

## Artificial STEM DI – Visualizing Polycrystalline Regions in High Resolution Images

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High resolution images of transmission electron microscopy (TEM) or scanning transmission electron microscopy (STEM) can easily be used to quickly identify polycrystalline regions in thin specimen (Fig.1). Identifying individual crystallites, however, is often a more tedious task. A common approach, as illustrated in Fig.2, is to first perform a Fourier-transform (FT), yielding a diffractogram of the whole image area, then mask individual peaks of the diffractogram, and finally carry out the inverse transformation. The resulting image highlights associated crystallites as intensity modulations. The analysis can then be repeated for all major spots (Fig.2).

In this contribution, we describe an alternative FT based approach and present an interactive exploration tool utilizing DigitalMicrograph's capabilities of displaying 4D data in STEM diffraction-imaging (STEM DI) [1,2]. In STEM DI, a 4D data set is created by recording and storing 2D convergent beam electron diffraction (CBED) patterns from each position of a scanned area. The data can easily be used to extract averaged CBED patterns from multiple positions, or to extract customized dark-field images by back-projecting intensity. The according software tools are interactive and allow a quick exploration of the data.

By processing high-resolution images into the STEM DI format, the same tools can be exploited to interactively explore FT derived information from high resolution images. We have created a script which creates a virtual STEM DI data set by calculating FTs of image subsections in a regular array across the original image.

Fig.1 shows a Cs corrected STEM bright-field image of a Pd/Sn nanoparticle. The polycrystalline nature of the shell is evident. The right side shows the according artificial STEM DI data set derived by calculating 128 x 128 FTs of subsections of the image. One such area is exemplarily shown as marker in the bright-field image. Spots in the artificial STEM DI can now be interactively examined by standard tools. Fig.3 shows the visualization of crystallites by the artificial STEM DI approach using the same spots as in the FT based analysis (Fig.2).

### References

- [1] software description, Gatan Inc., <http://www.gatan.com>
- [2] B. Schaffer et al., *Microsc. Microanal.* 14/Suppl 2 (2008) 70.
- [3] The authors would like thank EPSRC for funding under grant EP/D040205/1 and Dr. Dietrich Häußler for providing the core-shell particle specimen.

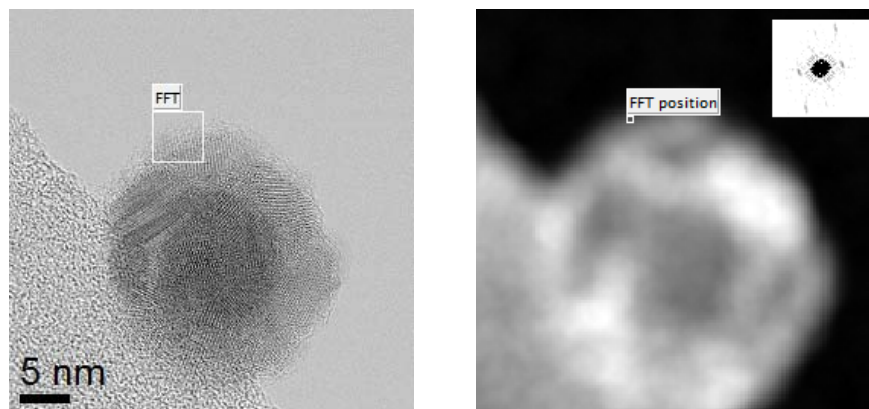


Fig.1. Left: STEM bright-field image of a Pd/Sn nanoparticle. Right: Back-projected intensity of the artificial STEM DI dataset ('artificial dark-field'). Each position of this map contains a diffractogram calculated from a subsection of the source image. The insert shows the diffractogram of the indicated position calculated from the subsection marked in the bright-field image.

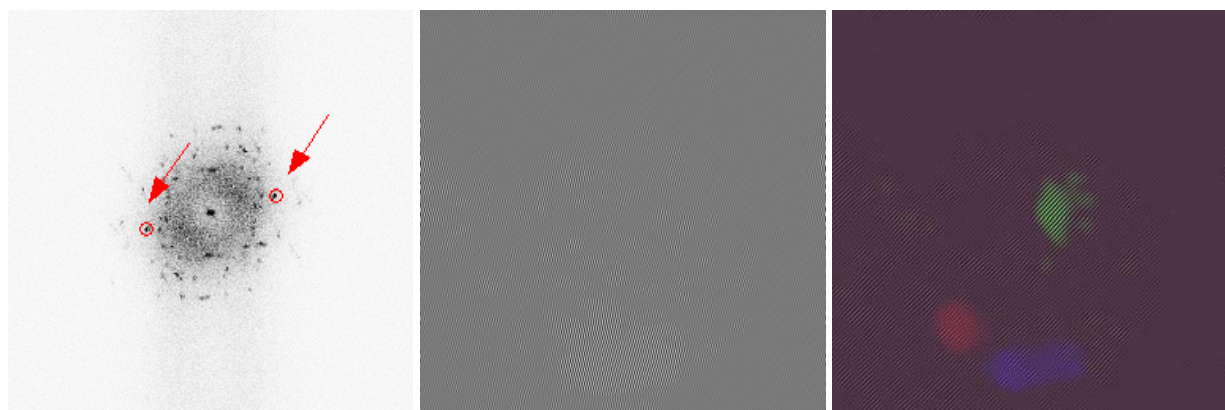


Fig.2. Crystallite analysis by Fourier-filtering. Left: FFT of image from Fig.1. Arrows mark spots used for analysis. Center: inverse transform of selected spots. Right: Color-overlay of three different analyzed spots.

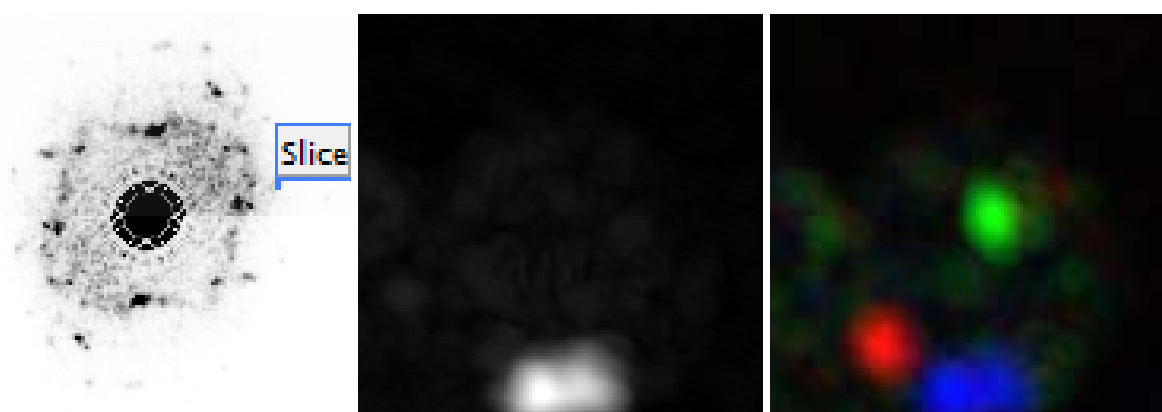


Fig.3. Crystallite analysis using artificial STEM DI. Left: Averaged diffractogram of all subsections. The marker indicates position displayed in the center image. Right: Color-overlay of three different analyzed peaks (identical to those of Fig.2).