Non-destructive mechanical characterization of semiconductor nanowires

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The novel and versatile physical and chemical properties of nanowires have stimulated large fundamental and technological interests during the last decades. The appearance of novel boundary conditions, compared to bulk materials, drastically modifies the behaviour of these materials. Modified sound velocity and thermal conductivity are examples of phenomena that have been observed in nanowires.1 It is thus important to develop novel technique that can in-situ and non-destructively characterize the mechanical properties of nanowires. Femtosecond time-resolved pump-probe spectroscopy is a unique way to generate and detect coherent acoustic phonons. An intense laser pulse is absorbed by a material and electron-hole pair are generated. These carriers yield their excess energy to the lattice, thus creating coherent acoustic phonons. A second, time delayed pulse, is sent to the sample and its reflectivity is modified by the coherent acoustic phonons. Here, we applied this technique to various arrays of semiconductor nanowires. We show that, due to the confined geometry of nanowires, phonon and photon dispersion are greatly modified and new modes emerge.2 By comparing the phonon modes observed experimentally to simulations, we are able to retrieve the mechanical properties of the structure.3 We applied this method to the zinc-blende and wurtzite phase of GaAs, which is metastable in bulk, and extract their complete elasticity tensor and geometric properties. Our results, in addition to the characterization capabilities, also provide an understanding of the effects of confinement on photon - phonon interaction and opens new possibilities for light control at the nanoscale. 1 P.-A. Mante, Y.-C. Wu, Y.-T. Lin, C.-Y. Ho, L.-W. Tu, C.-K. Sun, Nano Lett. 13, 1139 (2013) 2 P.-A. Mante, L. Belliard, B. Perrin, Nanophotonics 7, 1759 (2018). 3 P.-A. Mante, S. Lehmann, N. Anttu, K. A. Dick, A. Yartsev, Nano Lett. 16, 4792 (2016).