Spectroscopy of phonons in colloidal semiconductor nanocrystals

Volodymyr Dzhagan[a,b], Alexander G. Milekhin[c], Mykhailo Ya. Valakh[b], Dietrich R. T. Zahn[a]

[a] *Semiconductor Physics, Chemnitz University of Technology, Chemnitz, Germany*
[b] *V. E. Lashkaryov Institute of Semiconductors Physics, National Academy of Sciences of Ukraine, Kyiv, Ukraine*
[c] *A.V. Rzhanov Institute of Semiconductor Physics, 630090 Novosibirsk, Russia*

The high flexibility of chemical routes for tailoring the properties of colloidal nanocrystals (NCs) and NC-based composites stimulates ever-growing activities on synthesis, investigation, and application [1]. Unveiling the internal structure of core-shell or other types of heterogeneous NCs and bringing them into accord with model expectations is even more challenging than for their homogeneous counterparts. Along with varying the NC size and composition, changing the ligand on NC surface is an additional powerful way of tuning the NC properties. Different spectroscopic techniques have been used for achieving a better understanding about the structure of the NCs and its relation with their physical and chemical properties. Here, an overview of the capabilities of vibrational Raman scattering and infrared (IR) absorption spectroscopies in probing the phonon spectra and the structure of various kinds of semiconductor NCs prepared by coloidal chemistry will be presented.

Vibrational Raman or IR spectroscopy of NCs can provide information phonon modes, lattice constant, structural disorder, and strength of electron-phonon coupling [2]. Owing to the possibility of selective probing materials having different bandgaps by using different excitation wavelengths in Raman experiments, core/shell and other hetero-NC morphology can be distinguished from alloyed NC formation [3]. The high sensitivity of the phonon frequency to the lattice constant of a crystal allows the lattice mismatch-induced strain in core/shell NCs to be measured. Studying the size-dependence of the phonon spectra provides a characteristic NC size at which the surface starts to dominate over the structure of the parential “bulk” crystal. Recently developed 2D colloidal semiconductor nanocrystals, or nanoplatelets, show a number of distinct phonon features which were not observed for spherical and other NC shapes [4]. Finally, the recent advances in arising methods with the capability of probing phonons in single NCs, namely surface- and tip-enhanced Raman spectroscopies, are reviewed.

1) J.M. Pietryga et al., *Chem. Rev.* **2016**, 116, 10513.
2) A. G. Rolo et al., *J. Raman Spectr.* **2007**, 38, 618.
3) V. Dzhagan et al., *J. Phys. Chem. C*, **2013**, 117, 18225.
4) V. Dzhagan et al., *Nanoscale* **2016**, 8, 17204.