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Sideband Raman Cooling of Optical Phonons in Semiconductors[1]

JUN ZHANG, Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, 637371, Singapore, LEONG CHUAN KWEK, Centre for Quantum Technologies, National University of Singapore, 3 Science Drive 2, Singapore 117543, QIHUA XIONG, Division of Physics and Applied Physics, School of Physical and Mathematical Sciences, Nanyang Technological University, 637371, Singapore — Last century has witnessed a tremendous success of laser cooling technology from trapped atomic ions to solid-state optical refrigeration[1,2]. As one of the laser cooling techniques, sideband Raman cooling plays an important role in quantum ground state preparation, coherent quantum-state manipulation and quantum phenomena study. However, those studies still limited in trapped atomic ions and cavity optomechanics, which need be cooled it below than 0.1 Kelvin even tens of nano-Kelvin due to very low frequency of phonons from several kHz to GHz. Here we report sideband Raman cooling and heating experiments of longitudinal optical phonon (LOP) with a 6.23 THz in semiconductor ZnTe nano-ribbons[3]. By using of red-sideband laser, we cool the LOP from 225 to 55 Kelvin, corresponding to an average occupation number reduced from 0.36 to 0.005. We also observe a LOPs heating from 230 to 384 Kelvin with a blue-sideband pumping. Our experiment opens a possibility of all solid state quantum applications using semiconductor optical phonon mediated coupling at room temperature. [1] arxiv, 1303.0733v1 (2013); [2] Nature, 493, 504 (2013); [3] J. Zhang, et. al, sideband Raman cooling of optical phonon in semiconductors, (prepared)

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Jun Zhang
Division of Physics and Applied Physics,
School of Physical and Mathematical Sciences,
Nanyang Technological University, 637371, Singapore

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