On the analysis of spatial correlations in multi-constituent specimens using synchrotron microtomography and 3D image analysis

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We investigate spatial cross-correlations between two constituents, both belonging to the same microstructure. These investigations are based on two approaches: one via the measurement of the cross-correlation function while the second estimates the probability density function of the distribution of spatial distances between the constituents. The cross-correlation function can be measured using the fast Fourier transform, while the probability density function of the distances is estimated via the Euclidean distance transform [1, 2].

The characteristics are derived from volume images contrasting different material phases obtained by synchrotron microtomography. The use of synchrotron radiation for imaging allows one to work with high resolutions, a low noise-level and employing different contrast modes besides the absorption contrast (which is sensitive to the local density and atomic number of the constituents) like holotomography (sensitve to the local electron density), fluorescence tomography (showing the chemical species distribution inside the sample), refraction enhanced tomography (reveals inner surfaces and interfaces) or topo-tomography (displays local crystalline lattice quality) [3]. Ideal conditions to apply subsequently a 3d image analysis.

As an example application we consider pore formation in metallic foams which are produced using the powder-metallurgical route: an alloy (e. g. AW-6061) to be foamed in powder form is mixed with a blowing agent (e. g. TiH_2) and then compacted in order to create a solid pre-cursor material. The pre-cursor is heated in a furnace. In an ideal case at the same point where the alloy transforms from solid into a mushy state the blowing agent starts to release gas which forms the pores. Quenching of the sample at the desired expansion state conserves the pore structure, resulting in a metallic foam with high specific stiffness, low density and weight but with very good energy absorbing and damping qualities.

Knowledge about the pore nucleation in early foaming stages is important to control the foam production process [4]. For this example we discuss the spatial cross-correlation between the pore space and the blowing agent particles in detail. The application of both approaches shows a re-organisation of the spatial correlation between pores and the blowing agent's particles during the early foaming process [1].

References

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