

Program

**Applications of electron microscope for  
the characterization of catalytic materials**

**Electron microscopy block course at the Dalian Institute of Chemical Physics**

by

Prof. Armin Feldhoff

Leibniz University Hannover, Germany

On Wednesday 14 March 2018, instrument check for SEM and TEM will be made together with lab manager  
Dr. Miao Shu

### **Lectures 1-2 + 1-3, Basics of the scanning electron microscope II (SEM)**

beam-specimen interaction, detectors, secondary electrons (SE), backscattered electrons (BSE), depth of focus, in-lens detection (high-resolution SEM), avoiding specimen charging,  $C_s/C_c$ -corrected SEM (ultra-high resolution)

### **Lecture 2-1, Basics of the transmission electron microscope I (TEM)**

history, virology, fundamentals, lens in wave optics, the 3-stage TEM, optical path for imaging and diffraction, resolution limit, Fourier optics, diffraction absorption contrast

### **Lecture 2-2, Basics of the transmission electron microscope II (TEM)**

phase contrast (high-resolution TEM), phase-amplitude diagrams,  $\lambda/4$  phase plate, phase-contrast transfer function, point resolution, delocalisation,  $C_s$ -corrected microscope, contrast simulation (multislice method), focal series reconstruction

### **Lecture 3-1, Diffraction and elemental analysis in the transmission electron microscope**

analogies and differences between electron diffraction and x-ray diffraction, selected area electron diffraction (SAED), from parallel to convergent illumination, convergent beam electron diffraction (CBED), scanning transmission electron microscopy (STEM), analytical electron microscopy (AEM), x-ray spectroscopy (EDXS, WDXS, EMPA), electron energy-loss spectroscopy (EELS)

### **Lecture 3-2, Some practical advice (SEM + TEM)**

sample preparation, media for image acquisition, avoiding beam damage

### **Practical Exercises**

#### **SEM (8 courses times 4 students = 32 students; all courses given by lab manager Dr. Miao Shu)**

Demonstration of effect of working distance (objective lens focal length) on resolution and depth of focus; secondary electron imaging and energy-dispersive X-ray spectroscopy.

#### **TEM (8 courses times 4 students = 32 students; all courses given by Prof. Armin Feldhoff)**

Demonstration of absorption contrast (bright-field, dark field) and selected area electron diffraction; how to avoid damage of beam-sensitive materials during observation.

### **Examination**

**Written test (45 minutes)** allows monitor the transfer of knowledge. Final discussion on results of test and issuing a certificate will close the block course.