Powder diffraction-based microtomography for depicting phase distributions in bulk materials

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Hard X-ray full-field microtomography (µCT) is frequently applied in materials research due to its excellent capabilities for depicting the internal morphology of a specimen. Specially by employing synchrotron radiation for µCT, an outstanding sensitivity can be achieved. Recently, the combination of scanning CT schemes with powder diffraction-based information allowed for extending tomographic contrast (XRD-µCT), so as to depict spatial phase distributions on one reconstruction slice [1, 2]. We used the so-called micro- and nano-branches of the ID22 beamline (European Synchrotron Radiation Facility [3]) to apply XRD-µCT in combination with full-field µCT schemes to selected problems from materials research which have so far not been accessible with µCT alone. Data processing was performed using the free software package XRDUA [4].

The presentation highlights developments in terms of the instrumentation as well as scientific results: one of them being mechanically triggered phase transformations like in zirconia-based dental prostheses, induced, e. g., by clinically practised surface manipulations. They are of high clinical relevance due to their significant influence on the failure behaviour of the latter. All the methods applied so far were essentially surface-probing in nature. By using XRD-µCT it was for the first time possible to visualize and quantify the depth of the transformation layer [5]. A different topic requiring XRD-µCT is the potential of heat-treated TiH_2 powder for metal foam production: it requires knowledge on the spatial distributions of crystalline phases within the micrometer-sized powder particles. XRD-µCT performed using a nano-focused beam reveals that these distributions tend to be very irregular. Hence, the aimed shift of hydrogen release into the melting range of the foaming metal alloy cannot be explained by simple core-shell models [6]. Very similar, studying the interaction layer of novel low enriched nuclear fuel particles (UMo fissile particles dispersed in an Al matrix) requires XRD-µCT as the only contrast accessible is between the different crystalline phases [7].

The combination of full-field µCT with XRD-µCT on the very same sample allows for monitoring the evolution of a microstructure and its phase transformation in an in-situ environment. This operating mode was used to map the spatial distribution of the phases present in complex systems such as Portland cement. Based on this data, estimation of the phase contents with spatial resolution is done [8].

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