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Diagnostic Aspects of Raman Spectroscopy in the Physics of Semiconductor Quantum-Sized Nanostructures

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Raman scattering spectroscopy has proved to be a highly efficient tool in investigation of semiconductors. As an example, the detection of local vibrations of impurities in bulk crystals, discovery of mixed photon-phonon excitations (polaritons) in polar crystals, as well as mixed plasmon-phonon excitations in heavily doped semiconductors. Raman spectroscopy has also played a key role in developing and establishing the theory of lattice dynamics of semiconductor alloys and of the phase transitions in ferroelectrics.

In this talk we present a set of examples of efficient application of Raman spectroscopy which contributed to building the modern picture of the physics of quantum confined semiconductor nanostructures. Some particular physical effects, studied by the authors in the past, will be briefly overviewed here:

- the folding effect of phonon branches in small Brillouin zone in quantum-sized superlattices (SL), the determination of SL-period;
- the manifestation of quantum tunnelling of electron excitations in short-period semiconductor SLs in resonant Raman scattering;
- the effect of giant interdiffusion in QDs grown by MBE and the role of non-uniform strain (a combined Raman and scanning Auger spectroscopy study);
- Raman scattering in core-shell QDs synthesized by the methods of colloidal chemistry;
- the surface-volume effects in ultrasmall (< 2nm) QDs.

In more details we discuss the most recent results obtained for morphology-induced phonon spectra of two-dimensional colloidal semiconductor nanocrystals CdSe/CdS, or nanoplatelets, obtained in cooperation with research groups from France and Germany [1]. The three types of nanoplatelets (NPLs) were studied: 1) the free-standing 2D CdSe-layers with lateral dimensions of tens of nm and thikness of several monolayers; 2) the core-crown NPLs obtained by extending the CdSe NPLs with CdS only in the lateral directions and 3) the core-shell NPLs with

CdS-shell around all sides of CdSe NPLs. For all types of NPLs the absorption measurements and Raman investigations were performed for different conditions of resonant excitation. In all cases the spectra were different for core-crown and core-shell NPLs. Moreover, the 2D type of NPLs even without any core or shell made it possible to detect specific differences in their Raman spectra in comparison with usual spherical QDs. The general conclusion concerning the difference between core/crown and core/shell NPLs is the following: in core/shell NPLs stronger coupling between two materials with formation of additional mixed interface/surface modes takes place. In opposite, in corn/ crown geometry a more decoupled and bulk-like behaviour dominates.

1. V. Dzhagan, A.G. Milekhin, M.Ya. Valakh, S. Pedetti, M. Tessier, B. Dubertret, D.R.T. Zahn, Nanoscale, 2016, **8**, 17204-17212.