STEM-DPC Image Simulation

Installation

Since this is a beta version, there is no installer. Simply unzip the xHREM_DPC.zip at the desktop. The xHREM_DPC has the same folder structure as the xHREM.

How to Use

Since this is the beta version, please launch the revised xMultiGUI and xSTEMimage in the Utilities folder, not from the Start menu. Owing to the same folder structure, the usage should be identical with other STEM simulations using the xHREM.

At first you calculate the DPC signals using xMultiGUI, and then generate the DPC images using xSTEMimage. Finally, a phase map can be obtained by integrating the DPC images by using the qDPC plug-in for DigitalMicrograph [1].

1. DPC signals calculation (using xMultiGUI)

To calculate the DPC signals select "DPC" in the STEM setting of the MultiGUI as shown below:
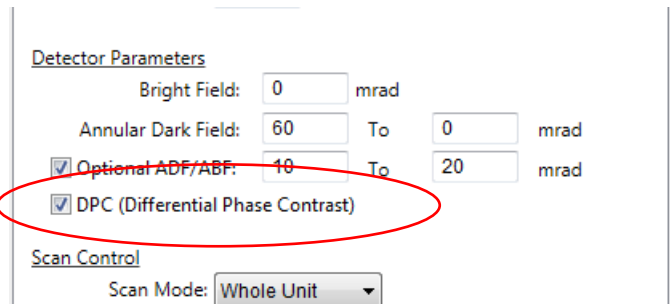
With this selection, the DPC signals will be calculated with File -> Execute STEM, and saved to .SD3 file.

2. DPC image generation (using xSTEMimage)

The DPC images will be calculated with xSTEMimage, when you select "DPC" from the Image Mode. Use "Display Control" section to set the output resolution (pixels/angstrom) and the output range as in the case of other STEM images.
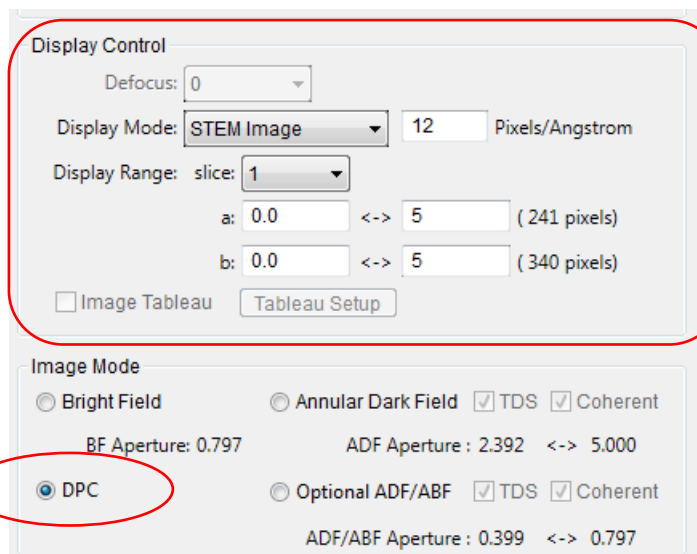
After setting the condition, when you push the "Generate" button, two DPC images, Dh and Dv, will be calculated. The images below show the DPC images for the GaAs, which correspond to the horizontal and vertical derivatives of the potential distribution of GaAs in the 001 projection, respectively.
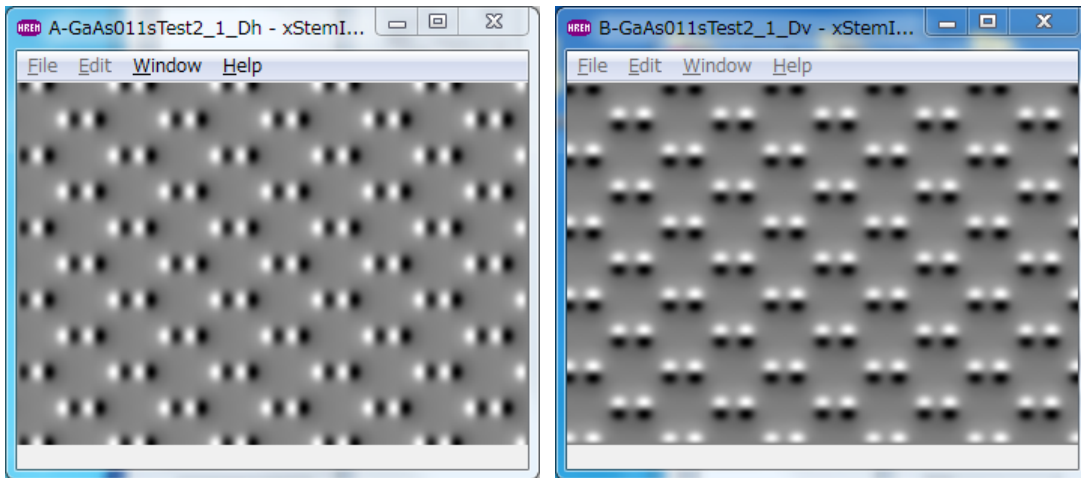
In order to integrate the DPC images using the qDPC, the DPC image data should be read into DigitalMicrograph. You can easily import them to DigitalMicrograph, when you save the DPC images in "gfx" format using File -> Export Data from xSTEMimage as shown below:
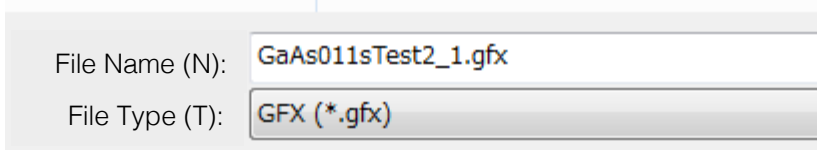
NOTE: When you export the DPC data from the xSTEMimage GUI, you don't need to generate the DPC images, and both Dh and Dv images will be saved at once. On the other hand, when you export the DPC image from the image window, only the corresponding image data, namely Dh or Dv image, will be saved.

3. Phase map calculation (using qDPC plug-in on DigitalMicrograph)

The gfx file can be simply read into the DigitalMicrograph using Open command of the File menu, when the file type "All file" is selected. Or, you can simply drag-and-drop the gfx file(s) to the DigitalMicrograph.

The phase map shown below was obtained from the above two DPC images using "DCT…" command of the qDPC.

DPC Signals

The STEM Differential Phase Contrast (DPC) corresponds to the derivatives of the phase distribution of the phase object. In electron microscopy the phase distribution for a thin sample is proportional to the projected static potential. Therefore, we can get the phase (potential) distribution of the sample by integrating the STEM-DPC signals [2]. Thus, the STEM-DPC is a technique to observe the phase object using a STEM.

The simulated DPC signals obtained with the DPC capability of the STEM Extension corresponds to the center of mass (CoM) of the diffraction intensity distribution at each scan point. These signals are equivalent to the signal obtained from the pixelated detector. Another way to obtain the DPC signal uses a segmented quadrant detector. It has been shown that the signals from the quadrant detector approximate the CoM, and they will give a reasonably good phase map [3]. Therefore, you can use the phase map obtained with the STEM Extension to evaluate the possibility of the STEM-DPC technique when applied to your sample.

References

[1] qDPC, DigitalMicrograph plug-in: https://www.hremresearch.com/Eng/plugin/qDPCEng.html (Microscopy Today 2018 Innovation Award product)

[2] Ishizuka A., Oka M., Seki T., Shibata N., and Ishizuka K. (2017) Boundary-artifact-free determination of potential distribution from differential phase contrast signals. Microscopy 66, 397-405 (The Japanese Society of Microscopy Award in 2019 paper)

[3] Ishizuka A. and Ishizuka K. (2020) Observation of Phase Objects using STEM - Differential Phase Contrast (DPC) microscopy, JEOL News 55, 24-31.