Abstract

The following nanostructures are studied by scanning tunneling microscopy and spectroscopy and atomic force microscopy:

- Strain-induced InAs quantum dots produced by molecular beam epitaxy
- InAs, InP, and CdSe nanocrystals synthesized by colloidal chemistry
- Single-walled carbon nanotubes prepared by laser evaporation technique

Strain-induced **InAs quantum dots** are grown on GaAs(001) by molecular beam epitaxy and are subsequently investigated by low temperature ultra-high vacuum scanning tunneling spectroscopy. It turned out that an ultra-high vacuum transfer system between molecular beam epitaxy and scanning tunneling microscope had to be established in order to achieve highly reproducible results. Above the quantum dots, several peaks are found in dI/dV curves which belong to different single-electron states of the particular dot. Spatially resolved dI/dV images at the peak positions reveal a (000), (100), (010), (200), and (300) character of the squared wave function, where the numbers describe the number of nodes in $[1\overline{1}0]$, [110], and [001] direction, respectively. The total number and the energetic sequence of the states are found to be different for different dots. The (010) state, for example, is often missing even if (200) and (300) states are present. This electronic anisotropy is attributed to a shape asymmetry of the quantum dots.

InAs, InP, and CdSe nanocrystals are chemically prepared in solution and not in ultra-high vacuum. This requires a preparation technique compatible with scanning probe methods. Therefore, a scanning probe equitable preparation technique for deposition of nanocrystals on Au on mica substrates is developed. Air tapping-mode atomic force microscopy and scanning tunneling microscopy images show randomly shaped nanocrystal agglomerates.

Single-walled carbon nanotubes are also deposited on Au on mica substrates and measured with low temperature ultra-high vacuum scanning tunneling microscopy and spectroscopy. Atomic resolution is obtained and metallic or semiconducting tubes are identified. Additionally, peaks are found in dI/dV curves on metallic tubes close to E_{Fermi} which are attributed to defect-induced confined states within the extended metallic tube. Spatially resolved spectroscopy reveal the extension of the confined regions to be about 20–40 nm. Thus, the quantum wire appears to be fragmented into quantum dots separated by defects. This is a direct evidence for defect induced backscattering within metallic carbon nanotubes.

Theophilos Maltezopoulos
e-mail: tmaltezo@physnet.uni-hamburg.de