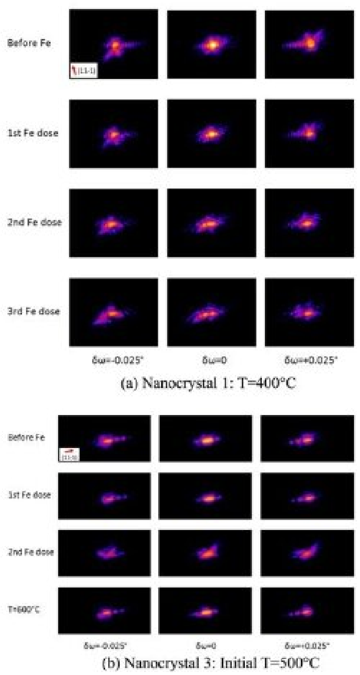
A novel synchrotron technique for studying diffusion in solids

24 May 2019



Changes in the diffraction pattern of the nanocrystals after iron deposition. Credit: Ana Katrina C Estandarte et al 2018 *New J. Phys*. 20 113026.

Understanding and controlling how the diffusion process works at the atomic scale is an important question in the synthesis of materials. For nanoparticles, the stability, size, structure, composition, and atomic ordering are all dependent on position inside the particle, and diffusion both affects all of these properties and is affected by them. A more thorough understanding of the mechanisms and effects of diffusion in nanocrystals will help to develop controlled synthesis methods to obtain the particular properties; however, conventional methods for studying diffusion in solids all have limitations.

Given the need for imaging techniques that are sensitive to slower dynamics and allow the diffusion behaviour in individual nanocrystals to be investigated at the atomic scale and in three dimensions (3-D), a team of researchers used the strain sensitivity of Bragg coherent diffraction imaging (BCDI) to study the diffusion of iron into individual gold nanocrystals in situ at elevated temperatures. Their work was recently published in the *New Journal of Physics*.

Measuring diffusion in solids

Direct methods for studying diffusion in solids (such as mechanical and sputter profiling, secondary ion mass spectrometry, and electron microprobe analysis) provide only a macroscopic quantity, the diffusion coefficient. Indirect methods (such as quasielastic neutron spectroscopy and Mössbauer spectroscopy) can provide microscopic information on the diffusion process, but are limited to a narrow number of isotopes and relatively fast diffusivity values. Existing methods for diffusion studies in solids also tend to average signals over a number of structures, but in nanocrystals sample heterogeneity is significant and can affect results. Transmission electron microscopy (TEM) allows diffusion to be studied in individual nanoparticles, but is limited to thin samples (