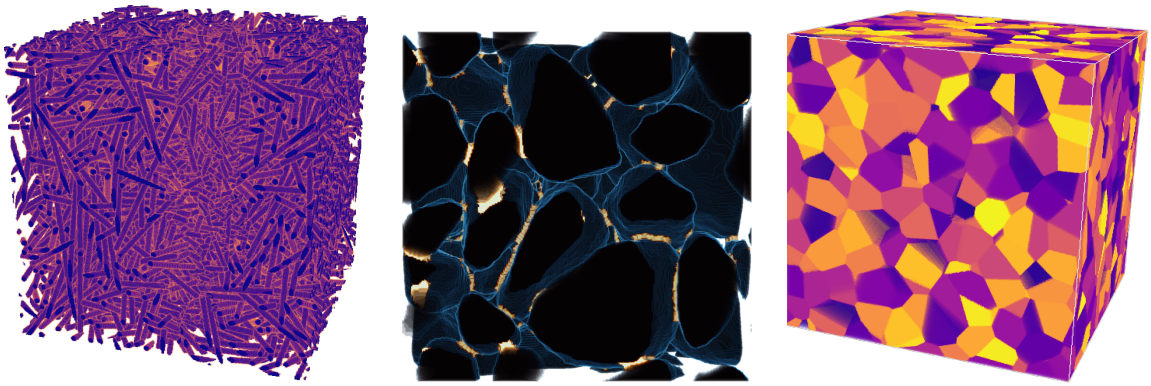
Announcement for the course

Digital Microstructure Characterization and Modeling



Microstructures: short-fiber reinforced thermoplastic (left), inorganically bound sand core (center) and polycrystalline structure typical for metals and alloys (right).

Topic

Microstructured materials – like metals, fiber-reinforced composites, concrete or foams – serve as a driving force for technological advances in industrial applications. Due to their intrinsic heterogeneity and the associated anisotropy, characterizing such materials experimentally may be prohibitively expensive. Modern imaging techniques, in-situ measuring devices and computational homogenization methods permit gaining detailed insights into microstructures and their effective material behavior.

This course provides an introduction to the theory of heterogeneous materials, discusses their characterization (e.g., based on μCT data), presents computationally efficient methods for generating digital microstructure models, and elaborates on specific material classes like porous materials, fiber-reinforced composites and polycrystalline materials.

A variety of different topics will be touched – aspects of materials science, computer science, optimization and statistics play a role.

The associated programming-based exercise sessions will start with an introduction to the programming language Python. Subsequently, participants will implement the microstructure characterization and generation methods from the lectures.

Literature

[1] Torquato, S.: Random Heterogeneous Materials. Springer, New York, 2002.

[2] Ohser, J. und Schladitz, K.: 3D images of Materials Structures. Wiley, Hoboken, 2009.

Schedule and exams

Lectures	Wednesdays, 11:30, 10.81 HS 62
Exercises	Thursdays, 15:45, 10.91 Oberer Hörsaal
Start of lecture	19th April
Exams	Oral
Volume	Lectures 2 SWS, Exercises 2 SWS, 6 LP
Lecture notes	Available on ILIAS
Course language	English or German if preferred
Contact	JProf M. Schneider, MSc A. Mehta

Target audience

This course addresses bachelor and master students with an engineering, mathematical or more general scientific background with an interest in materials. This course is complementary to other events offered at the Institute of Engineering mechanics.

Prerequisites:

All relevant results will be developed during the course.

Content

- Laminate microstructures:

  Analytical solutions for multi-phase laminates; provides a specific example for an interesting class of microstructures

- Digital microstructure characterization:

  intrinsic volumes; n-point correlation functions; reconstruction of μCT data and segmentation; Euclidean distance transform and single-particle segmentation; further geometric invariants

- Generating digital microstructures:

  Why the fuss?; Influence of boundary conditions; pseudo- and quasirandom numbers; sphere-packing algorithms; morphological operations

- Fiber-reinforced composites:

  Fiber-orientation tensors and Folgar-Tucker dynamics; closure approximations; microstructure generation of fiber systems

- Polycrystalline materials:

  Voronoi and Laguerre tessellations; connection to semi-discrete optimal transport; priority queues and descriptions by level-set functions; spatial tree structures in computer science