Resolving electronic features of 2-dimensional semiconductor structures

S. Sadewasser, Th. Glatzel, O. Douhéret[1], D. Fuertes Marrón, A. Meeder, K. Maknys[1], S. Anand[1], M.Ch. Lux-Steiner
Hahn-Meitner Institut, Glienicker Str. 100, 14109 Berlin, Germany
[1]The Royal Institute of Technology, Electrum 229, S-164 40 Kista, Sweden
sadewasser@hmi.de

Scanning probe microscopy is one of the most suitable characterization tools for the investigation of low dimensional material structures. For the understanding of 2-dimensional (2D) semiconductor structures local electronic information is of special interest. In this respect, Kelvin probe force microscopy (KPFM) provides access to the local work function; however, for quantitative evaluation the lateral and energy resolution of the technique have to be considered.
We applied resonant Kelvin probe force microscopy (KPFM) in ultra high vacuum to study resolution limits in the characterization of 2D semiconductor structures. We demonstrate that KPFM is capable of detecting InGaAs/InP quantum wells as narrow as 5 nm (Fig. 1). From comparison to 1D Poisson/Schrödinger simulation we observe evidence for charge carrier accumulation in the well [1]. Another form of a 2D structure are grain boundaries in polycrystalline semiconductors. For grain boundaries in p-type $CuGaSe_2$ thin films we find a downwards band bending corresponding to a barrier for hole transport (Fig. 2); this is shown to be reduced upon sample illumination [2]. By means of locally resolved surface photovoltage measurements we are able to distinguish different types of grain boundaries (Fig. 3), presumably associated to different crystallite orientation. The lateral and energy resolution in the measurements of these 2D structures is discussed with respect to the influence of the space charge regions around the 2D semiconductor structures.

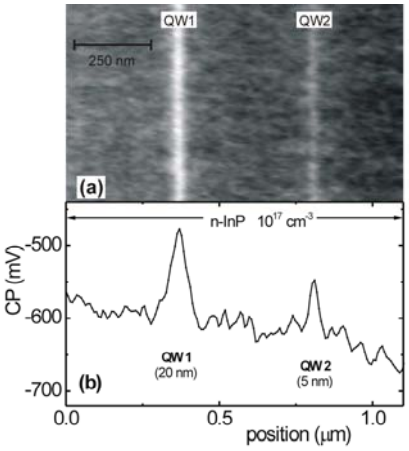

Figure 1

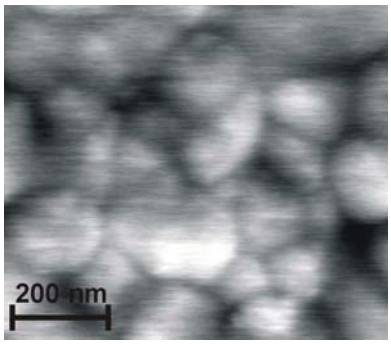

Figure 2

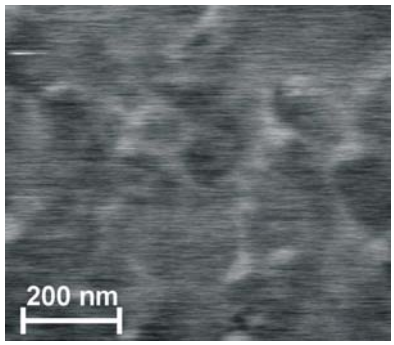

Figure 3

[1] O. Douhéret, S. Anand, Th. Glatzel, K. Maknys, S. Sadewasser, Appl. Phys. Lett. **85**, 5245 (2004).
[2] D. Fuertes Marrón, S. Sadewasser, A. Meeder, Th. Glatzel, M.Ch. Lux-Steiner, Phys. Rev. B **71**, 033306 (2005).