In-situ and ex-situ micromechanical testing of open-cell metal foams

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Metal foams are cellular materials with structural features resembling to lightweight load-bearing materials such as bones. Their high stiffness-to-weight-ratio coupled with their long flat stress-strain response make them ideal candidates as energy absorbers. Their macroscopic properties are strongly influenced by both the mechanical behaviour of single pores at the mesoscopic level and the struts and their structure at the microscopic length-scale based on a strong structure-property relationship. Whereas macroscopic mechanical characterisation is widespread, micromechanical characterisation and assessment of parameters on single struts is very limited. Micromechanical characterisation of individual struts is very challenging but an emerging field of research. The present contribution deals with the mechanical characterisation of open-cell foams on the meso and micro scale. In-situ and ex-situ micro compression and micro tensile tests respectively were conducted on individual pores as well as individual struts. X-ray computed tomography (CT) and a photogrammetric method were used to create 3D finite element models of the pores as well as the struts in order to perform numerical simulations. Furthermore, in-situ X-ray CT micro tensile tests and ex-situ micro tensile tests were conducted on individual struts. There is a large scattering in the micro material parameters deduced from individual strut. X-ray CT scans during micro tensile testing and ex-situ micro tensile tests performed on struts, where the local microstructure (blowholes, pores, cracks and intermetallic inclusions) was previously determined in CT scans, were performed. The scattering in the material parameters is largely connected to the occurring defects in the microstructure of individual struts.