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In situ observations and measurements of plastic deformation, phase transformations and fracture with 4D-STEM

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In situ TEM experiments are typically recorded either in real space or diffraction space. However, it would be ideal to have information from both for when transient events occur that cannot be repeated exactly (ie- defect generation or irreversible phase transformations). 4D-STEM can come close to providing simultaneous real-space imaging and diffraction analysis during *in situ* testing, making it possible to perform strain mapping via diffraction pattern analysis during in-situ deformation in a TEM. This talk will highlight recent *in situ* 4DSTEM nanomechanical deformation experiments that explore transient events where both information from diffraction space and real space are used. The diffraction patterns are used to identify different phases, defects, orientations and relative strain, while the images formed by using virtual apertures provide microstructural context for the analysis. Example experiments include defect generation and fracture in multi-principal element alloys [1] and phase transformations in functional oxides [2].

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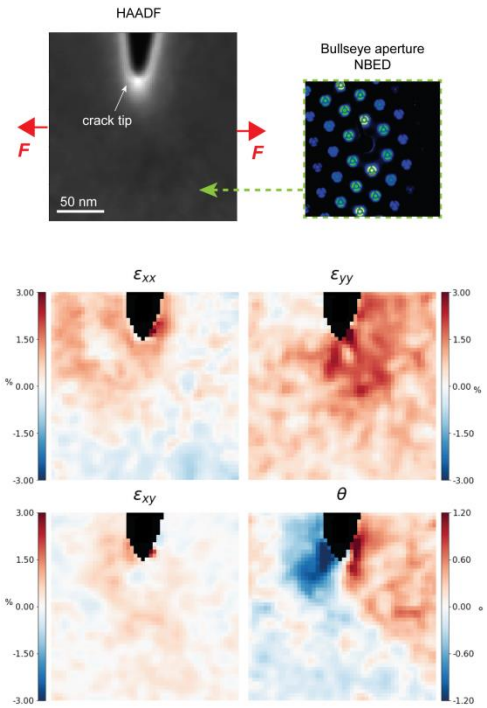

Figure 1. 4D-STEM strain mapping of crack tip in CrCoNi medium entropy alloy during in situ deformation.

References

[1] Ruopeng Zhang, Shiteng Zhao, Jun Ding, Yan Chong, Tao Jia, Colin Ophus, Mark Asta, Robert O. Ritchie & Andrew M. Minor "Short-Range Order and Its Impact on the Properties of the CrCoNi Medium Entropy Alloy" *Nature*, 581 (7808), 283-287

[2] Yu Deng, Christoph Gammer, Jim Ciston, Peter Ercius, Colin Ophus, Karen Bustillo, Chengyu Song, Ruopeng Zhang, Di Wu, Youwei Du, Zhiqiang Chen, Hongliang Dong, Armen. G. Khachaturyan and Andrew M. Minor,"Hierarchically-structured superelastic deformation in ferroelastic-ferroelectrics", *Acta Materialia*, 181, 501-509 (2019)

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