Electron holography of few-monolayer-thick dichalcogenide crystals

F. Winkler[1], S. Borghardt[1], J. Barthel[1], A. Tavabi[1], E. Yucelen[2], A. Chaturvedi[3], C. Kloc[3], B. Kardynal[1] and R. E. Dunin-Borkowski[1]

[1] *PGI, Forschungszentrum Jülich, Jülich, Germany*

[2] *FEI Company, Eindhoven, The Netherlands*

[3] *MSE, Nanyang Technological University, Singapore*

Electron holography can be used to measure externally generated electrostatic fields in thin 2D materials on nanometer scale, providing a powerful tool to study transport properties of this material systems. Such measurements require, however, that sample thickness is known. In this work we study few layer thick WSe_2 and establish necessary conditions for assigning the sample thickness with very high spatial resolution from phase contrast in electron holography. Single unit cells of phase images were analyzed to determine the average phase shift from a histogram of all cells' values. (Figure 1). Image simulations which include experimental variables such as defocus and sample tilt are used to compare the measured with the expected phase shifts for samples with different thickness. We show that amplitude maps can be used to correct for the sample tilt extending the range when sample thickness can be determined. The study shows that for samples with up to three - four monolayers, sample thickness as well as - in future - electrostatic potentials with very high spatial resolution can be measured from electron holographic phase images.

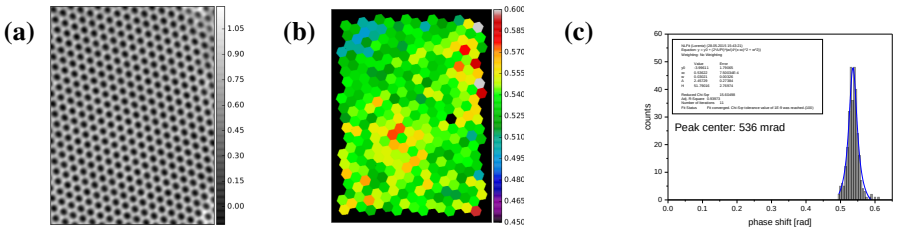

Figure 1: (a) Phase image of a 4 layer thick untilted WSe_2 sample. (b) Phase image after Voronoi tesselation. (c) Histogram of phase shift determined by the Voronoi algorithm (binning: $5\,\mathrm{mrad}$). The peak center is located at $536\,\mathrm{mrad}$, which indicates a sample thickness of 4 monolayers.