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Synchrotoron X-ray micro- and nanotomography

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Summary

The technique for measuring the spatial distribution of the X-ray attenuation coefficient is known as computed tomography. As is well known, the tomographic technique has been employed in industry as well as medical diagnostic imaging. Meanwhile, third-generation synchrotron radiation (SR) facilities, such as the ESRF and SPring-8, have been identified as ideal X-ray sources for the tomography, providing a high-energy X-ray beam with excellent lateral coherence and monochromaticity. Micro- and nanotomography performed using SR facilities has enabled the reconstruction of volumes with a maximum spatial resolution of about a few hundredth of a micrometer to several micrometer. Thanks to recent advances in the Synchrotoron X-ray micro- and nanotomography, encouraging experiments have been conducted within the hard X-ray region, demonstrating 3-D images of internal microstructure and fabrication defects in light materials such as light metals. Especially, 4-D (i.e. 3-D + time) imaging has been demonstrated as a robust tool for the materials science and medical applications. In-situ 3-D observation of fracture and fatigue, and the visualization of microstructural change during materials processing are typical examples. We also have some attempts to investigate the feasibility of applying the 3-D imaging technique to image-based numerical simulation. The micro- and nanotomography also has a unique possibility to extract internal information in 3D/4D. For example, we have clarified that internal mechanical quantities, such as strain, displacement, crack driving forces, are measured as a form of 3-D high density mapping by tracking internal microstructural features with loading. The measurement techniques are clearly advantageous compared to quite limited procedures to measure internal mechanical quantities in the current literature and indispensable to check the validity of the above-mentioned image-based numerical simulations. Overall, high resolution synchrotron X-ray micro- and nanotomography offers a highly effective way of assessing various issues in materials science and engineering.