Coupling of X-ray tomography and DEM for fracture simulation

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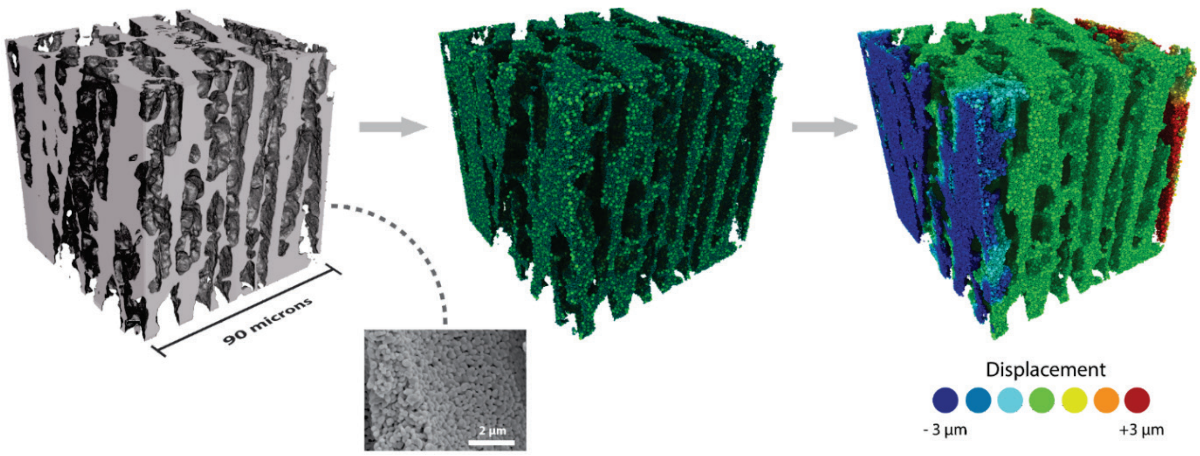
ABSTRACT

We use X-ray nano and micro-tomography reconstructed volumes of porous ceramics to compute their strength with the Discrete Element Method (DEM). Images are obtained with submicronic resolution to provide a realistic initial microstructure for the simulations. Classically, thermal conductivity, elasticity and elastic limit can be calculated from 3D images of real microstructures by using Finite Element Methods (FEM). Fracture involves significant local topological modifications (crack branching, bifurcation, or healing) that are challenging to apprehend with FEM. Particles based methods are an interesting alternative since the topological modifications that come with fracture are easier to capture. Because ceramics are processed from powders, they keep a clear signature of their initial particulate nature even when sintered at high temperature. Thus, particles implemented in the DEM attempt to simulate real particles of the ceramic. Two examples illustrate the approach, involving both experiments and numerical simulations. For porous ceramics dedicated to cathode applications, the effect of macro-pore anisotropy is investigated on volumes approximately 90 µm3 in size (Figure) [1]. The second example involves porous sub-millimetric microspheres in which internal defects were evidenced by tomography. In both cases, the numerical samples were crushed uniaxially using DEM with appropriate microscopic fracture properties taking into account the elastic-brittle nature of the sintered bridge between particles. Considerations on the importance of the numerical sample volume are discussed, with regards to comparison with experiments.



From an X-ray tomography reconstructed volume to a DEM simulation of crushing strength.

REFERENCES

[1] D. Roussel, A. Lichtner, D. Jauffrès, J. Villanova, R.K. Bordia, and C.L. Martin, “Strength of hierarchically porous ceramics : discrete simulations on X-ray nanotomography images,” Scr. Mater., 113 250–253 (2016).