KTH SOLID MECHANICS SEMINAR; Thursday, February 12th, 15.15; KTH Solid Mechanics Seminar room

Christophe L. Martin "Mechanics of Materials with Discrete Element Simulations"

The modeling of processes involving particulate media (typically metallic, ceramic or polymeric powders for engineering applications) needs taking into account the particulate nature of the materials involved. The Discrete Element Method (DEM) is well suited for such a task. It allows the macroscopic behavior of an assembly of particles to be calculated from the contact forces generated between each particle. We will show also that the framework of granular models can be used for more general applications than only particulate materials. Indeed, granular type models can be used to simulate very efficiently fracture and crack propagation in dense materials. Granular models can also be coupled with spectral analysis to obtain effective properties on sintered materials (electrical or thermal conductivity, …).

The seminar will introduce the basics of the numerical and physical modeling aspects used in DEM. We will show specific examples of applications for materials sciences with the aim of demonstrating the possibility of the method. The contact laws that are necessary to tackle the physical problem will be briefly reviewed for each example. These laws describe the interactions at the contact scale between two particles. They include elasticity, adhesion, plasticity, fracture or rate-dependence.

Using these contact laws, we will show practical examples of DEM simulations on such applications as the compaction of aggregated ceramic powders, the green strength of powder compacts, the sintering of powders at high temperature, and the fracture of porous and dense brittle materials. We will finally show that X-ray tomography observations can be advantageously coupled with DEM simulations to obtain mechanical properties of realistic microstructures.

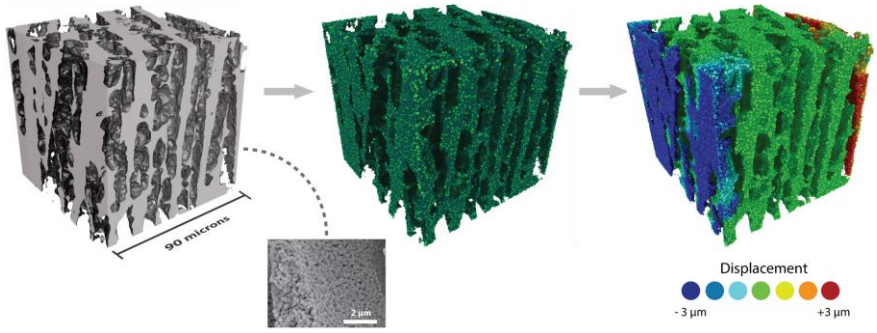

Fig.: An X-ray tomography image of an anisotropic porous ceramic which is meshed with particles and subsequently crushed in the DEM simulation.

Christophe Martin is a CNRS Research Professor at Univ. Grenoble Alpes, SIMAP laboratory in France. He received a M.S. degree in Mechanical Engineering from M.I.T., USA and a PhD from Grenoble INP, France. His research is focused on particulate media, with a particular interest for powders with engineering applications. During a sabbatical year at the University of Kyoto in 2000, he developed with Pr. Shima discrete simulations for metallic powders. Since 2001, he is the principal investigator in the development of a discrete element code, dp3D, dedicated to the processing of powders (compaction and sintering) and to the investigation of the fracture behaviour of brittle materials. In 2006, he spent a sabbatical year at University of Washington where he developed the sintering module of dp3D with Pr. Bordia. The applications of dp3D are mainly on materials for energy applications (nuclear pellets, ceramic electrodes, thermoelectric materials, capacitors), but may also relate to other fields like the densification of snow or the mastication of cellular food. The numerical simulations are coupled and compared as much as possible with experiments such as x-ray tomography.