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SIMULTANEOUS 4D X-RAY RADIOSCOPY/TOMOGRAPHY AND ENERGY DISPERSIVE DIFFRACTION AT THE EDDI BEAMLINE

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Summary: An X-ray tomography with simultaneous energy dispersive diffraction setup was developed and implemented at the EDDI beamline, Bessy II, Berlin. As an example of the potential of the system we present different case studies such as the evolution of evolving liquid AlMg15Cu10 foam, the foaming behaviour of AlSn3Co3 + 1wt.%TiH_2 or the morphological evolution of operating batteries.

1. INTRODUCTION

Time resolved in-situ tomography, also called 4D tomography, is gaining interest at different beamlines [1-5]. In addition, the combination of fast in-situ tomography with simultaneous diffraction is highly demanded and specially appreciated in cases where structural or morphological changes are correlated with chemical reactions or phase transformations, e.g. in the course of temperature variations. Our previous work showed already that our unique facility at EDDI, Bessy II, Berlin is well suited for time-resolved in-situ diffraction experiments combined with fast imaging, i.e. for recording a tomography and simultaneously a diffraction pattern [6].

2. EXPERIMENTAL METHOD

We present and updated setup at the EDDI beamline, Bessy II, Berlin, Germany for 4D radioscopy or tomography with simultaneous energy dispersive diffraction. The system can achieve a time resolution of 0.25 s (4 Hz) for tomography and of 1 s (1 Hz) for diffraction simultaneously. The spatial resolution of 3 µm pixel-size and the field of view of 2 mm × 4 mm was found to be sufficient for most of the cases studied. The sample environment composed of contactless IR heating lamps or resistive ceramic plates allows for heating the samples up to 800 °C and measuring the temperature in the sample with a rotating thermocouple. The whole rotation stage can be tilted by 90° in chi, allowing all degrees of freedom of the 5-axis diffractometer. Additionally a perpendicularly placed camera can record macroscopic morphological changes like foam expansion.

3. RESULTS

The upgrade of the EDDI beamline allows now for up to 4 Hz tomography and 1 Hz full diffraction patterns simultaneously. For the first time the phase transformation of foaming AlMg15Cu10 is monitored in-situ and simultaneously with the 4D tomographic analysis of the evolving liquid foam structure. The development of the Al(111) lattice parameter, expansion, porosity and relative density clearly shows overall relationships, closely related to temperature control and phase composition. Further case studies of the dependence between macrostructure development and phase transformations acting during the processes will be presented like the foaming behaviour of AlSn3Co3 + 1wt.%TiH_2 or the structural changes during charging and discharging of Li-based batteries.

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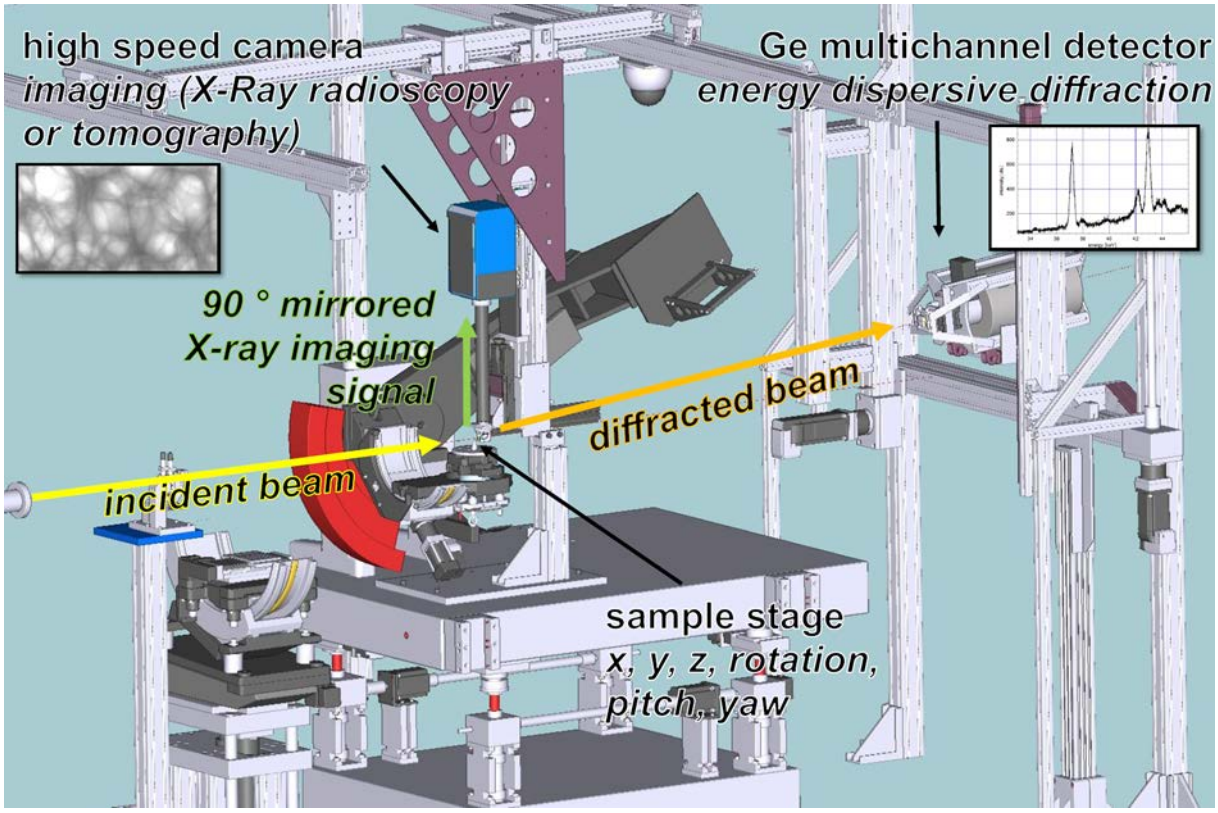

Figure 1: Overview of the instrumentation at the EDDI beamline, Bessy II, Berlin. The setup for simultaneous X-ray radioscopy/tomography with energy dispersive diffraction is composed mainly of a diffractometer and a high speed camera. The yellow line depicts the incident, the green one the transmitted and the orange one the diffracted beam. The insets shows a radiography of a liquid metallic foam (left) and the corresponding diffraction pattern (right).