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Strain Imaging at the Nanoscale with Coherent X-ray Diffraction.

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Coherent scattering occurs when the size of the investigated sample is comparable to the coherence length of the illumination beam. With the advance of highly brilliant third generation synchrotron sources, sufficiently intense beams with coherence length in the 1-50 µm range are now accessible in the x-ray regime. For the small coherently illuminated volume, the phase of the complex-valued illumination function is well defined over the illumination volume, ensuring that the phase relation between the scatterers, *i. e.* the atoms, is preserved. It allows for a strong sensitivity to the atomic positions for the whole sample under illumination. This sensitivity appears as strong fluctuations in the intensity pattern, the so-called *speckles*, which is of particular interest for structural investigation of crystalline defects such as dislocations or stacking faults.
Furthermore, as the speckle distribution is related to the exact position of the scatterers, it is highly desirable to invert the diffraction pattern in order to *retrieve* their direct space description. But the experiment gives access to the intensity only, which is the magnitude of the complex-valued exit wave function. This is the famous phase problem. A solution of this problem has been given by Sayre in 1952: the full wavefield function can be retrieved from intensity measurements under the condition that sufficiently high oversampling of the coherent diffraction pattern is used [1]. This is the base for another rapidly developing application of coherent x-ray diffraction, called Coherent x-ray Diffraction Imaging (CDI) or lens-less imaging [2]. The reconstruction is performed with iterative algorithms using back and forth Fourier transforms, together with a set of reasonable constraints applied at each iteration, both in the direct and reciprocal spaces. Application to strain investigation in nanocrystals has been recently demonstrated for diffraction experiments performed in the Bragg geometry [3].
This presentation aims at illustrating two aspects of Coherent x-ray Bragg Diffraction: crystalline defects sensitivity and lens-less imaging. Recently obtained results will be presented [4-6], where the limitations imposed by the strain non-homogeneities or by the use of focusing optics will be pointed out.

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Monochrome and Colour X-ray Diffraction Imaging.

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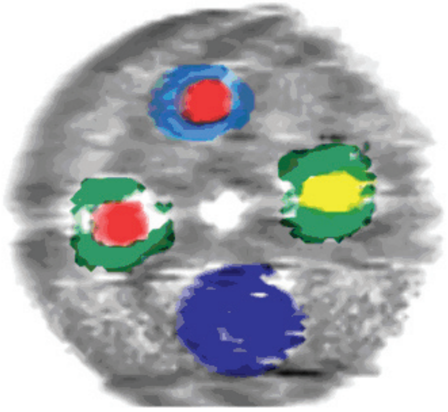

Map of six different materials in a phantom test object found by X-ray diffraction imaging

The continued advancement of X-ray generation and collection mean that it is now possible to obtain high quality scattering data from materials with second/sub-second time resolution. This has facilitated the practical application of diffraction based imaging [1,2,3] as a tool to map materials within samples. Such methods have the obvious advantage over contrast imaging techniques such as traditional CAT scanning, in that the diffraction signal (and other scattering signals) can be used to uniquely identify and quantify the materials within the sample/object under study.

It is the intention in this presentation to overview the diffraction based imaging methods, showing what information can be yielded and the current limitations of these methods. This will include a discussion of the use of both angle- and energy-dispersive diffraction as techniques to image samples. The latter, for example, offering an abundance of useful scattering information in addition to the diffraction signal, that can be used to identify and map non-crystalline materials. The application of these types of imaging will be discussed with examples in the study of both static and dynamic systems. This will include recent results obtained from the studies of the preparation and operation of supported catalysts. Finally, future prospects and opportunities will be discussed.

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