Additive Manufacturing of open porous structures

Correlation of laboratory testing to simulations for application related properties

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Siemens AG Technology

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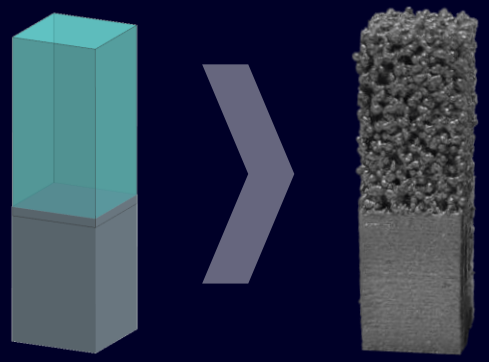
Workflow Additive Manufacturing

PBF-LB

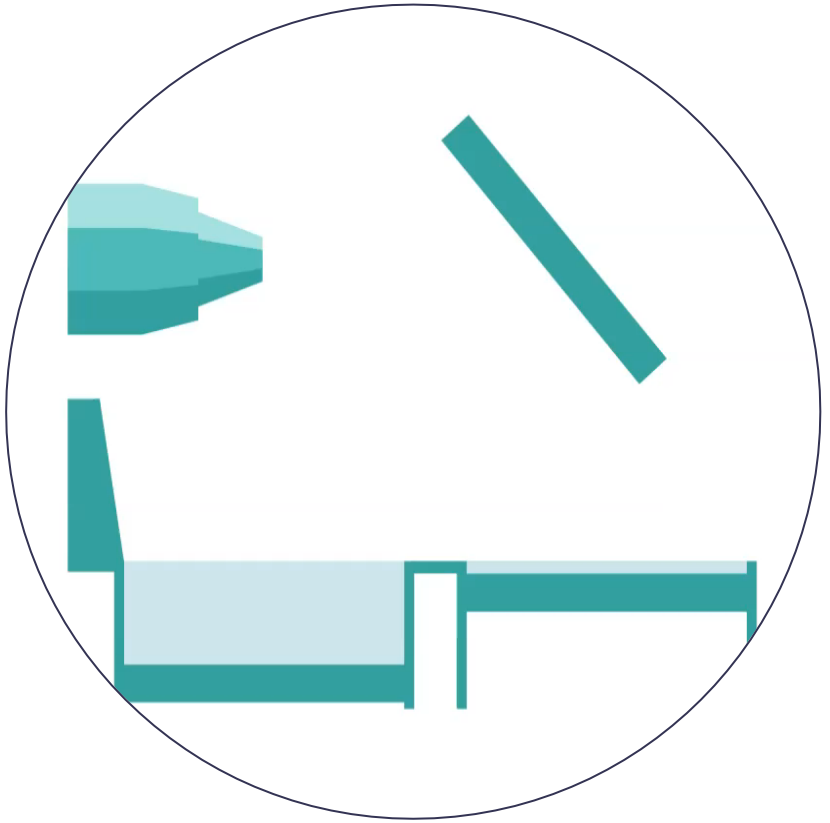


Sample design

Physical sample

Additive Manufacturing of open porosities

Technology: Laser-beam powder bed fusion (PBF-LB)



Animations: Courtesy to Nikolas Witter, DI MC AMF

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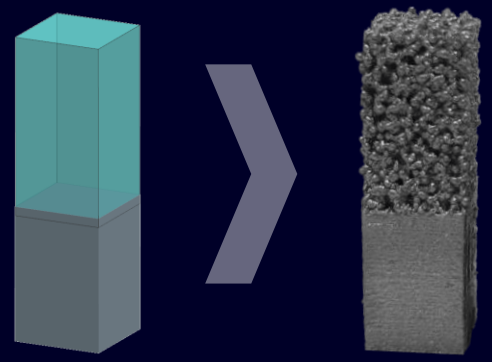
Workflow Additive Manufacturing

PBF-LB



Sample design

Physical sample

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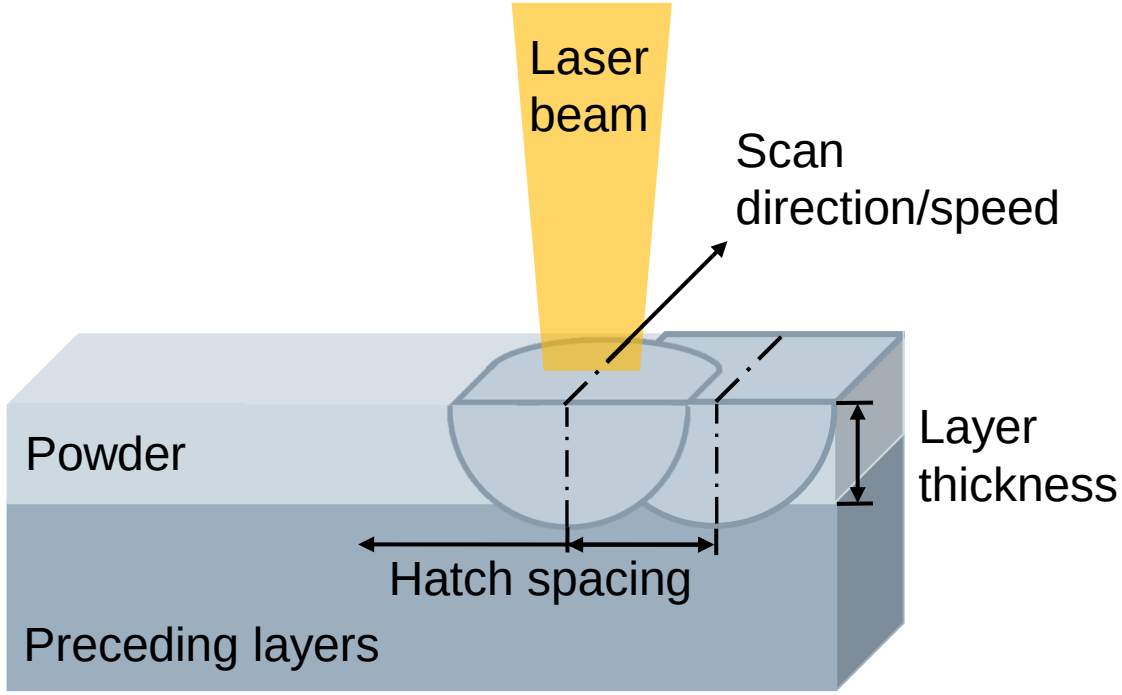
Process parameter:



R. Otto et al., Additive manufacturing of open porous functional structures: roadmap from manufacturing to the application, 15th CIRP CIRP ICME '21 Virtual Conference, Procedia CIRP, Elsevier, ISSN: 2212-8271, (in print), Gulf of Naples, Italy, 2021

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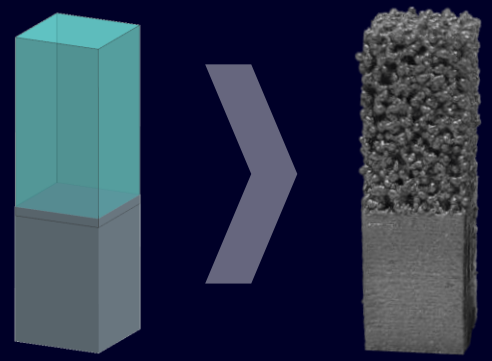

Sample design

Physical sample

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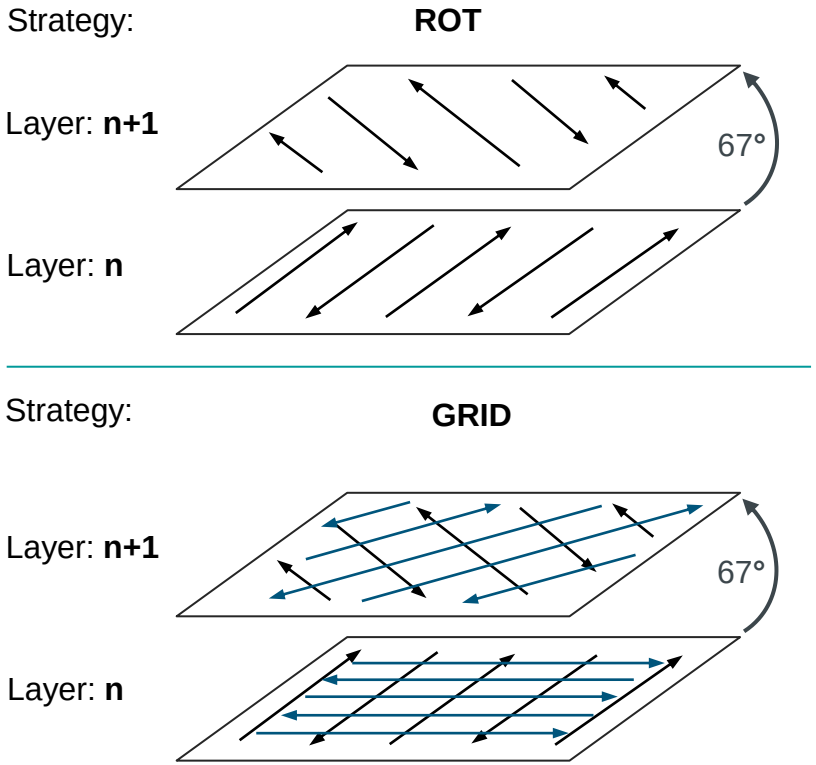
Scan strategies:



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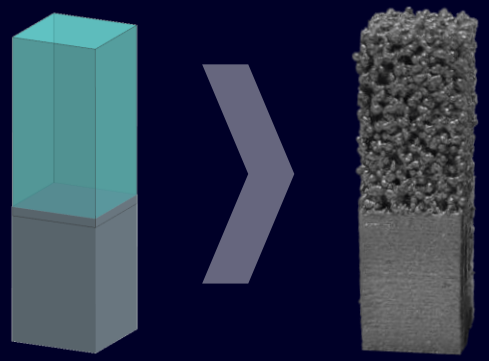
Workflow Laboratory testing

PBF-LB



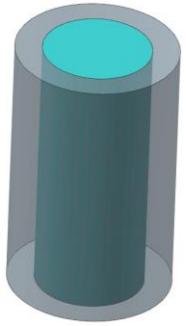
Sample design

Physical sample

Laboratory testing

Property: Permeability

Sample design:



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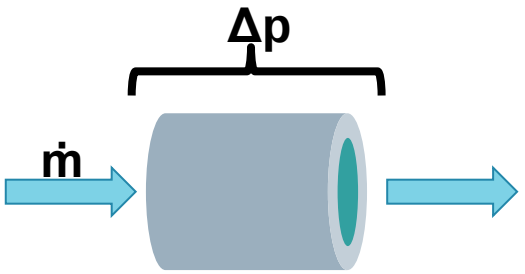

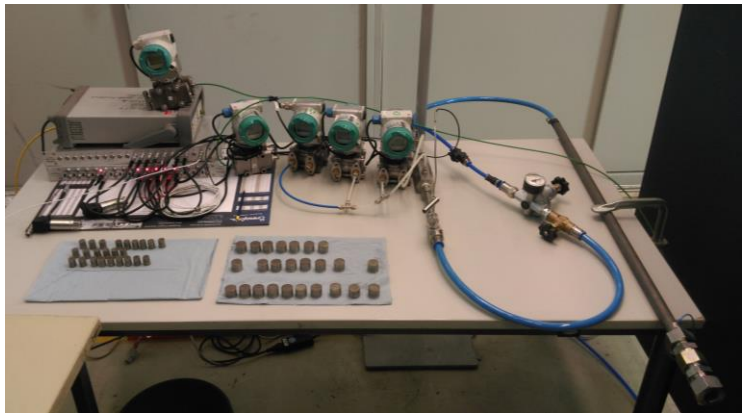

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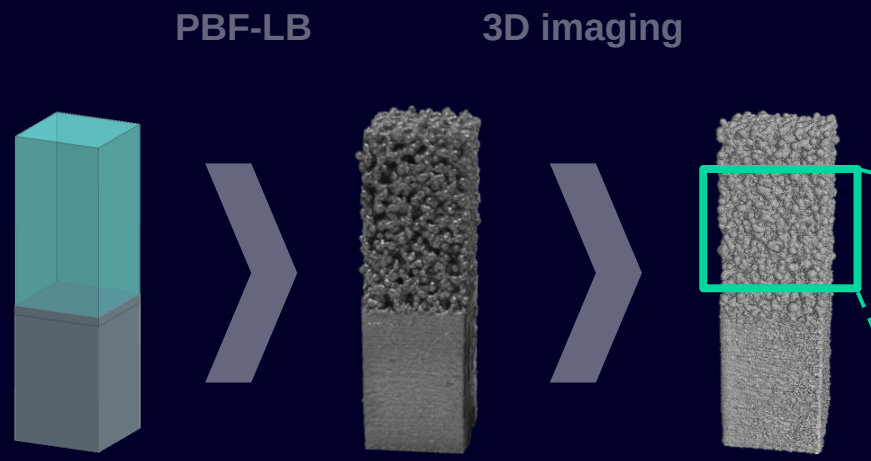
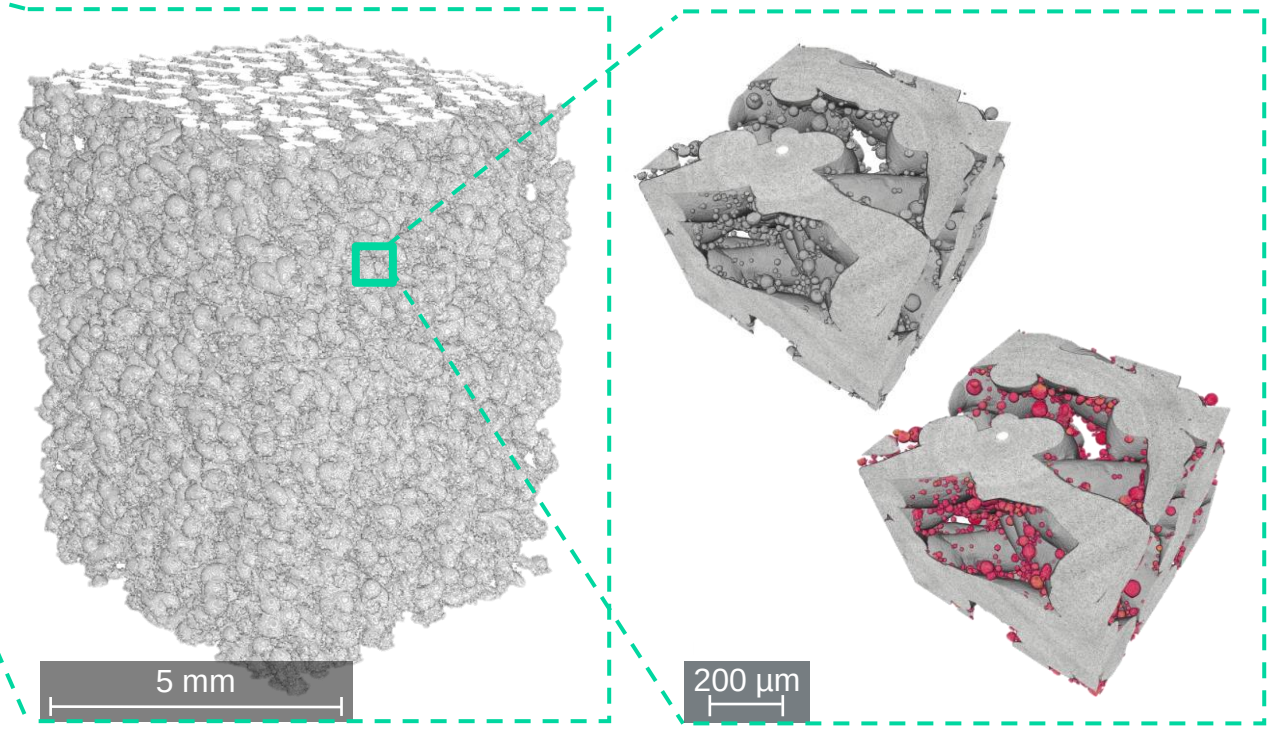
Workflow 3D-imaging



3D-imaging of open porosities

Technology: Synchrotron µ-CT

Feature characterization:



Robert Otto, Knut Sørby, Bernhard Hesse, Javier Gerber, Emely Bortel, Christoph Kiener, Synchrotron µ-CT-based morphological characterization of additively manufactured open porous structures, Additive Manufacturing, 2022, https://doi.org/10.1016/j.addma.2022.102874.

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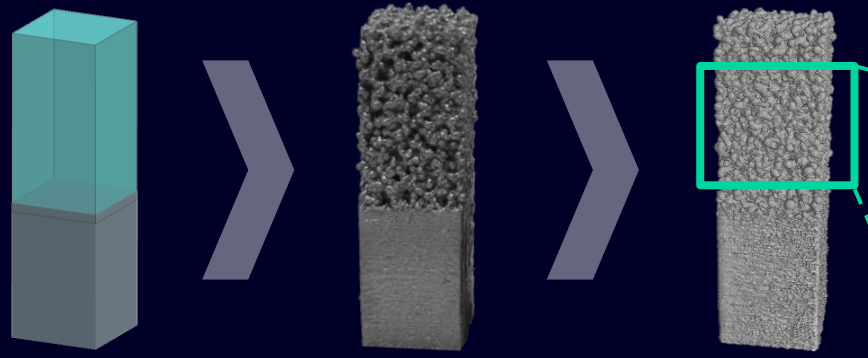
Workflow 3D-imaging

PBF-LB

3D imaging



Sample design

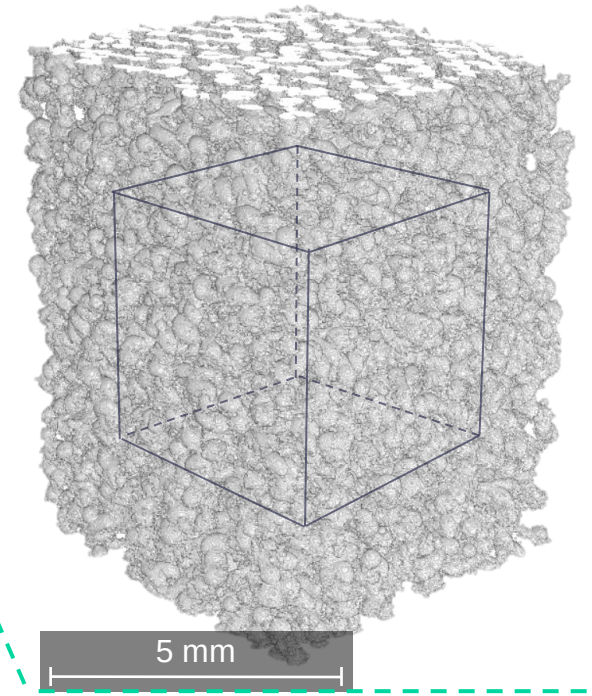
Physical sample

“Digital twin”

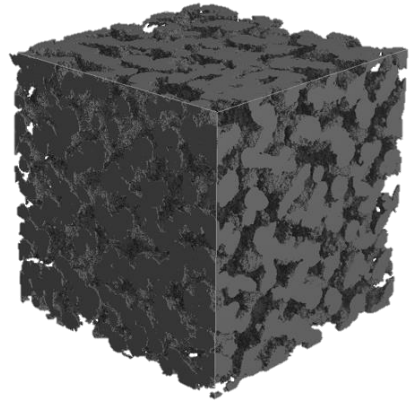
3D-imaging of open porosities

Technology: Synchrotron µ-CT

Simulation of functional properties:



Representative volume:



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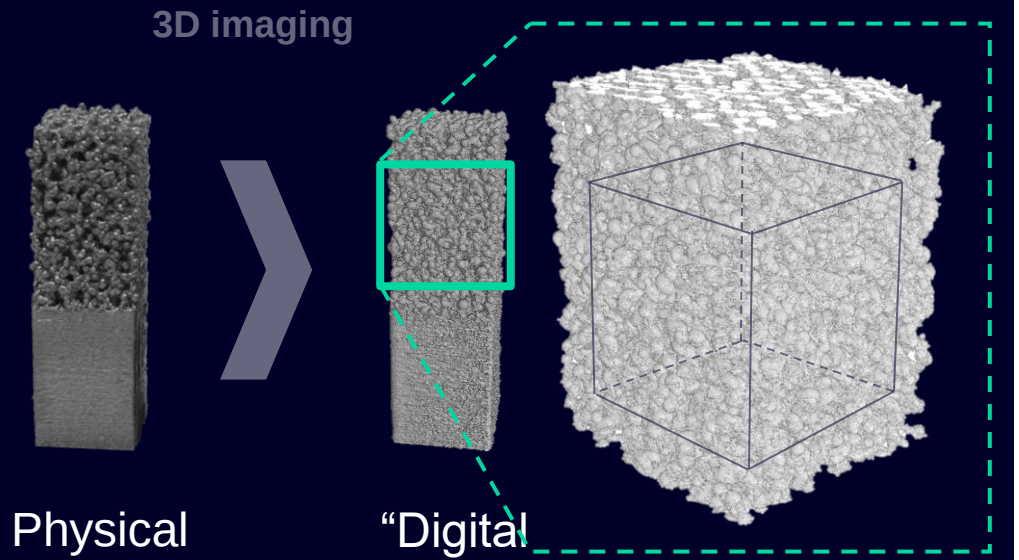
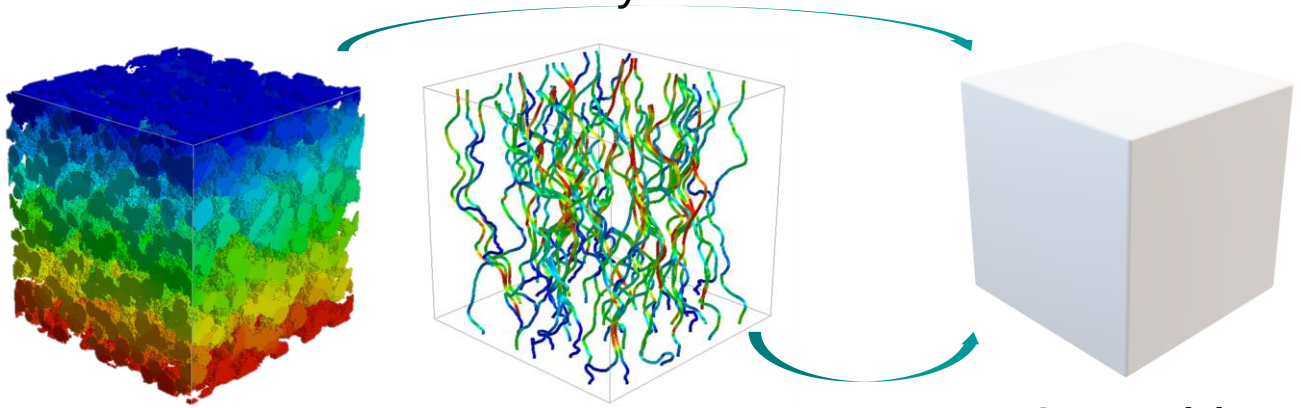
Simulation approaches



Simulation of porous properties

micro-CT based material analysis



Solid state
Heat transfer

Fluid flow
Permeability

CFD Model
w/o real porous geometry

Properties investigation workflow

- Testing of porous samples: pressure losses, thermal conductivity, phase transition and capillary forces
- Simulation of porous samples based on high resolution CAD (x-rays pictures)
- Simulation of porous samples based on models for porous region (real porous geometry is not included in simulation model)

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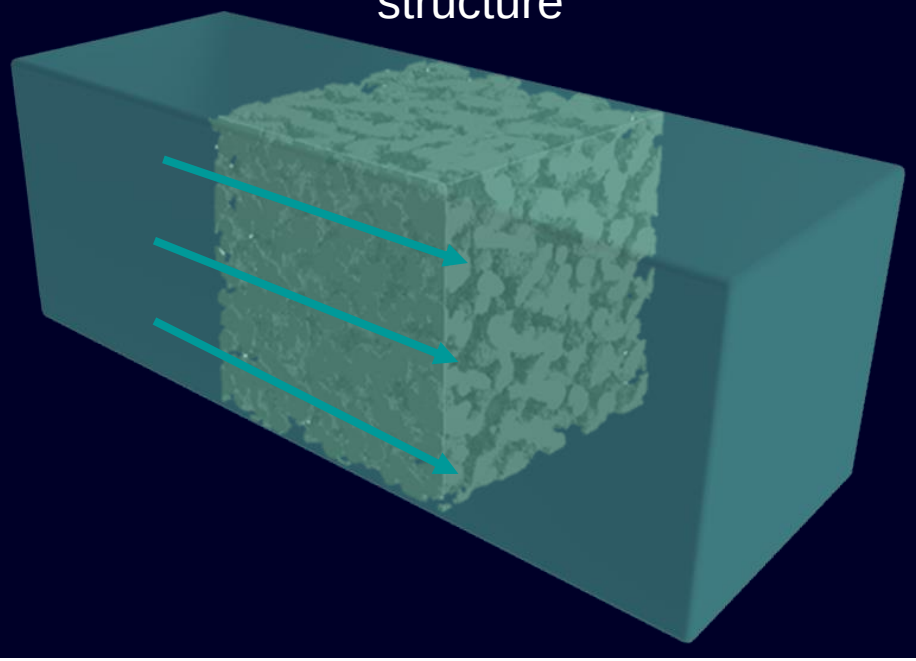
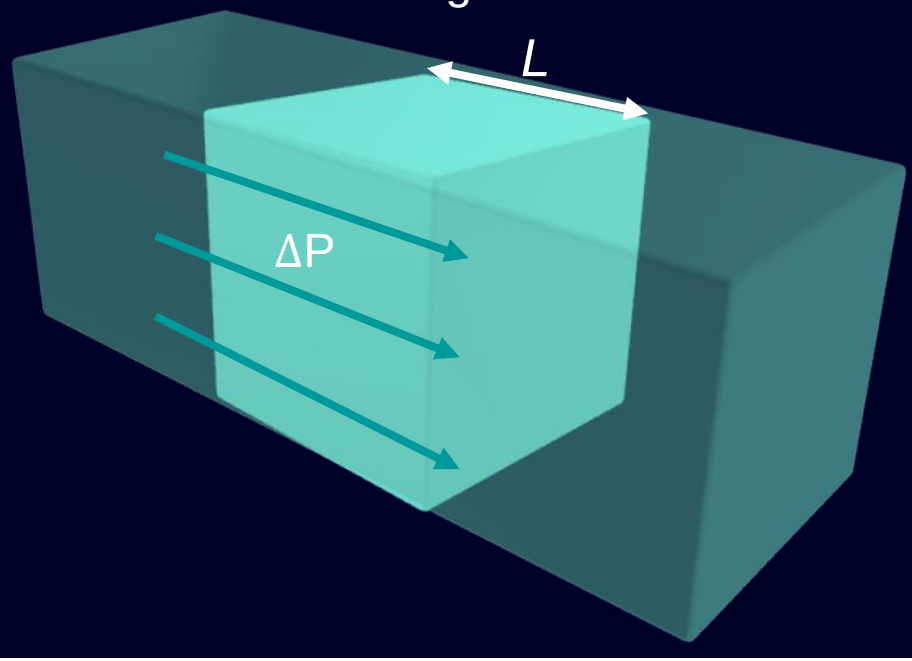
Simulation basics

Flow through real porous structure



Flow through modeled porous region



Navier–Stokes equations for description of flow through porous structure.

Consideration of real porous geometry increases computational efforts

Real porous structure not considered in simulation. Pressure drop and heat flux across porous structure described by **Navier–Stokes equations + equation for pressure drop across porous region**

Darcy-Forchheimer eq. $\frac{\Delta P}{L} = \frac{\mu}{K} v_s + C \rho v_s^2$

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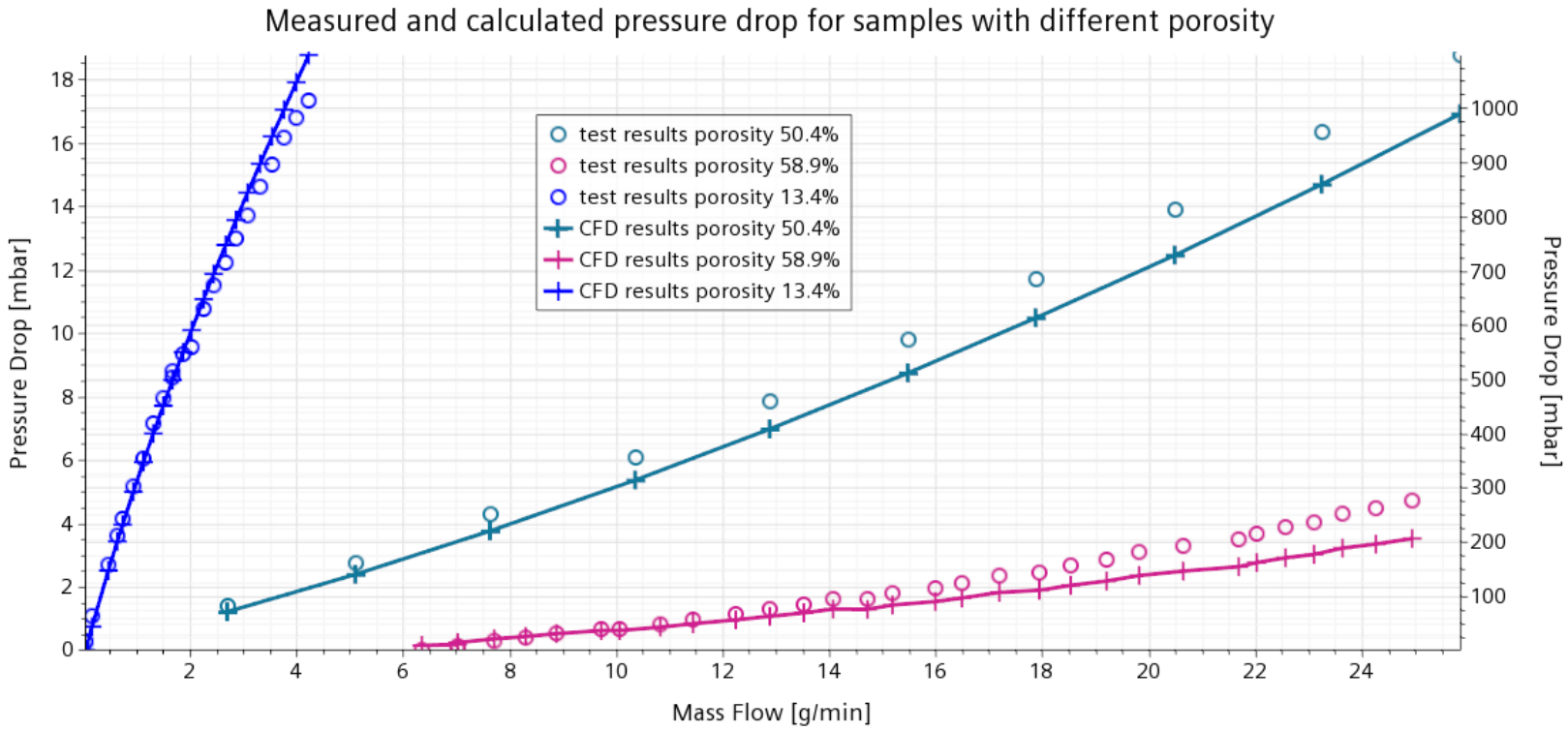
Simulation results – correlation lab. testing



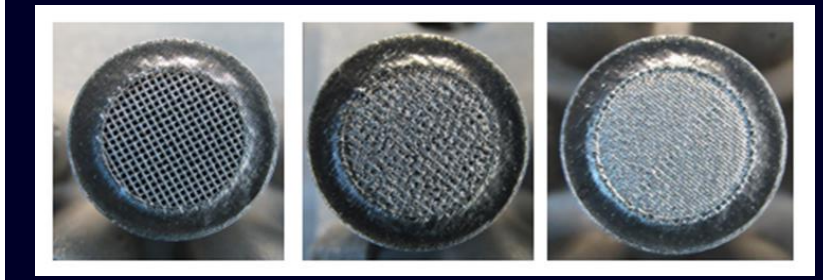
Darcy-Forchheimer eq. - $\frac{\Delta P}{L} = \frac{\mu}{K} v_s + C\rho v_s^2$

Form drag coefficient

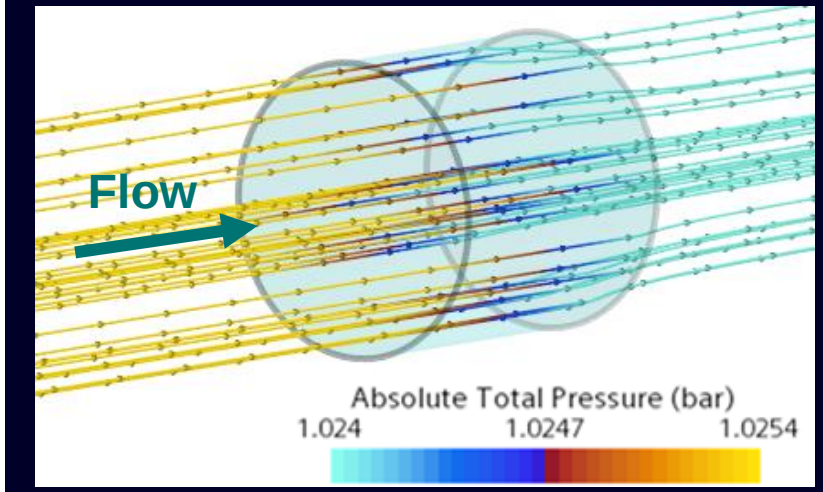
$C = \frac{C_f}{K^n}$

Permeability based on X –ray CT imaging

Physical sample



CFD Model



Contacts

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Thank you for your attention!

Stay tuned!

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