASME Journal of Heat Transfer **131**, 061301-1 (2009)
[2] S. Sklan and J. C. Grossman, in *Son et Lumière: from microphotonics to nanophononics*, Les Houches, France, September 17th to 28th, 2012. http://arxiv.org/abs/1301.2807
[3] J Welser, “Priorities of the NRI in Computing Technologies”, presentation at the Guardian Angels Worlshop, March 2012, San Francisco