Potential of Timepix Hybrid Sensor in 4D-STEM in a Scanning Electron Microscope (SEM)

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In recent years we have witnessed several new generations of hybrid detectors getting slow adoption in the electron microscopy, mostly used as a radiation hard direct-electron camera for diffraction on TEM. We have shown previously the advantages of the use of Timepix sensor for electron backscatter diffraction (EBSD) and for the reflected Kikuchi diffraction (RKD). In combination with the high speed electronics we are able to acquire up to 2000 fps of diffraction images. In combination with on-line post-processing algorithms full information about the sample crystalline lattice is obtained. After productization efforts this technology is commercially available as an option to regular Thermo Scientific scanning electron microscope (SEM). Here we'd like to present the advantages of using a Timepix hybrid sensor for the use in 4D-STEM in SEM. The method relies on collection the full diffraction image of the transmitted electrons through a thin sample (10 – 150 nm) for every pixel position on the sample.

This technique offers similar performance to many TEM-based 4D STEM methods, but in 6 – 30 kV energy range and on FOVs up to mm range. The low energy implies stronger interaction in extremely thin 2D materials, allowing us to image sheet orientation, bending and stress within the sheet over very large regions of interest. Additionally, use of such low energies mitigates knock-on damage to 2D material lattice, which is an issue in a TEM.

With the high acquisition speed of the 4-th generation of Timepix sensor we plan to combine the 4D-STEM with in-situ nano-reactor. Such combination will allow real-time in-situ experiment monitoring, revealing the chemical phase transitions spatially resolved to less than 10 nm feature sizes. Moreover, the improved resolution of the Time-of-Arrival information of the hybrid detector allows us to get sub-ns temporal insight into the chemical reaction or phase-transition on catalyst nanoparticles, nanowires or nanotubes.

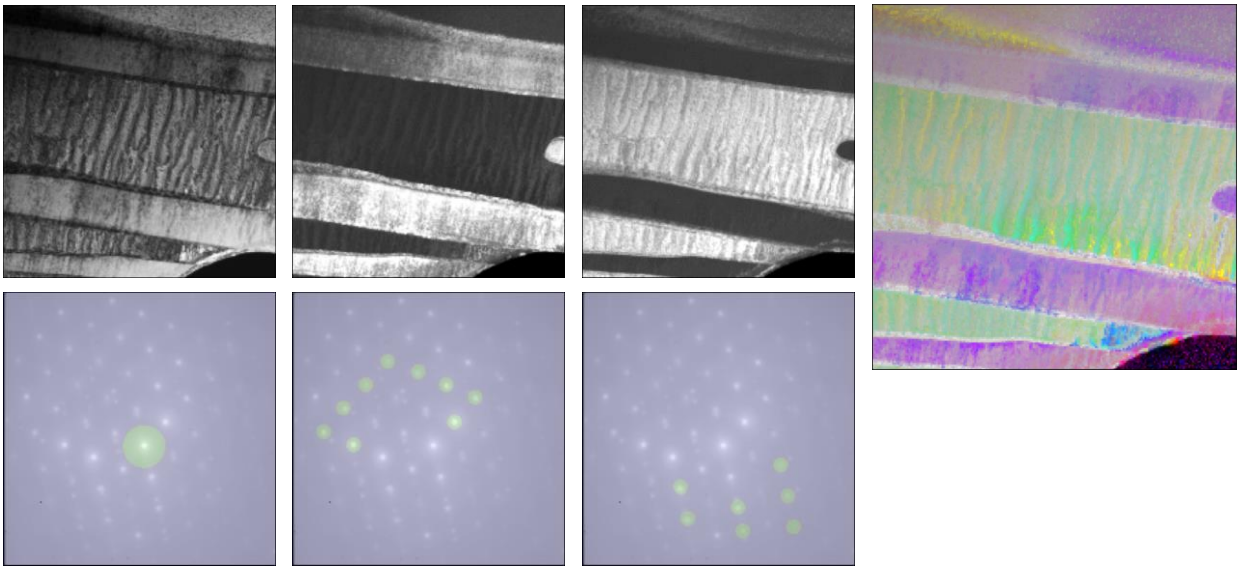

Figure 1: A Cu alloy lamela analyzed using 4D-STEM with Timepix(1) on Thermo Scientific Helios 5 FX system. Shown are virtual bright-field map, 2x custom orientation maps and a dark field center-of-mass orientation map (showing slight intra-grain striped structure)