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Ptychographic microscopy, in forward or Bragg diffraction geometry has produced impressive results based on the ability to image in 3D and at high spatial resolution the structural details of complex samples [1]. It takes advantage of inversion procedures, which retrieve the sample complex-valued scattering contrast by phasing back the coherent diffraction intensity patterns acquired at different sample-beam positions with enough beam overlapping between neighboring positions. This introduces redundancy which is the key for the inversion algorithm to converge. In the Bragg geometry, a ptychography modality our group has pioneered [2], new structural details obtained on a shell calcite prism have allowed us to progress in the understanding of calcareous biomineralization [2]. As they are based on the use of coherent x-rays, those inversion methods will further spread out with the forthcoming sources of increased coherent flux (a factor of about 100 is expected with the ESRF EBS program).

However, "less successful" results, where experiments have been corrupted by the onset of radiation damages, are reported. Those damages result in a strong modification and ultimately destruction of the diffracted signal, as a function of the x-ray dose [3]. Some attempts to circumvent this problem have been proposed, such as performing fast acquisitions of a given damaged sample state [3]. However, the blurring of the signal, due to the time evolving sample, strongly compromises the quality of the reconstruction [3].

Here we propose a novel strategy, which has been proved to be successful with simulation. We used a simple model for the radiation-induced structural evolution, but a more realistic model might be introduced, based on the ongoing advances regarding the understanding of radiation damage propagation. The proposed strategy is based on a ptychography approach, which has already shown the capability to retrieve additional parameters (like the probe profile and positions, the mode structure, etc.). Our simulation shows that a ptychography scan of a sample experiencing radiation-induced structural evolution (leading to its destruction) contains enough information to ensure the retrieval of the different evolving sample states (5 states in our simulation). The radiation-induced structural evolution is linearly dependent on the photon dose deposited on the sample. Hence, when a Gaussian beam illuminates the sample, the region in the vicinity of the beam maximum evolves rapidly, while the regions with less photons evolve slowly. Thereby, at each beam position, many evolving states coexist, and their diffraction patterns add up incoherently to give the final intensity pattern. With the redundancy introduced by the overlapping scan, the reconstruction is successful, and the retrieved states present good agreement with the original ones. Note that given the fact that a finer sampling of the state evolution is possible, we are confident that the more realistic case of a continuous sample evolution is also solvable with this transient-ptychography approach.

This work was funded by the European Research Council (ERC) under the European Union's Horizon H2020 research and innovation program grant agreement No. 724881.

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