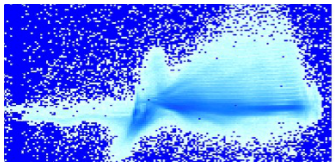

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Structured probes for BCDI: Toward the imaging of dynamic and distorted crystals

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This work proposes speckle Bragg coherent diffraction imaging (spBCDI), a new approach to improve the time-resolution in BCDI microscopy. The method uses structured (or speckled) illumination to induce a convolution of the 3D frequency content associated with the nano-sized crystal with a broad kernel, acting partially along the rocking-curve (RC) direction. Such a convolution encodes 3D structural information about the sample in each 2D image, and hence significantly reduces the required oversampling ratio along the RC direction (i.e., with respect to the Nyquist frequency).

Extensive numerical simulations demonstrate data spBCDI obtained with low oversampling ratios (i.e., < 2) along the RC yield reliable reconstruction of the crystal phase. Such reductions in the oversampling ratio reduce the measurement times which are between 1.5 – 14 times (depending on the incidence angle and the speckle size) shorter than for standard (plane wave) BCDI [1], enabling spBCDI for imaging time-evolving systems in the 0.5 - 1s time scale at 4th generation synchrotrons. The simulations also explore the limits of spBCDI by evaluating the minimum oversampling ratio along the RC which still yields an invertible data set [1]. This new method is also remarkably well suited for robust imaging of strongly distorted crystals, which remains challenging in plane wave BCDI [1].

A proof-of-concept experiment has been performed at the ID13 beamline (ESRF) [2]. The structured illumination was obtained by introducing a tailored phase-plate, that we designed to match the required speckle and beam envelope sizes (manufactured by XRnanotech GmbH, Switzerland). Combined with the powerful focusing optics of ID13 (Multi-Laue lenses), this new optical device produces a structured illumination at the sample position, with speckle grains of 70 nm laterally distributed within a beam of ~ 1 µm size. This illumination was used to image a 3D crystalline nano-structured Si thin-film with a set of oversampling ratios along the RC direction ranging from 4 down to 0.4.

[1] I. Calvo-Almazán, V. Chamard, T. Grünewald and M. Allain, Inhomogeneous probes for BCDI: Toward the imaging of dynamic and distorted crystals, in preparation

[2] I. Calvo Almazán, T, Grünewald, P. Li, P. Fenter, F. Bartolomé, M. Burghammer, A. Medjahed, M. Allain and V. Chamard, Real-time imaging of dynamic crystals with strongly structured probes for BCDI, in preparation

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