Amorphous materials are among the most intriguing to analyse with microscopies since single atom positions cannot yet be resolved. Whereas the pair correlation function gives information about next neighbor distances from evaluation of diffraction patterns, variance plots in fluctuation electron microscopy (FEM) were shown to be sensitive to small structural changes in the amorphous material. In metallic alloys amorphisation is often induced by adding larger atoms B to a transition metal A. When exceeding a critical concentration $x_c$ of atom B in $A_{1-x}B_x$, the alloy will transform from the crystalline to the amorphous phase. Thus, it is likely that the structure of the amorphous material depends on the concentration difference $x - x_c$.

With this idea in mind, we have analysed Fe$_{1-x}$Zr$_x$ samples as a function of $x$ ($x=0.1-0.29$), where the $x$ is chosen to be above $x_c$. The films were grown by sputter deposition where the amorphous Fe$_{1-x}$Zr$_x$ was 14nm thick. The films were analysed by FEM in plan view geometry in the STEM geometry of FEM. Our data were obtained from the quantitative evaluation diffraction patterns contained from a full scanning transmission FEM (STFEM) data set. We have optimized the acquisition such that oxidation of the sample, the influence of cladding Al$_{0.7}$Zr$_{0.3}$ layers did not impact the analysis.

The variance as a function of q-vector was extracted from such diffraction patterns and subsequently, the size of structurally coherent clusters was determined (Fig. 1). The structural coherence length depends only weakly on $x$. In addition, correlographs, computed from the data such as in ref [3] show a clear increase of structural order with decreasing $x$.

In order to understand how the FEM data are related to the structure of the amorphous films, we have simulated the amorphous structure by melting a supercell using classical molecular dynamics and considering an embedded atom model interatomic potential. We calculated the FEM diffraction patterns for both, perfectly amorphous structures as well as for structure models containing crystalline clusters of various sizes and orientations (Fig. 2). We observe changes in the variance of micro-diffraction patterns and correlate them with experimental findings.


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Fig. 1: Typical variance diffraction pattern (left) and variance plot (right) of the Fe0.81Zr0.19 sample.

Fig. 2: FEM diffraction pattern calculated from the model of amorphous FeZr.