CARL VON OSSIETZKY universität OLDENBURG Institut für PHYSIK

PHYSICAL COLLOQUIUM

INVITATION

Monday, 06.11.2017, 4.15 p.m., W2-1-148

Speaks

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about

GHz phonons in Si phononic crystals

GHz and sub THz phonons are detected in free-standing silicon membranes patterned with holes into phononic crystals. Their study is motivated by the need to understand thermal transport, which has attracted increasing attention as potential thermal interface materials as well as structures for acousto-metamaterials. One aim is to advance the understanding of how the volume-to-surface ratio [1], phononic crystal periodicity, disorder [2] and air convection [1] impact on thermal phonon propagation. We will discuss the physical regimes under which the dominance of each and all of the above takes place.

The experiments were performed over a range of 300 to 1000 K [1] in purpose-designed 2D phononic crystals in the form of free-standing membranes patterned by electron beam lithography and dry etching [3]. The band structure of 2D phononic crystals was calculated using FEM [4], the experimental methods include Brillouin scattering, pump-and-probe picosecond acoustics [2] and laser Raman thermometry [5].

The key parameter in the reduction of the thermal conductivity, by a factor of almost 30, and its temperature dependence is closely correlated with the pattern feature size. We also show the effect of convection losses in a quantitative manner by comparing measurements in ambient and in vacuum conditions. Based on two-phonon Raman spectra, we attribute this behaviour to diffuse (incoherent) phonon-boundary scattering.

Furthermore, the realisation of solid-solid phononic crystals (an array of pillars supported on the membrane) points to the possibility to tailor multiple ways of storing and retrieving energy in these periodic oscillators when coupled to Lamb waves.

[1] B. Graczykowski et al., Nature Comms, 4 Sept 2017, DOI: 10.1038/s41467-017-00115-4.

[2] M. R. Wagner et al, Nano Letters 16 5661 (2016)

[3] M. Sledzinska et al., Microelectronic Eng, 149, 41 (2016)

[4] B. Graczykowski et al., Phys. Rev. B 91 075414 (2015)

[5] E. Chavez Angel et al., Appl. Phys. Lett. Materials 2 012113 (2014); J. S. Reparaz et al., Rev. Sci. Instruments 85 034901 (2014).

All interested persons are cordially invited.
Sgd. Prof. Achim Kittel