Thermal properties of silicon phononic crystals with pacman holes

IIS[1], LIMMS[2] Univ. of Tokyo, °Sergei Gluchko[1,2], Roman Anufriev[1], Ryoto Yanagisawa[1], Sebastian Volz[1,2] and Masahiro Nomura[1]

E-mail: gluchko@iis.u-tokyo.ac.jp

In the last decade, phononic crystals showed their ability to control heat conduction at nanoscale and their potential for thermoelectric devices. The increase of thermoelectic efficiency originates from the reduced thermal conductivity due to enhanced phonon surface scattering. However, the drawback of such thermal conductivity reduction is the concurrent reduction of material volume. In this work, we demonstrate that silicon based phononic crystals with pacman-shaped holes can outperform those with conventional circular holes due to a higher surface scattering at smaller volume reduction. We used micro time-domain thermoreflectance technique (μTDTR) shown on Fig.1 and experimentally demonstrated that both phonon scattering and phonon transmission through narrow necks contribute to the thermal conductivity reduction and that their contribution changes with temperature. We have also investigated the effect of the orientation of asymmetric holes and their filling factors but found no rectification effects. Our results open new possibilities for thermoelectric devices engineering and manipulating heat at nanoscale.

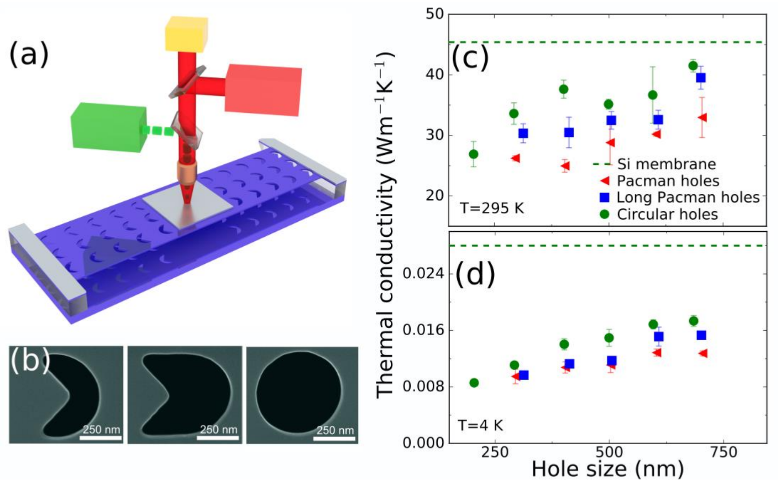

Fig1. (a) Micro time-domain thermoreflectance measurement; (b) SEM image of pacman, long pacman, and circular holes from left to right, respectively; (c) thermal conductivity of silicon phononic crystals with different type of holes at 295K and (d) 4K.

Acknowledgements

Kakenhi (15H05869 and 15K13270), PRESTO JST, MEXT, Japan, and the Postdoctoral Fellowship of JSPS