Analysis of spatial correlations in metal foams using synchrotron micro-tomography and 3D image analysis

by Alexander Rack, L. Helfen, T. Baumbach, J. Banhart, K. Schladitz, J. Ohser

European Synchrotron Radiaton Facility,
BP220, 38043 Grenoble, France
Email: arack@snafu.de

We investigate spatial cross-correlations in metal foams to understand control mechanisms behind their pore formation. The metal foams are produced using the powdermetallurgical route: an alloy (e. g. AW-6061) to be foamed in powder form is mixed with a blowing agent (e.g. TiH2) 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 metal foam with high specific stiffness, low density and weight but with very good energy absorbing and damping qualities.

The characteristics are derived from volume images contrasting different material phases obtained by synchrotron micro-tomography. The use of synchrotron radiation for imaging allows one to work with high spatial resolution, a low noiselevel 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). Ideal conditions to apply subsequently a 3d image analysis.

Our analysis is 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.

Reference:

A. Rack, L. Helfen, T. Baumbach, S. Kirste, J. Banhart, K. Schladitz, J. Ohser, “Analysis of spatial cross-correlations in multi-constituent volume data”, Journal of Microscopy vol. 232, issue 2, 282-292 (2008)