X-ray Tomoscopy: Time-resolved Microtomography for Materials Science

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Time-resolved in-situ and operando microtomography is increasingly moving into the focus of materials research. Recent improvements in temporal and spatial resolution allow for detailed image analyses of fast phenomena and processes in 4D. The work was performed at our own facility at the EDDI beamline, Bessy II, Berlin, Germany as well as at the TOMCAT beamline, Swiss Light Source, Villigen, Switzerland. The setup and sample environment are composed of a fast and precise rotating stage and contactless IR heating of X-ray transparent crucibles made, e.g., of boron nitride, into which samples are placed. We applied X-ray tomoscopy with acquisition rates of 25 up to 1000 tomograms per second and spatial resolutions in the micrometer range [1-3]. We show how such approach can be combined with simultaneous energy-dispersive diffraction, which is of special interest in cases where structural or morphological changes are correlated with chemical reactions or phase transformations.

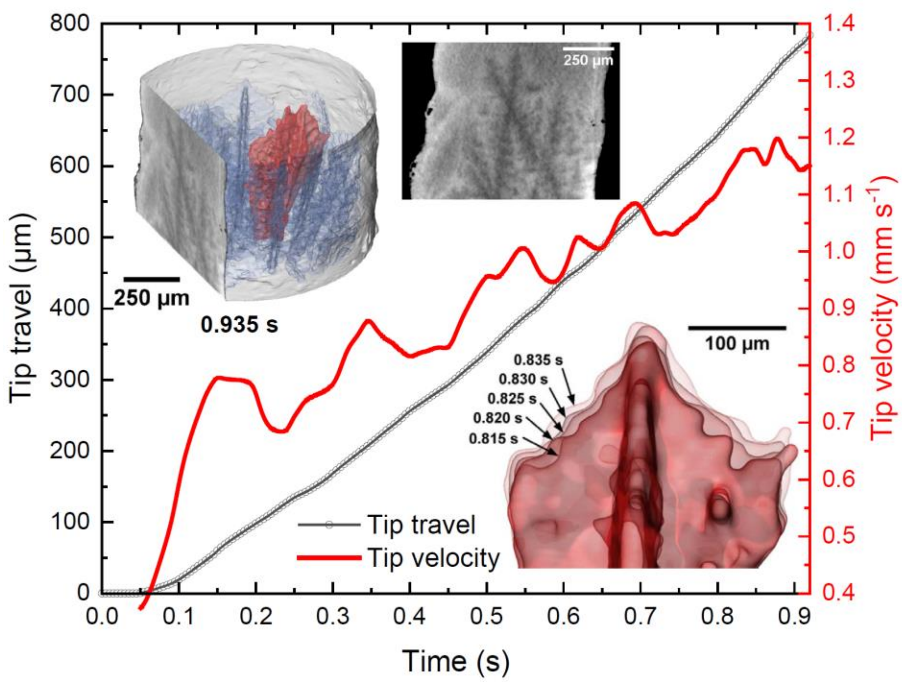

Figure 1. Evolution of aluminum dendrites in AlGe10 alloy during solidification at a cooling rate of 17 K s−1 and recorded continuously at 200 tps during a period of 60 s [3].

Some recent results and case studies will be presented, including: (i) The immiscible hypermonotectic reaction of AlBi10 (in wt%) alloy. (ii) Dendrite evolution in AlGe10 (in wt%) casting alloy during fast solidification (Figure 1) [3]. (iii) The combustion process and the evolution of the constituents in a burning sparkler. (iv) Process phenomena and interaction between laser beam and metal during laser welding and additive manufacturing of metals. (v) Analyses of the evolution of the structure and density of liquid metal foams, where knowledge about the mechanisms of bubble formation, growth and ageing over a long period of time are gained and quantitative analyses of bubble parameters with millisecond temporal resolution can be derived (Figure 2) [3].

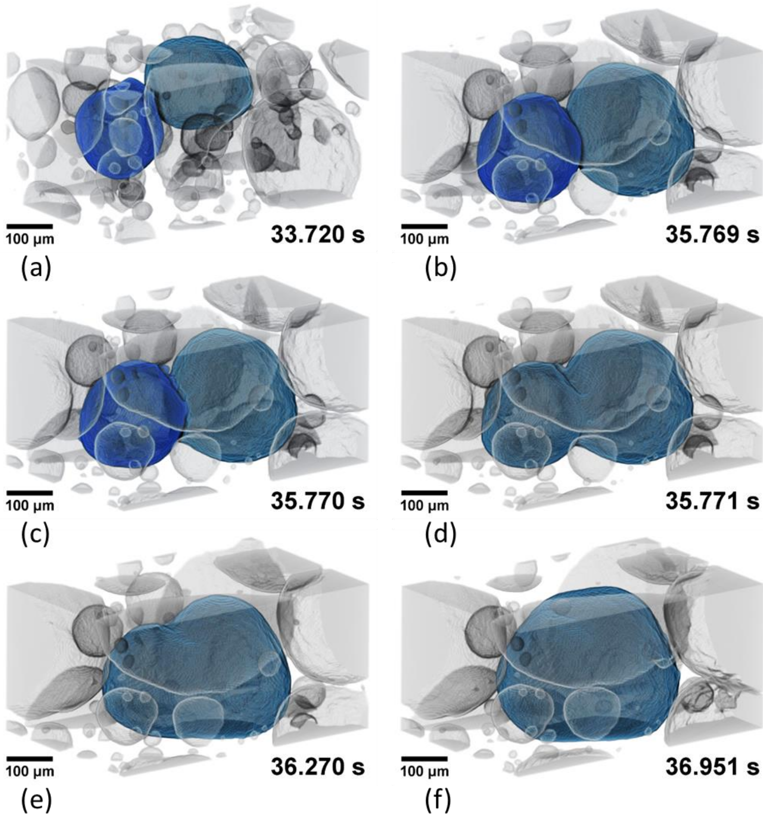

Figure 2. 3D rendering of the gas bubble arrangement in a liquid AlSi8Mg4 foam recorded with 1000 tomograms per second. The metallic matrix is kept transparent and the bubbles are colored (inverted contrast). a) Two separated bubbles marked in cyan and blue. b–d) 3D sequence of the rupture of the separating film in just <1 ms followed by the coalescence of the two bubbles to one. e,f) Relaxation of the resulting bubble by adopting a more spherical shape in the next ≈1.2 s [3].

References:

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