Quantitative 3D X-ray imaging of densification, delamination and fracture in a micro-composite under compression - DTU Orbit (06/12/2018)

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Phase-contrast three-dimensional tomograms showing in unprecedented detail the mechanical response of a micro-composite subjected to a mechanical compression test are reported. The X-ray ptychography images reveal the deformation and fracture processes of a 10 μm diameter composite, consisting of a spherical polymer bead coated with a nominally 210 nm metal shell. The beginning delamination of the shell from the core can be directly observed at an engineering strain of a few percent. Pre-existing defects are shown to dictate the deformation behavior of both core and shell. The strain state of the increasingly compressed polymer core is assessed quantitatively through the local densification at sub-micron resolution, supported by finite element analysis. Nanoscale mechanics is of rapidly growing importance in materials science, biotechnology and medicine, and this study demonstrates the use of coherent X-ray microscopy as a powerful tool for in situ studies of the mechanical properties of nanostructured devices, structures, and composites. Ptychographic X-ray microscopy can be used for quantitatively studying the mechanical properties of microscale composites. Phase-contrast three-dimensional tomograms reveal with unprecedented detail the mechanical response, including delamination, densification and fracture, of a polymer-core/silver-shell micro-composite subjected in situ to a mechanical compression test.

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