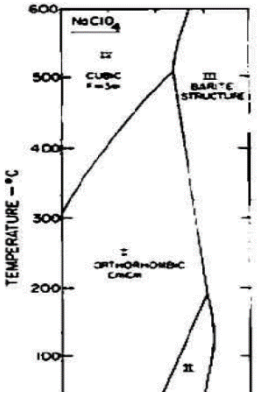
Effects of graphene encapsulation on KH_2PO_4 and $NaClO_4$

Master Thesis, Electron Microscopy Group of Materials Science, Prof. Ute Kaiser

Background

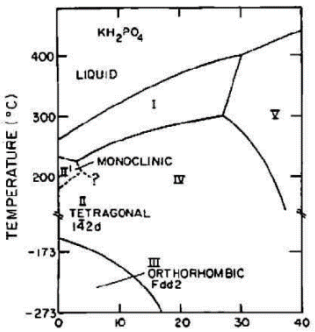
Modern low-voltage transmission electron microscopes (TEM) reach single atom resolution at low acceleration voltages in the range of 20-80 kV [1,2,3]. This gives the possibility to study materials with low knock-on thresholds. But not only knock-on damage plays a role when specimens are interacting with the electron beam, also mechanisms like radiolysis, heating, charging and chemical etching. It was shown that encapsulation of a specimen with graphene prevent against radiation damage [4]. But the graphene encapsulation is still not fully understood. It was found that anhydrite $CaSO_4$ crystallizes from a liquid between graphene layers which can only occur at high pressures in the range of kPa – MPa. This is a remarkable result because in the TEM the vacuum level is 10^{-6} Pa. Thus crystallization is an indication for the Van-der-Waals pressure between graphene.



High pressure phase diagram of $NaClO_4$ [5]

Aim

The aim of the master thesis is to achieve a better understanding the formation of quasi 2D materials between graphene. The main focus is to perform and evaluate in-situ HRTEM experiments including electron energy loss spectra to find out if phase transitions of the salts are taking place which are pressure and/or temperature dependant. According to the phase diagrams of the two materials, phase transitions should occur due to the Van-der-Waals pressure and/or heating due to the interaction with the electron beam.



High pressure phase diagram of KH_2PO_4 [5]

Workplan

- introduction to electron microscopy, radiation damage, basics of KH_2PO_4 and $NaClO_4$
- fabrication of samples for encapsulated liquids
- HRTEM simulations of KH_2PO_4 and $NaClO_4$
- recording image sequences with aberration-corrected HRTEM at different accelerating voltages (this will be mainly performed by the supervisor)
- data post-processing of recorded image sequences and EEL spectra

Requirements

- good physical understanding
- a basic chemical understanding is advantageous
- high interest in laboratory work
- enjoying scientific work in our international team

Supervisor: doctor cand. Tibor Lehnert

The work will be performed on our newly developed SALVE microscope [3].

[1] U. Kaiser *et.al.* Ultramicroscopy **111 (8)**, 1239-1246 (2011)
[2] M. Linck et al. Phys. Rev. Let **117** 076101 (2016)
[3] www.salve-project.de

[4] G. Algara-Siller, *et.al.* Appl. Phys. Lett. **103(20)**, (2013)
[5] J.B. Clark, P.W. Richter; Rev. of Phys. Chem. of Japan **50**, (1980)