Application note: Faster, smarter, more robust precession enhanced 4D-STEM (SPED) through advanced SenseAI algorithms

SenseAI and NanoMEGAS have partnered to deliver a new accelerated workflow for 4D-SPED.

4x faster acquisition

Whilst maintaining excellent crystallographic reconstruction quality.

Background

Precession-enhanced 4D-STEM, also known as Scanning Precession Electron Diffraction (SPED), has become a leading technique for structural analysis at the nanoscale. In recent years, the technique has gained popularity both in science and industry for orientation and phase mapping, strain mapping, electric field mapping, amorphous materials mapping and more. With the introduction of fast pixelated electron detectors, data collection speed has gone up with a factor of 10-100x.

A novel approach for improving data collection speed is the use of advanced software algorithms based on compressed sensing. A smart data collection strategy, sparse sampling, in which only 25%-10% of the scan area is measured, is sufficient to reconstruct the full image without major information loss.

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The solution

SenseAI and NanoMEGAS have partnered to deliver a new accelerated workflow for 4D-SPED. By combining SenseAI's intelligent sparse acquisition technology with NanoMEGAS' industry-leading PED platform, users can achieve at least a 4× reduction in acquisition time while maintaining excellent crystallographic reconstruction quality.

The main advantages of sparse sampling are: fast acquisition times (a factor of 4-10x); reduced electron dose on the sample (well suited for highly beam sensitive material); easy to implement to new and existing installations; works with any camera/detector supported by NanoMEGAS.

The joint solution reduces the number of measured scan positions while preserving the information required for reliable PED analysis.

Conventional Workflow	SenseAI + NanoMEGAS
100% sampled	Sparse sampling using Compressed Sensing
Full acquisition time	At least 4-10 × faster (depending on the sample)
High dose	4-10x less dose
Higher drift risk	Reduced drift
Lower throughput	More experiments per day

RESULTS

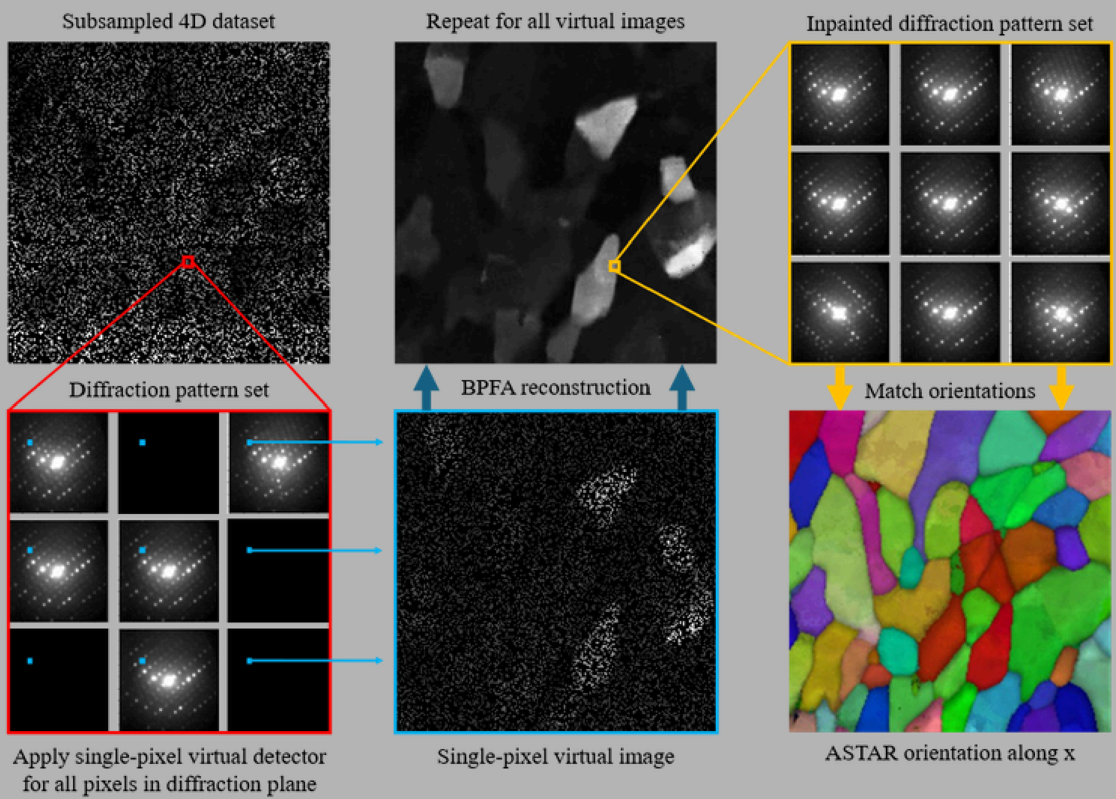

Figure 1. Process for inpainting a 4-dimensional dataset. First, an incomplete set of diffraction patterns is acquired. A full set of virtual images is formed for each pixel in the diffraction plane. Each of these virtual images is inpainted, in this case using BPFA. Each of those virtual images is packed back into a 4-dimensional array. The array is resliced to view the diffraction patterns, which can be analysed further using conventional techniques. In this instance, ASTAR software is used to produce grain orientation maps, with colour indicating orientation and intensity indicating correlation index.

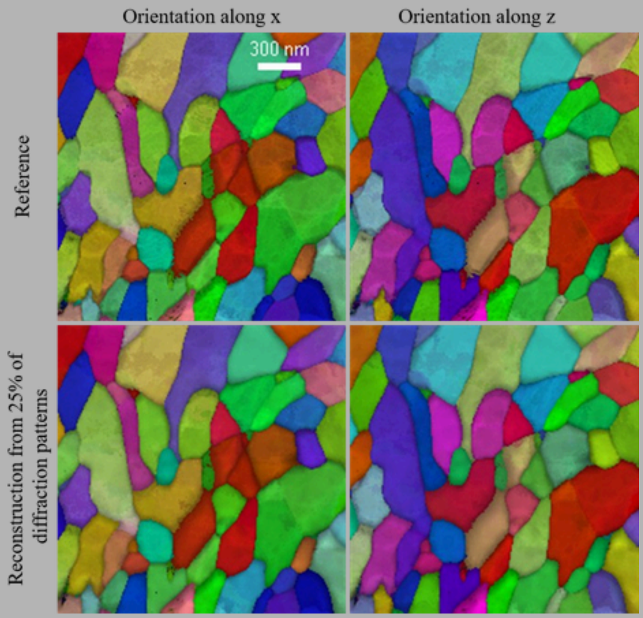

Figure 2. Result comparing ASTAR orientation maps along x (left) and z (right) axes produced from a complete diffraction pattern set (top) and the inpainted recovery of a subsampled diffraction pattern set which contained only 25% of the total diffraction patterns (bottom). This would result in an at-acquisition increase in framerate of a factor of 4.

"NanoMEGAS has spent more than two decades making precession electron diffraction an indispensable tool for crystallographic characterisation. Partnering with SenseAI allows us to address one of the remaining barriers to wider adoption — acquisition speed. Together we're enabling users to perform significantly faster SPED experiments while preserving the analytical performance our customers expect."
Stavros Nicolopoulos, CEO, NanoMEGAS

"For decades, advances in electron microscopy have come from better detectors, better optics and better microscopes. We believe the next major leap comes from smarter acquisition. By combining SenseAI's intelligent sampling technology with NanoMEGAS' world-leading PED platform, we're enabling researchers to collect the crystallographic information they need in a fraction of the time—without compromising the quality of the science. That's a fundamental step towards the autonomous microscope."
Dan Somers, CEO, SenseAI

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