In-situ 3D Strain Mapping in Engineering Materials with X-ray Computed Tomography

Ercan Cakmak, Maxim Gussev, Singanallur V. Venkatakrishnan and Thomas R. Watkins
Oak Ridge National Laboratory, Oak Ridge TN, USA

With advances in manufacturing technologies, advanced parts with complex geometries (e.g. with numerous internal channels, cavities, insertions of different materials, etc.) can now be easily obtained. In metals, deformation begins elastically, but as yielding occurs transitions to plastic. This transition starts locally and discretely within a few particularly oriented grains and progresses to include a majority of the microstructure under load. Studying these initial local regions of deformation and tracking them is important because controlling this part of deformation impacts the remaining behavior of the entire sample, particularly when the complexity of the part increases.

Laboratory x-ray computed tomography (X-cT) allows convenient and direct observation of internal microstructural features (i.e., internal voids, cracks, sometimes different phases). In contrast to other techniques, X-cT allows 3D imaging of deformation processes and provides an opportunity to quantify strain.

In this work, in-situ loading with X-cT is performed on a set of engineering materials. Digital Volume Correlation is employed to calculate the strain fields acting in the bulk of the specimens. The results are compared to ex-situ analyses employing Digital Image Correlation and also simulations of the same samples with Finite Element Modeling.