

STEPHEN HALL

"Quantitative 3D and 4D imaging of material structures and evolution"

X-ray tomography, as a non-destructive 3D imaging technique, has opened up the possibility to follow material evolution in 3D during, for example, mechanical or electro-chemical process. Such 3D+time, i.e., 4D, imaging is becoming increasingly used in various areas of research. Two key components are required in such studies, first an experimental set-up adapted for experiments in-situ in an x-ray tomograph and, second, 4D image processing to extract meaningful information from the time-lapse 3D image sequences. 4D image processing can involve multiple 3D image analyses to characterize certain properties or structures in each image or they can be full 4D analyses of changes from one image to the next. The former could be, for example, determination of porosity at each step to follow its evolution. The latter could be displacement and strain field analyses by Digital Volume Correlation (DVC; also known as 3D Volumetric Digital Image Correlation).

The possibilities for the 4D characterization of material evolution using 4D x-ray tomography and 4D image analysis, including DVC, will be discussed and illustrated using different examples, including one involving the deformation of granular material and another considering the discharge and failure of Si-Li battery cells. In the former, the characterization of structural evolution, including of porosity, grain-contacts and deformation, in terms of continuum strain fields and individual grain kinematics, will be described. For the Si-Li battery cell study, the evolution of the lithiation of the silicon electrode particles during cell discharge is quantified through the change in image intensity, which is correlated with DVC-derived volumetric strain measurements.



Stephen Hall studied Geophysics followed by a PhD on subsurface rock fracture characterisation and seismic anisotropy in Leeds, UK. During his PhD he worked with both Shell, in the Netherlands, and BP, in the USA. He then held a 3.5 year postdoctoral position at Heriot-Watt University, in Edinburgh, working on 4D seismic imaging of hydrocarbon reservoirs. Stephen moved to Grenoble, France, in 2003 where he held a Marie-Curie Individual Fellowship working at Laboratoire 3SR on experimental geomechanics. In 2006 Stephen entered the CNRS, the French national research agency, and continued to work in Grenoble at 3SR. In 2011 Stephen moved to Lund, Sweden, where he now has a senior lecturer position in the Division of Solid Mechanics at the Faculty of Engineering, where he works primarily on experimental geomechanics. Stephen works extensively with x-ray and neutron methods at different large-scale facilities in Europe plus is closely involved in the MAXIV and ESS projects in Lund. In 2013, Stephen gained significant funding from the faculty to purchase a state-of-the-art laboratory x-ray tomograph that is the central part of the 4D Imaging Lab that he runs, working with users from a broad range of research areas.