Material Models and Property Prediction based on CT-Scans

3D-IMS, Hourtin, 09.09.2010

Erik Glatt, Stefan Rief and Andreas Wiegmann

Fraunhofer Institute for Industrial Mathematics ITWM

Kaiserslautern, Germany

Fraunhofer ITWM

Introduction

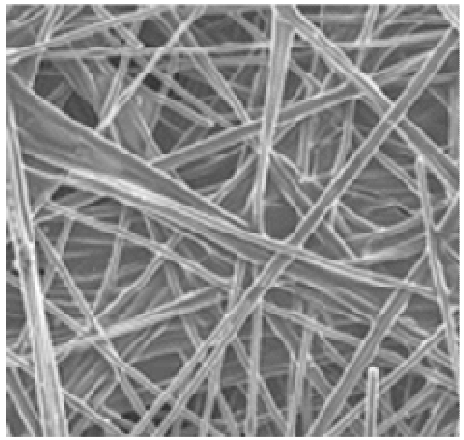
1. General approach to computer aided material engineering

2. Examples
   - Knitted wire meshes
   - Woven metal wire meshes

Aim: Computer Aided Material Engineering

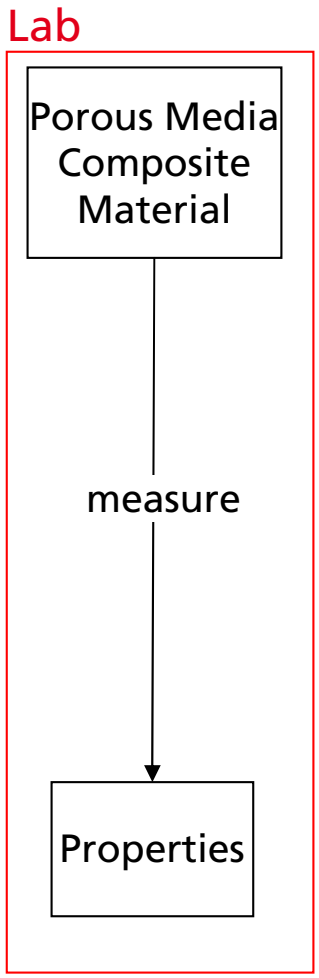
Lab

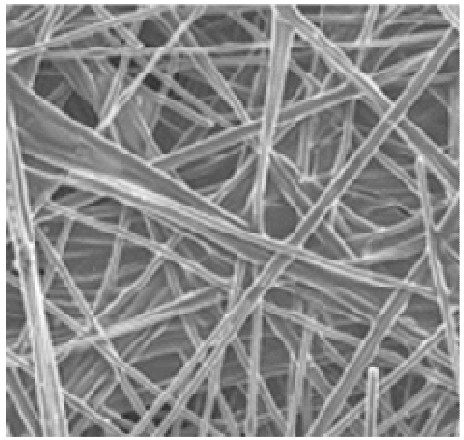
Porous Media Composite Material



Fraunhofer ITWM

Aim: Computer Aided Material Engineering

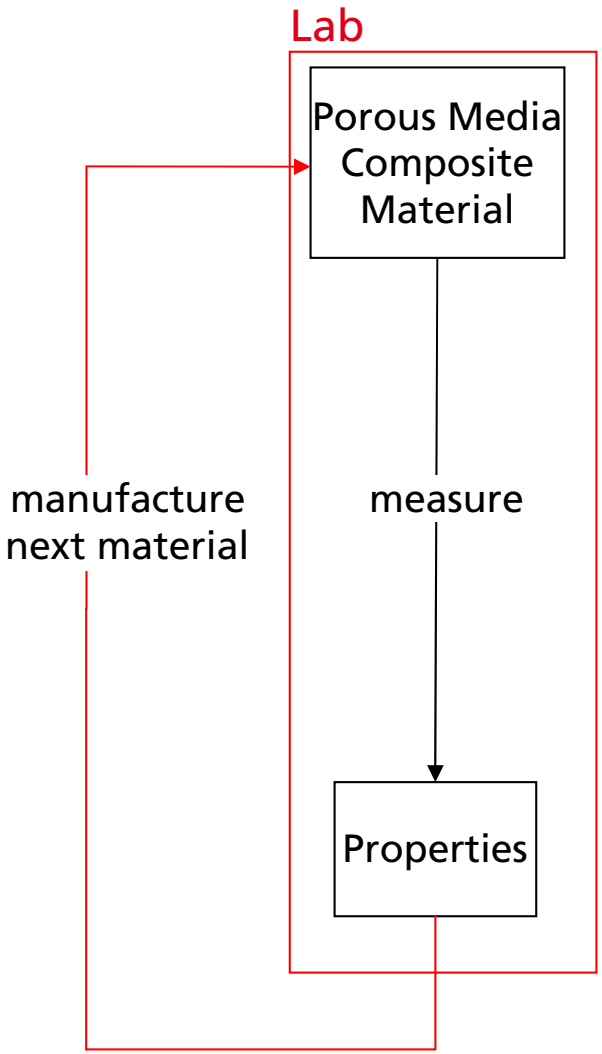


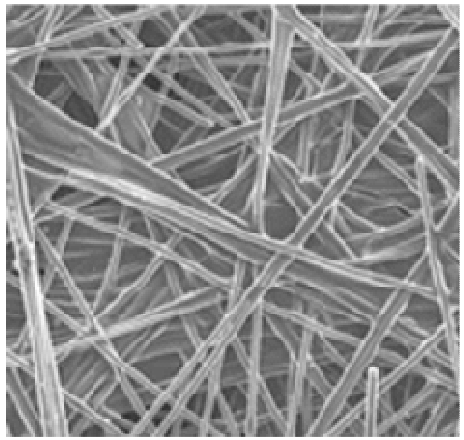


Properties are:
- pore size distribution
- permeability
- diffusivity
- capillary pressure curve
- ...

Fraunhofer ITWM

Aim: Computer Aided Material Engineering

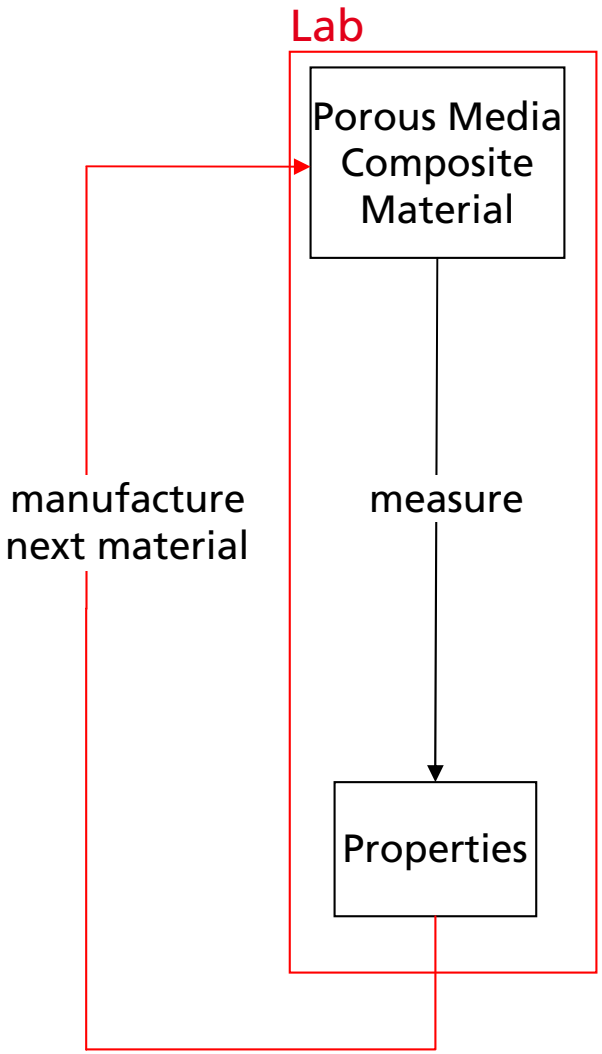




Properties are:
- pore size distribution
- permeability
- diffusivity
- capillary pressure curve
- ...

Fraunhofer ITWM

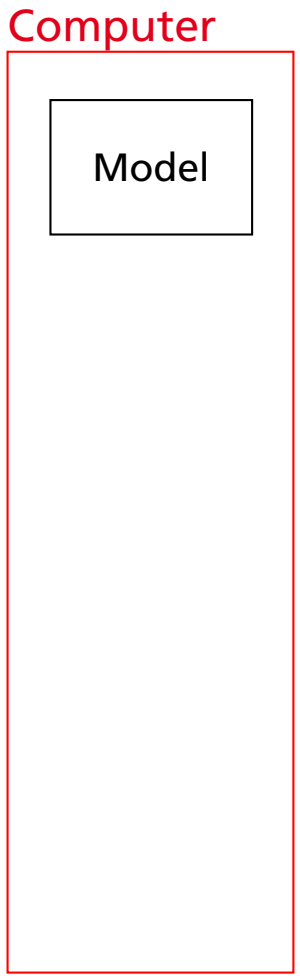
Aim: Computer Aided Material Engineering




```
<Object1>
  Color 2
  NumberOfSegments 1
  <Point1>
    Coordinates 0,0,1
    Radius 0.25
  </Point1>
  <Point2>
    Coordinates -1,0,0
    Radius 0.25
  </Point2>
  RoundedEnd 0
  Type CircularFiber
</Object1>
```

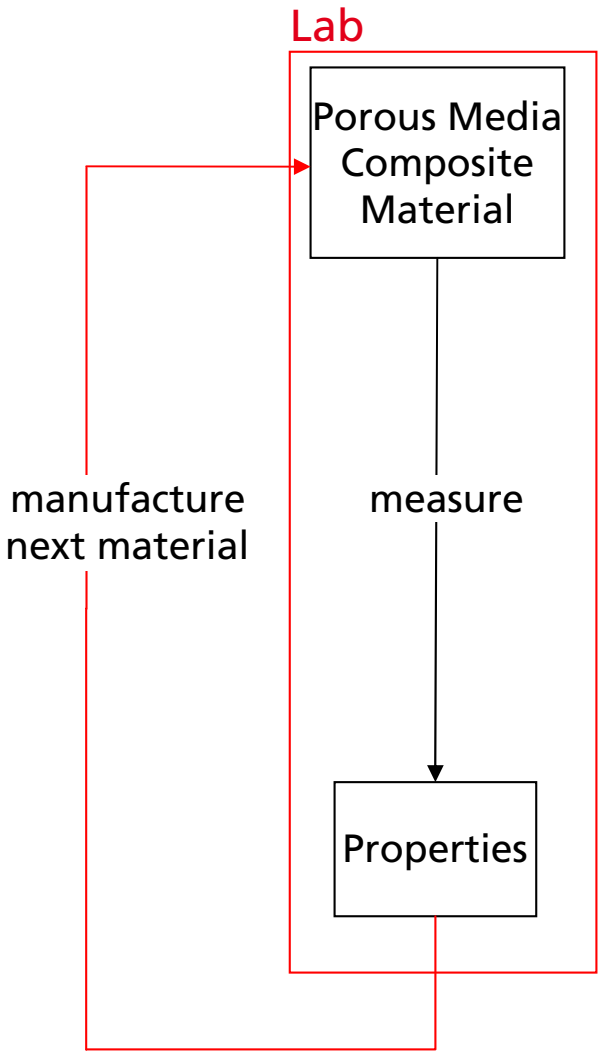
Properties are:

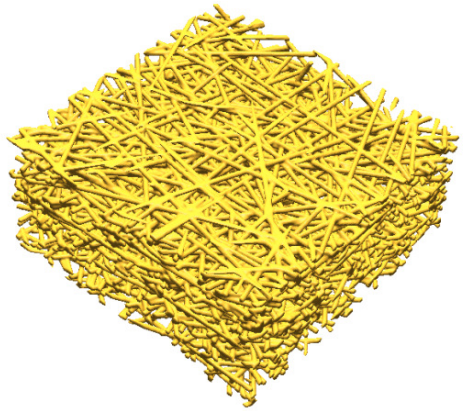
- pore size distribution
- permeability
- diffusivity
- capillary pressure curve
- ...



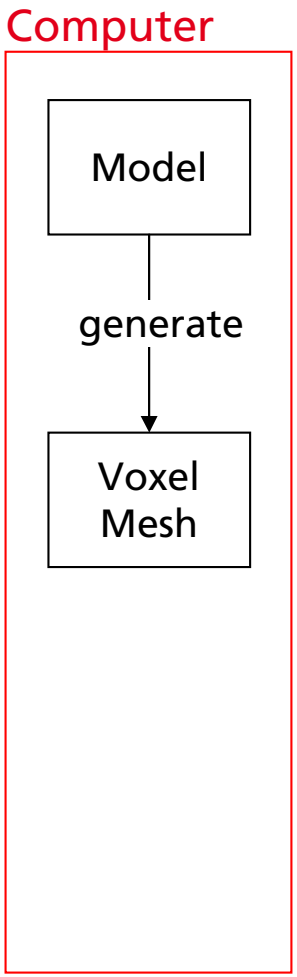
Fraunhofer ITWM

Aim: Computer Aided Material Engineering



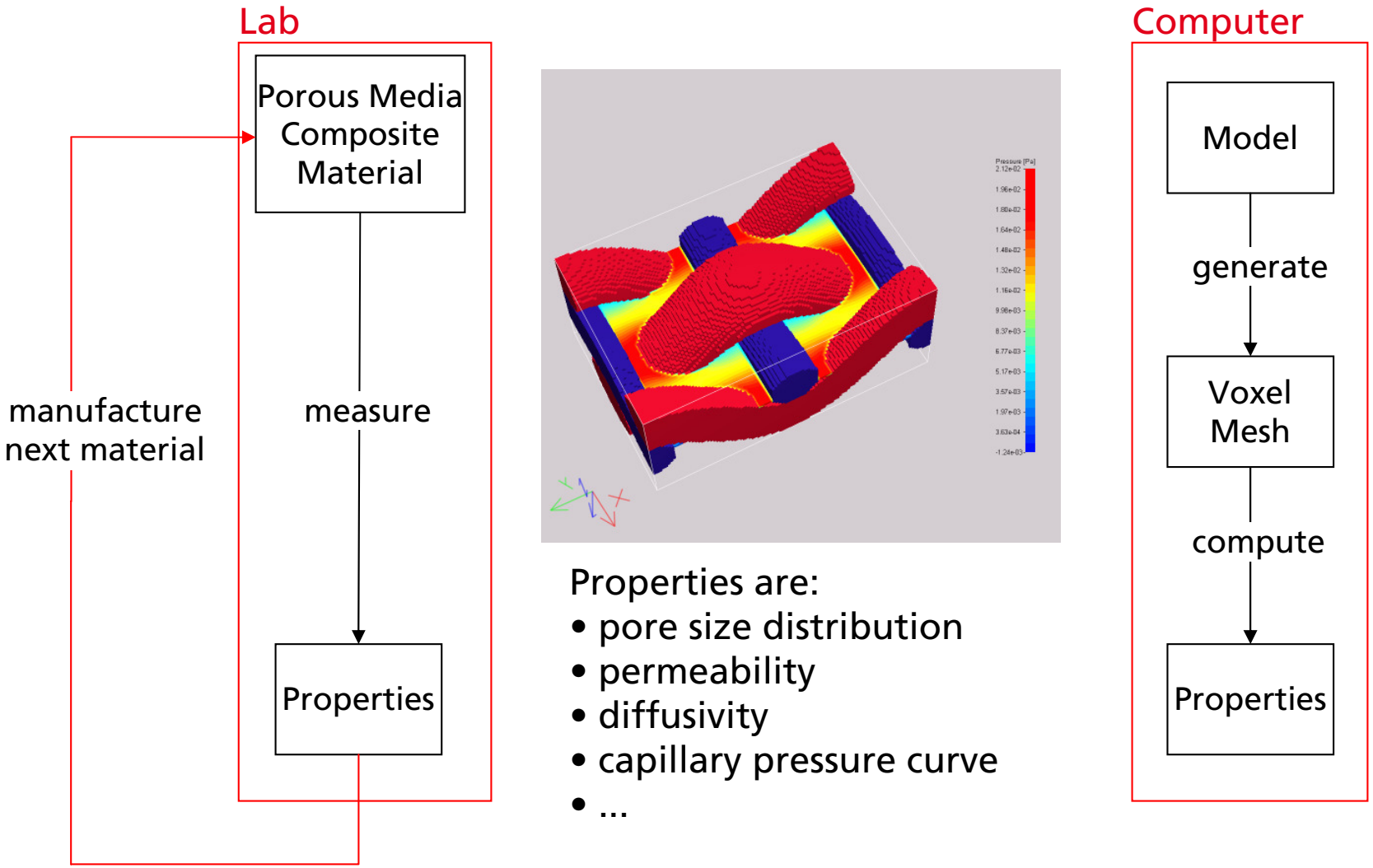


Properties are:
- pore size distribution
- permeability
- diffusivity
- capillary pressure curve
- ...



Fraunhofer ITWM

Aim: Computer Aided Material Engineering

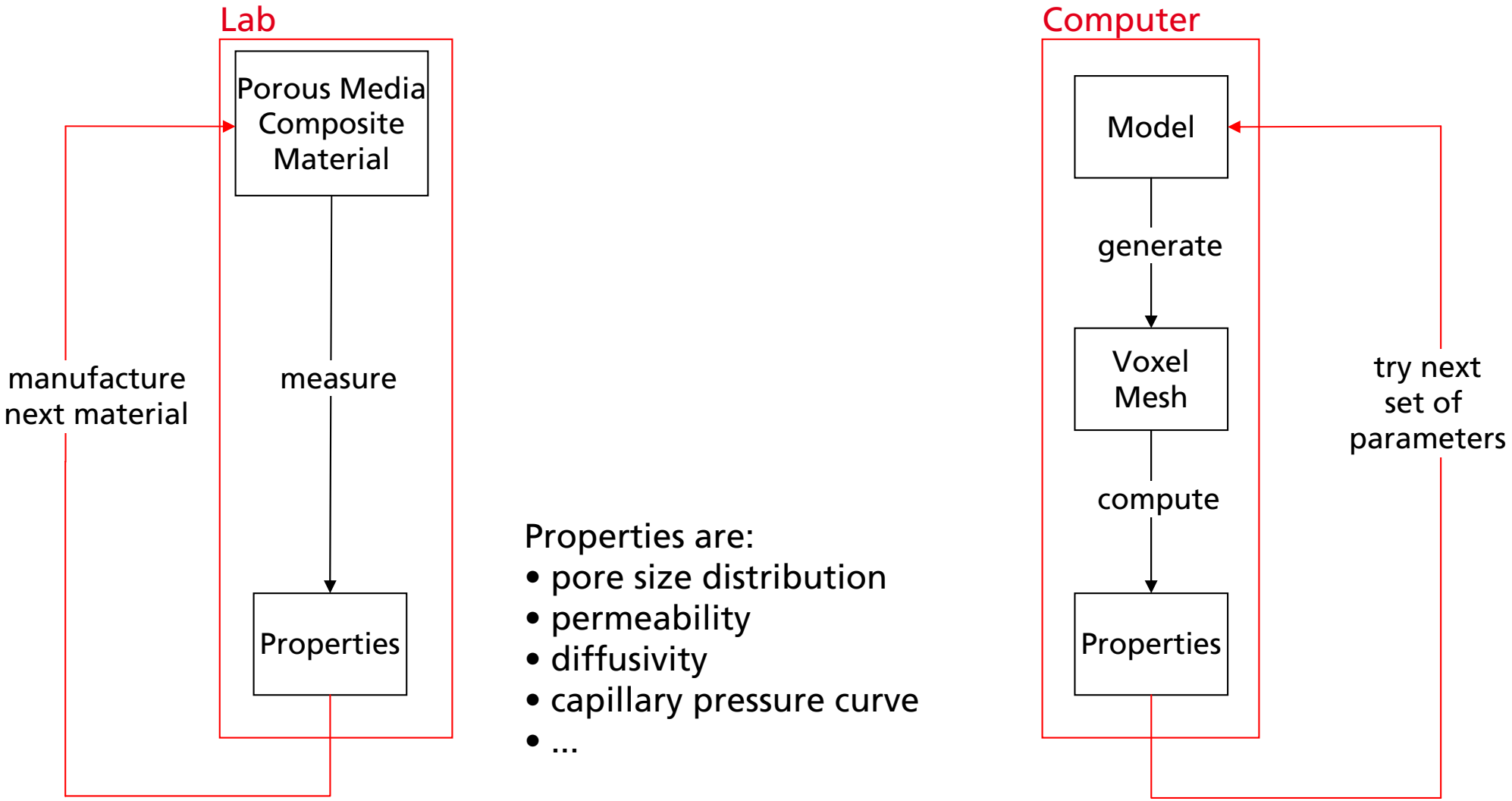


Properties are:

- pore size distribution
- permeability
- diffusivity
- capillary pressure curve
- ...

Fraunhofer ITWM

Aim: Computer Aided Material Engineering

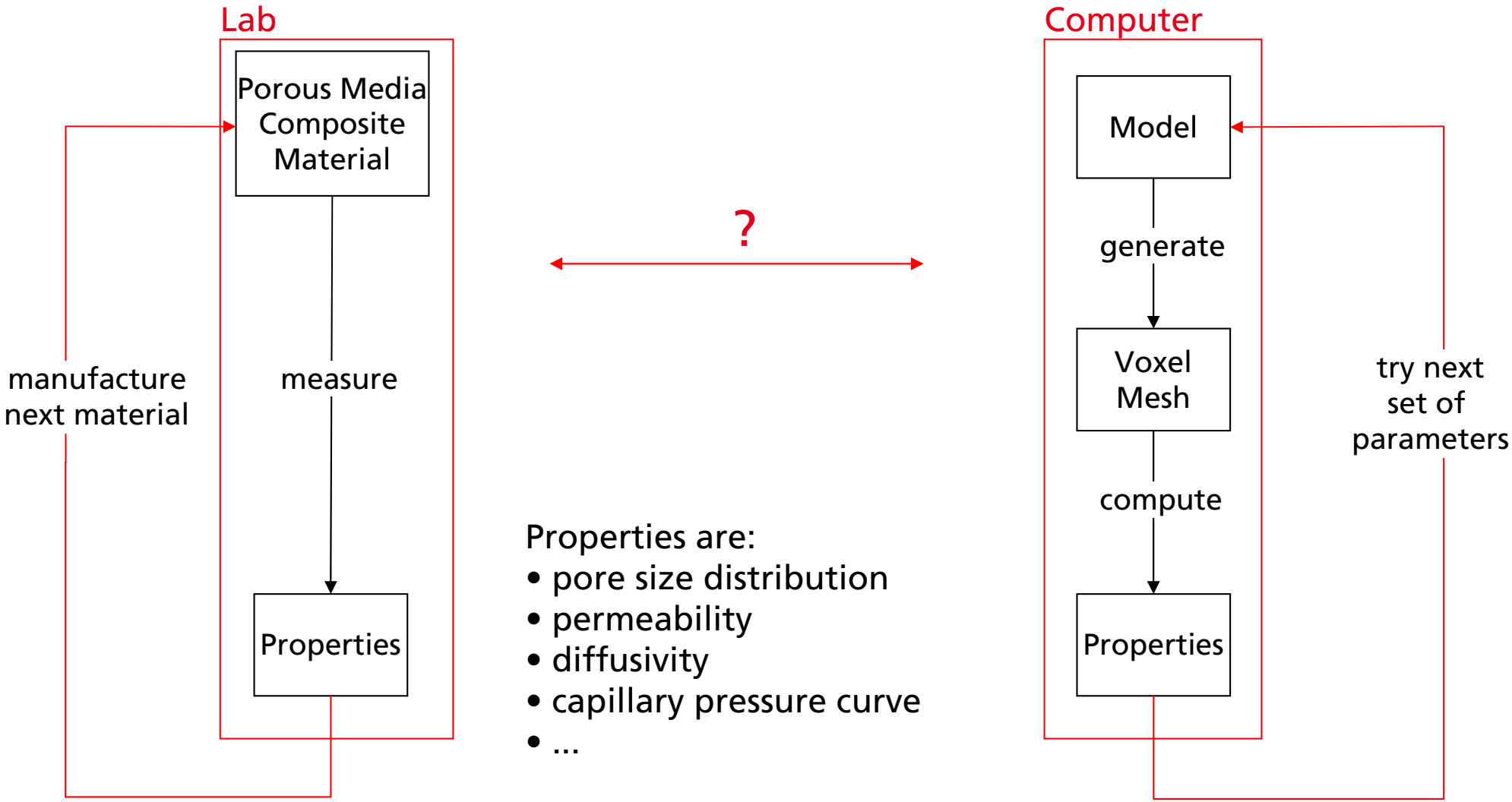


Properties are:

- pore size distribution
- permeability
- diffusivity
- capillary pressure curve
- ...

Fraunhofer ITWM

Aim: Computer Aided Material Engineering

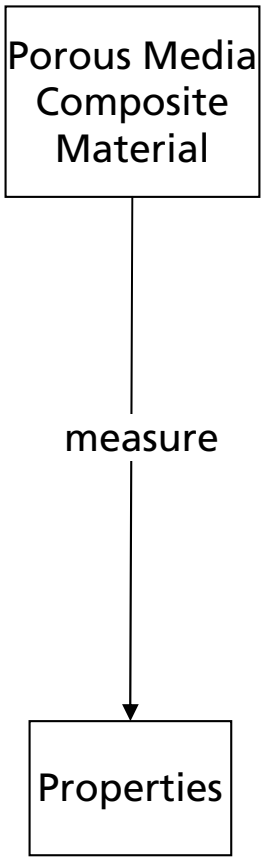


Properties are:

- pore size distribution
- permeability
- diffusivity
- capillary pressure curve
- ...

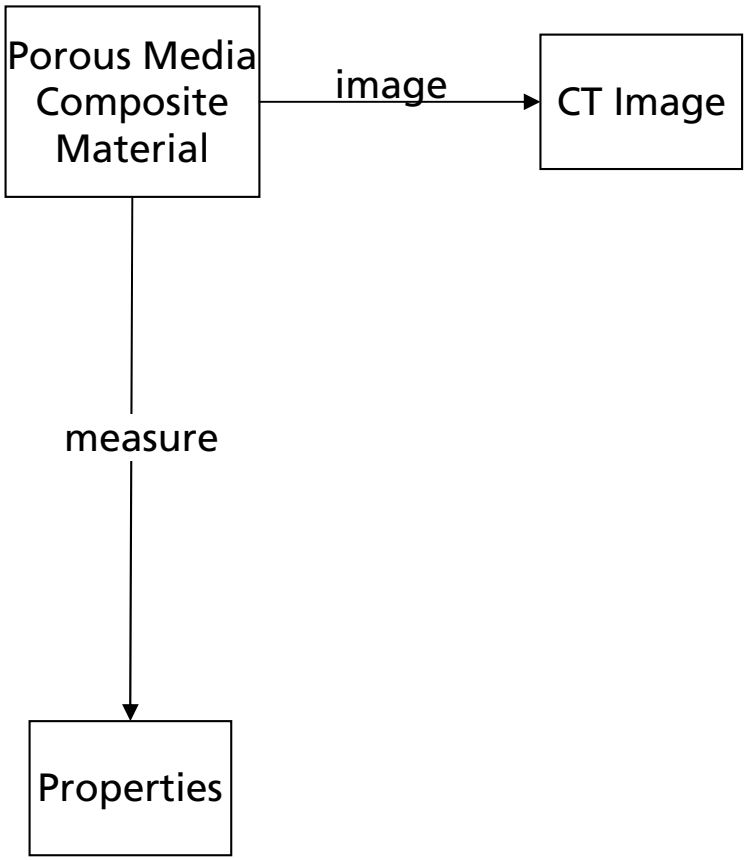
Fraunhofer ITWM

Validation - Step 1: Property Computations



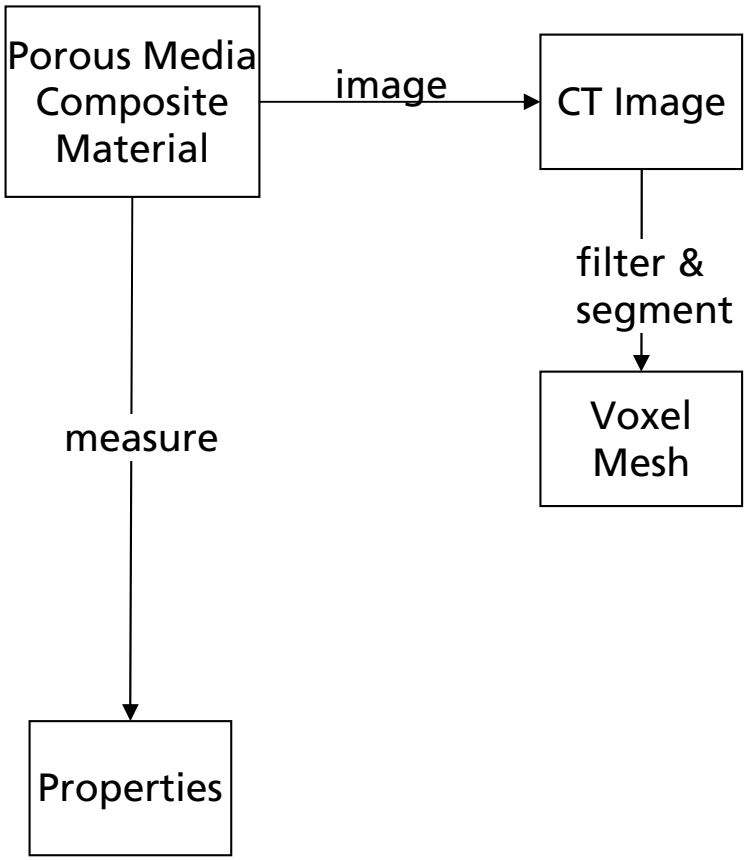
Fraunhofer ITWM

Validation - Step 1: Property Computations



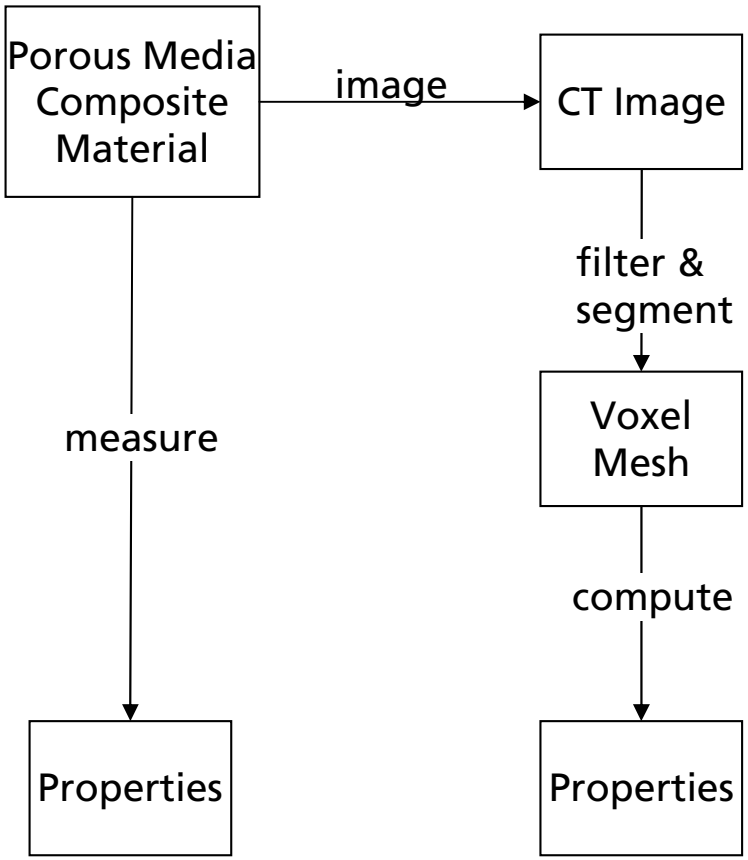
Fraunhofer ITWM

Validation - Step 1: Property Computations



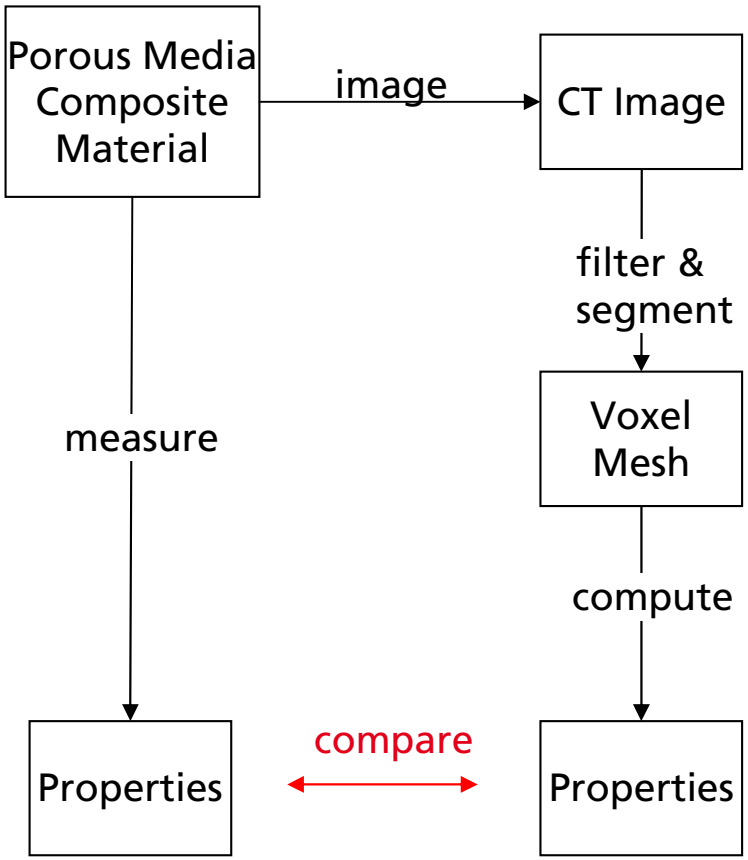
Fraunhofer ITWM

Validation - Step 1: Property Computations



Fraunhofer ITWM

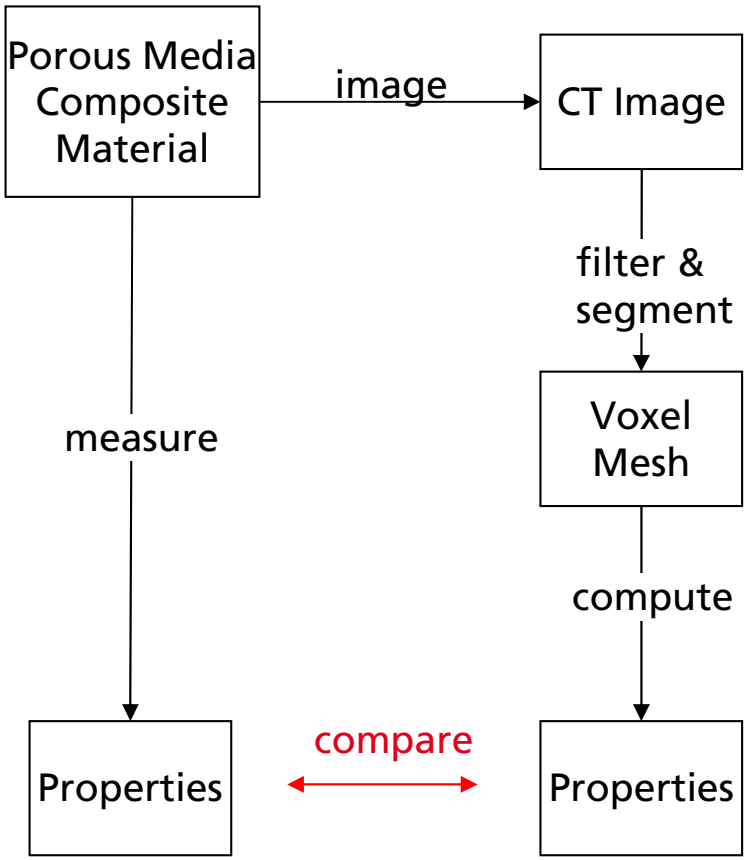
Validation - Step 1: Property Computations



Fraunhofer ITWM

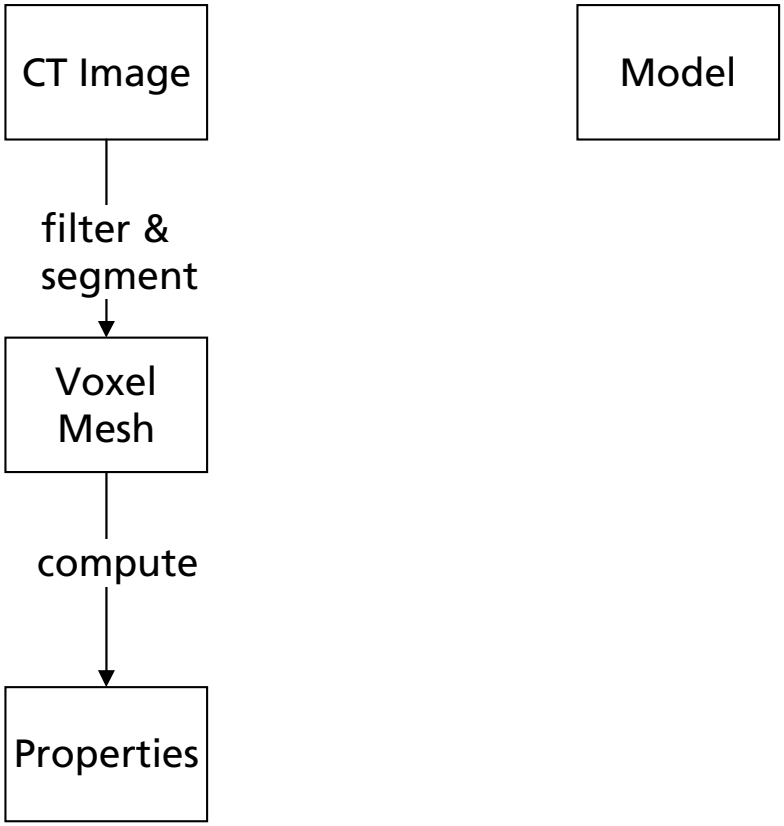
Validation - Step 1:

Property Computations
... and image acquisition
... and image processing
... and measurements



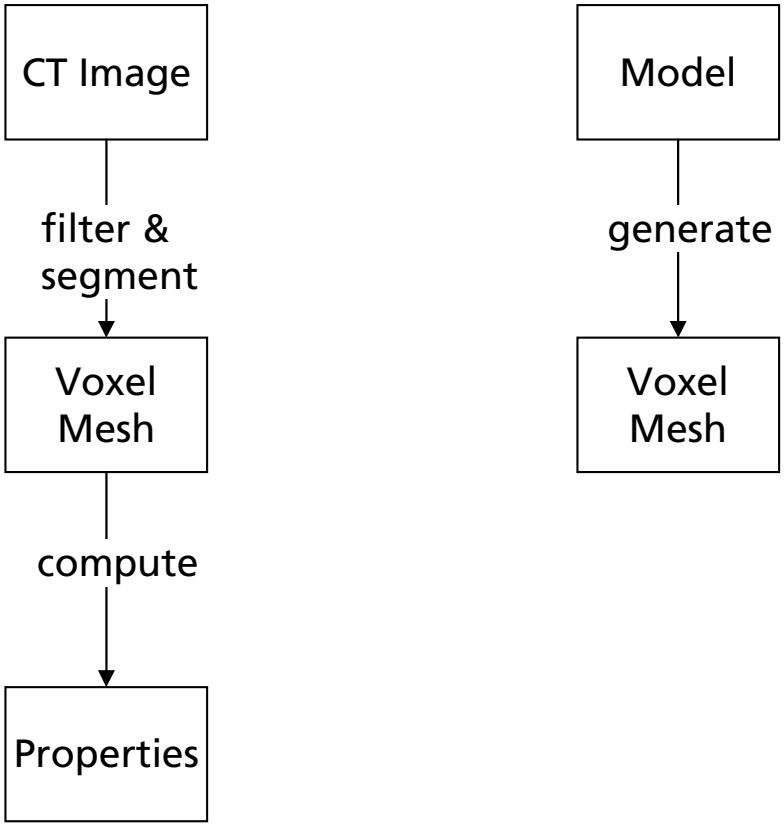
Fraunhofer ITWM

Validation - Step 2: Material Models

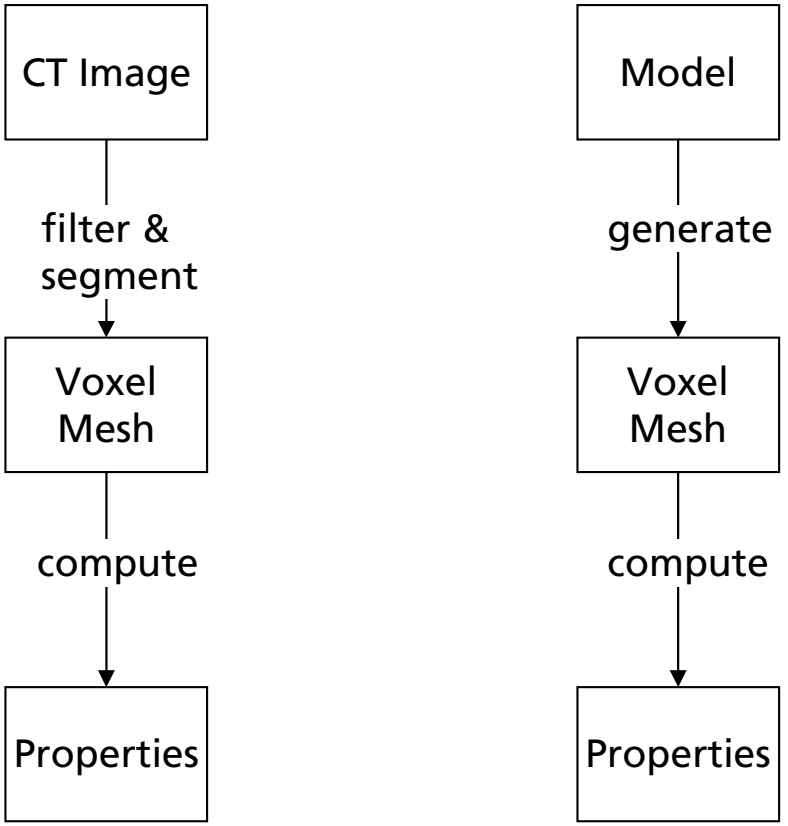


Fraunhofer ITWM

Validation - Step 2: Material Models

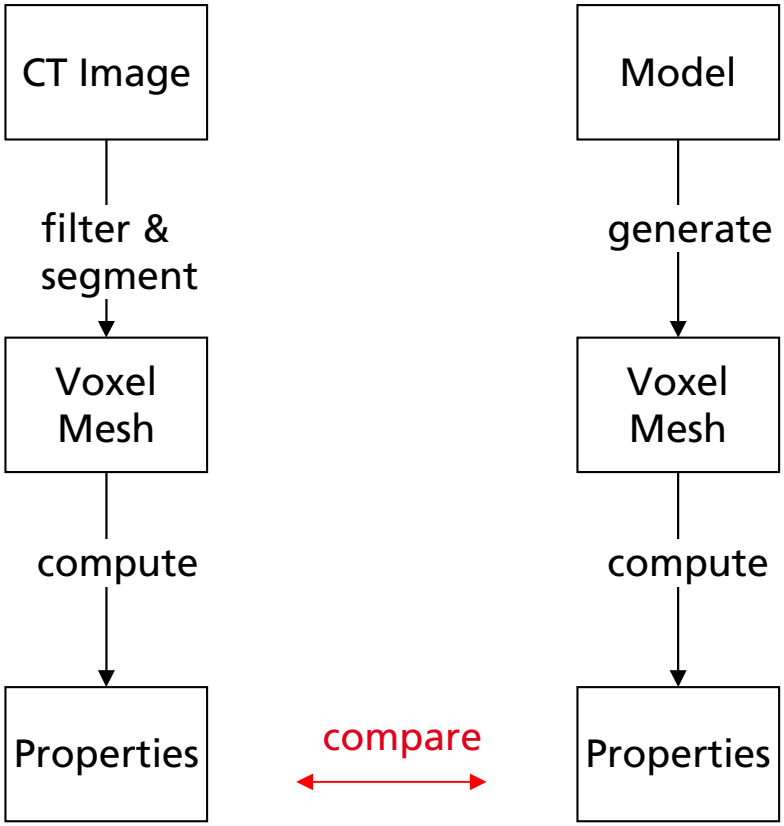


Validation - Step 2: Material Models



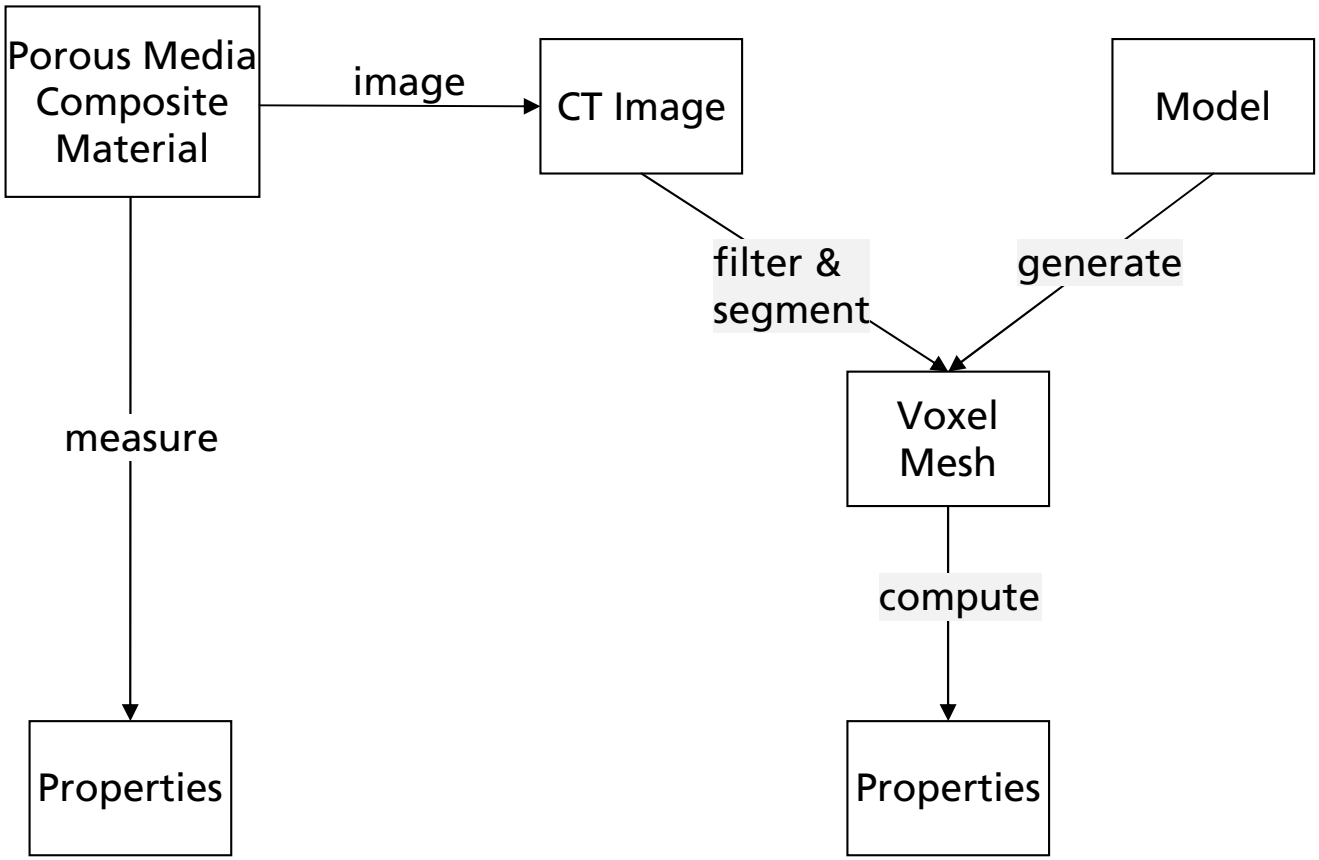
Fraunhofer ITWM

Validation - Step 2: Material Models



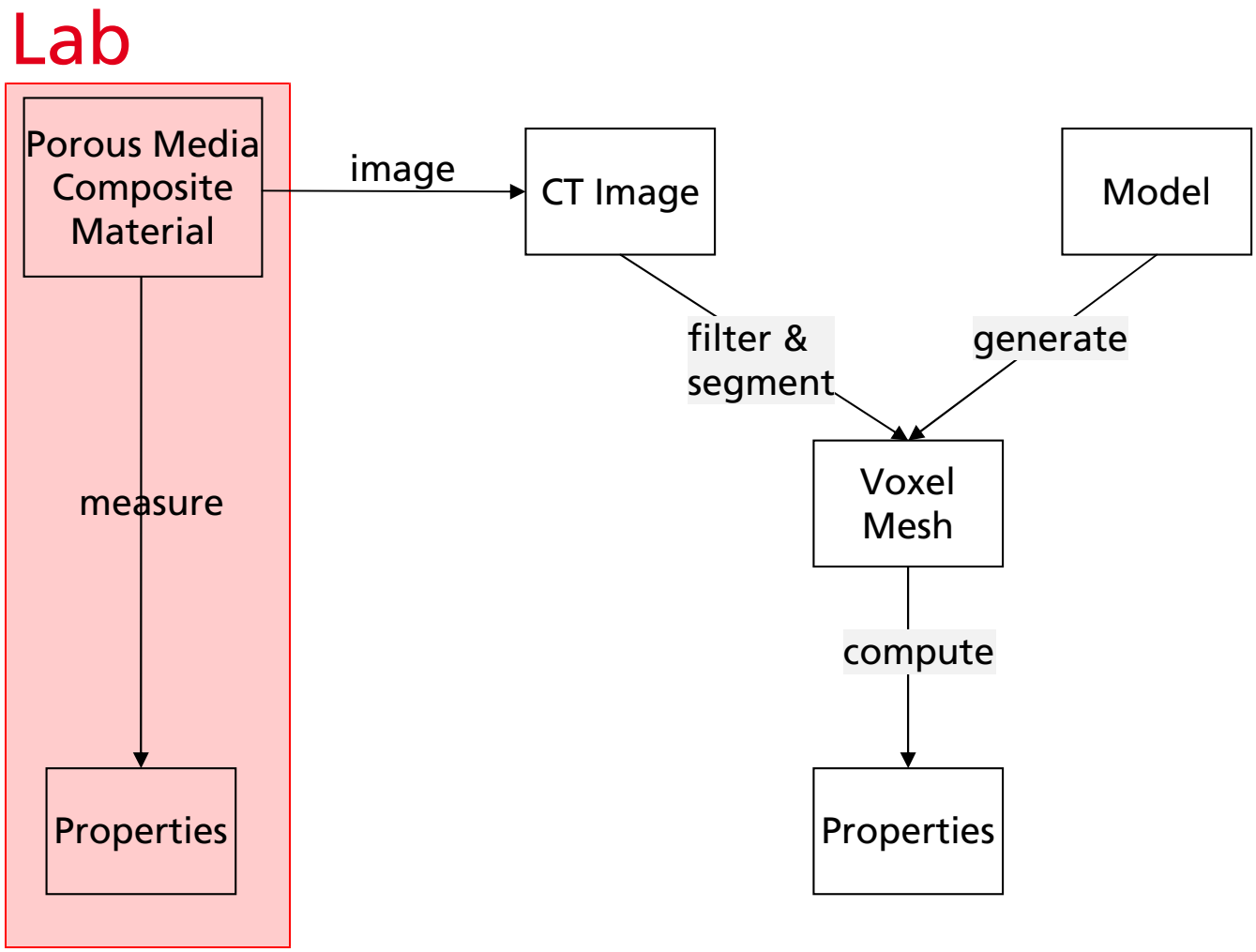
Fraunhofer ITWM

Computer Aided Material Engineering with GeoDict



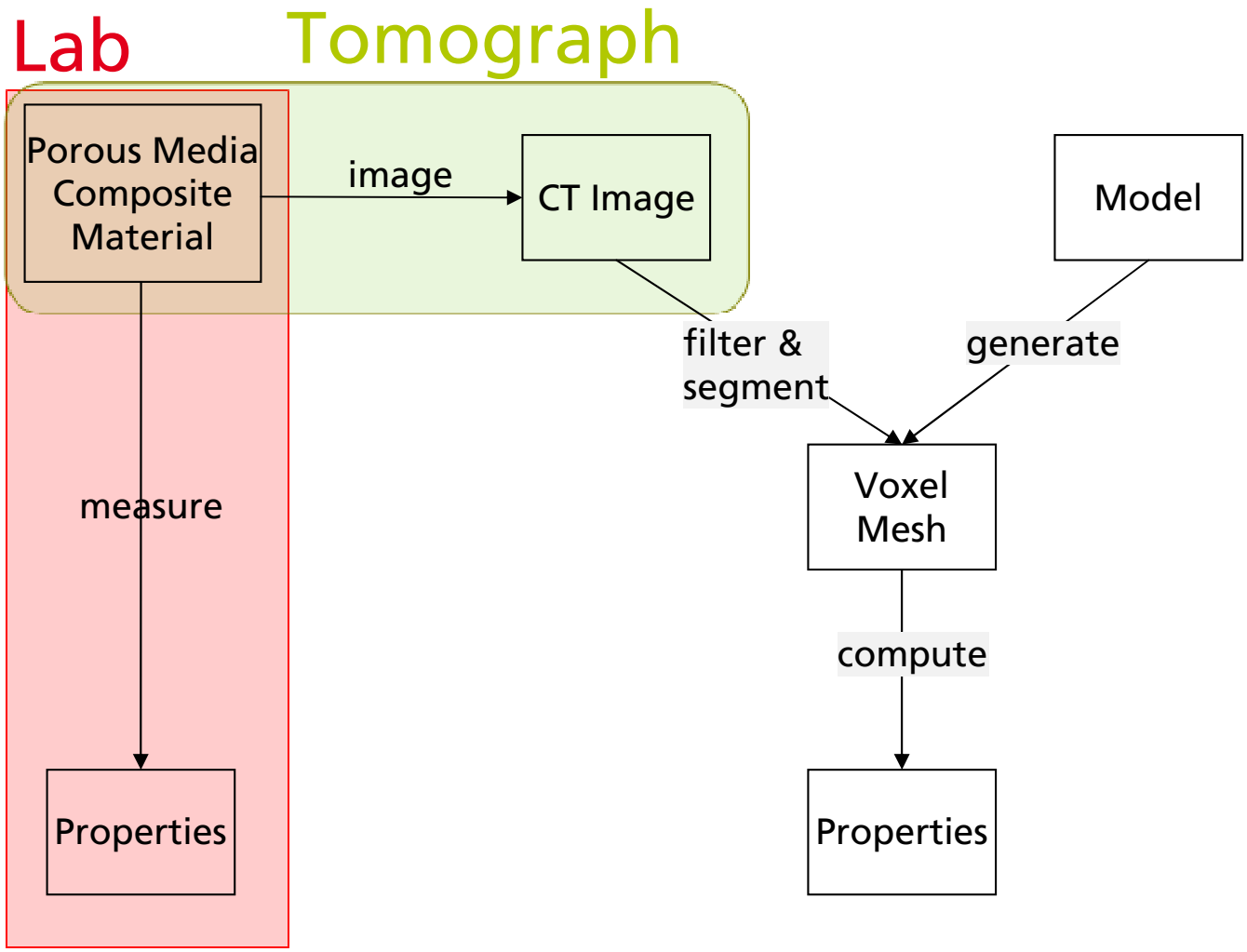
Fraunhofer ITWM

Computer Aided Material Engineering with GeoDict



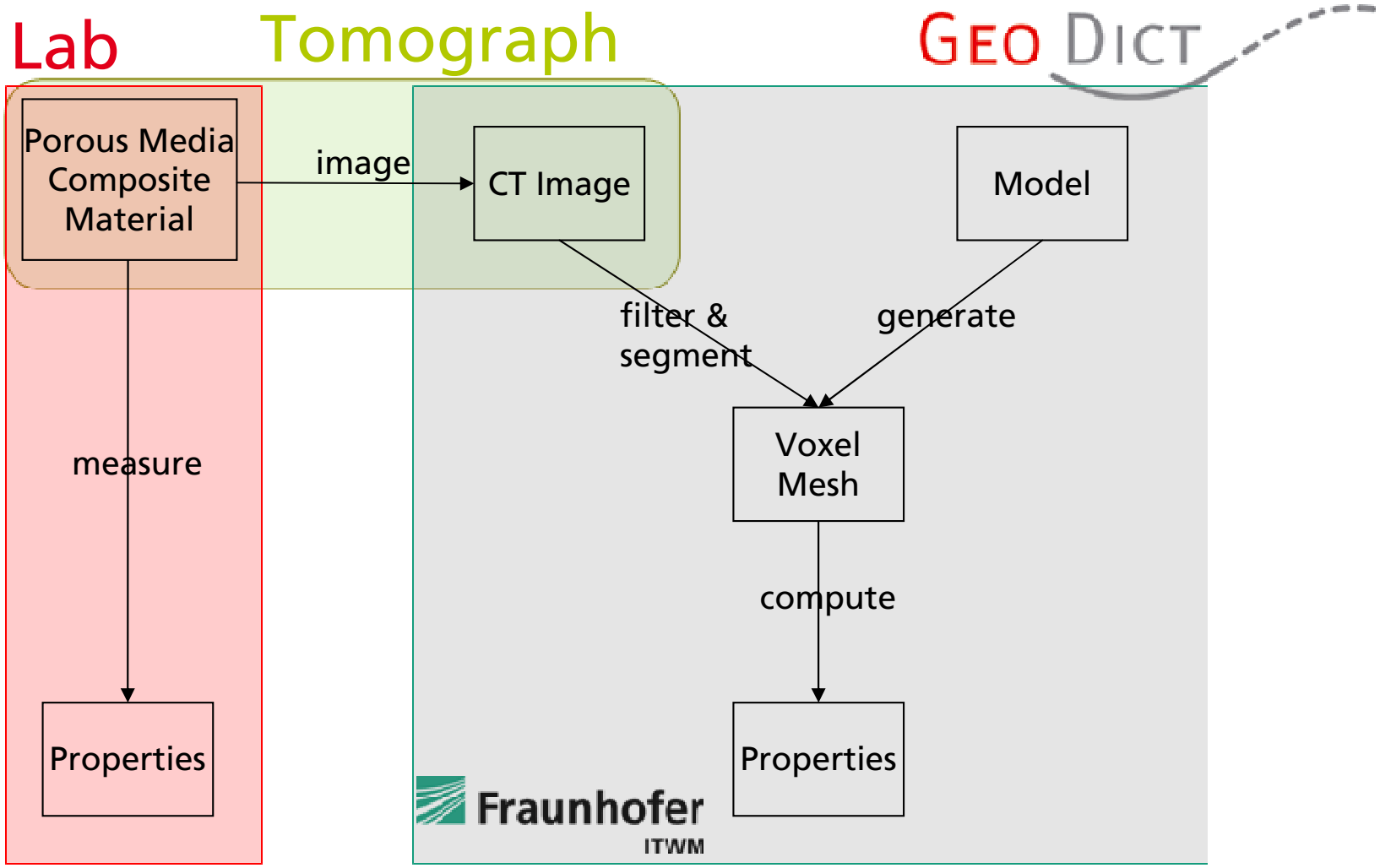
Fraunhofer ITWM

Computer Aided Material Engineering with GeoDict



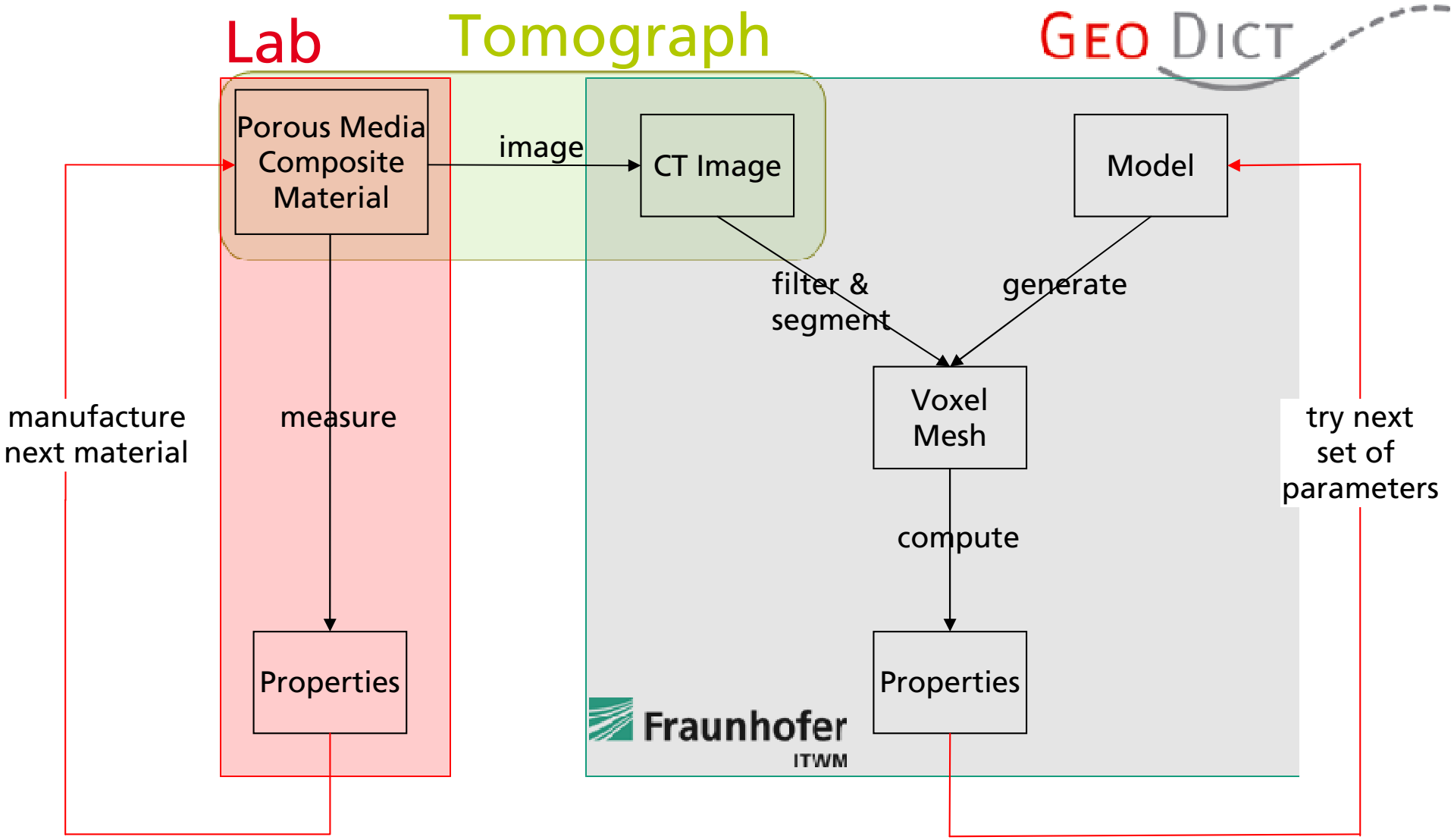
Fraunhofer ITWM

Computer Aided Material Engineering with GeoDict



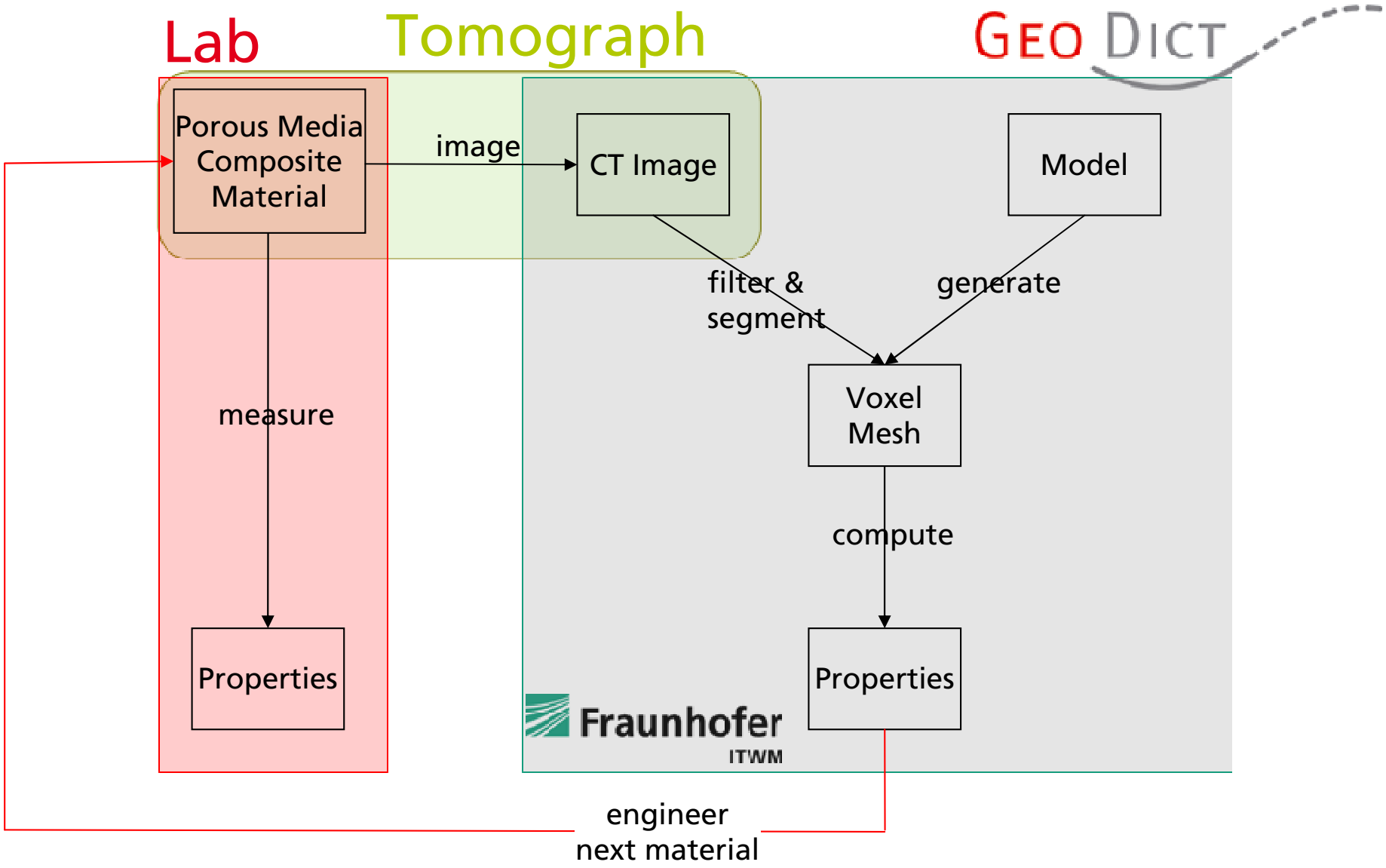
Fraunhofer ITWM

Computer Aided Material Engineering with GeoDict



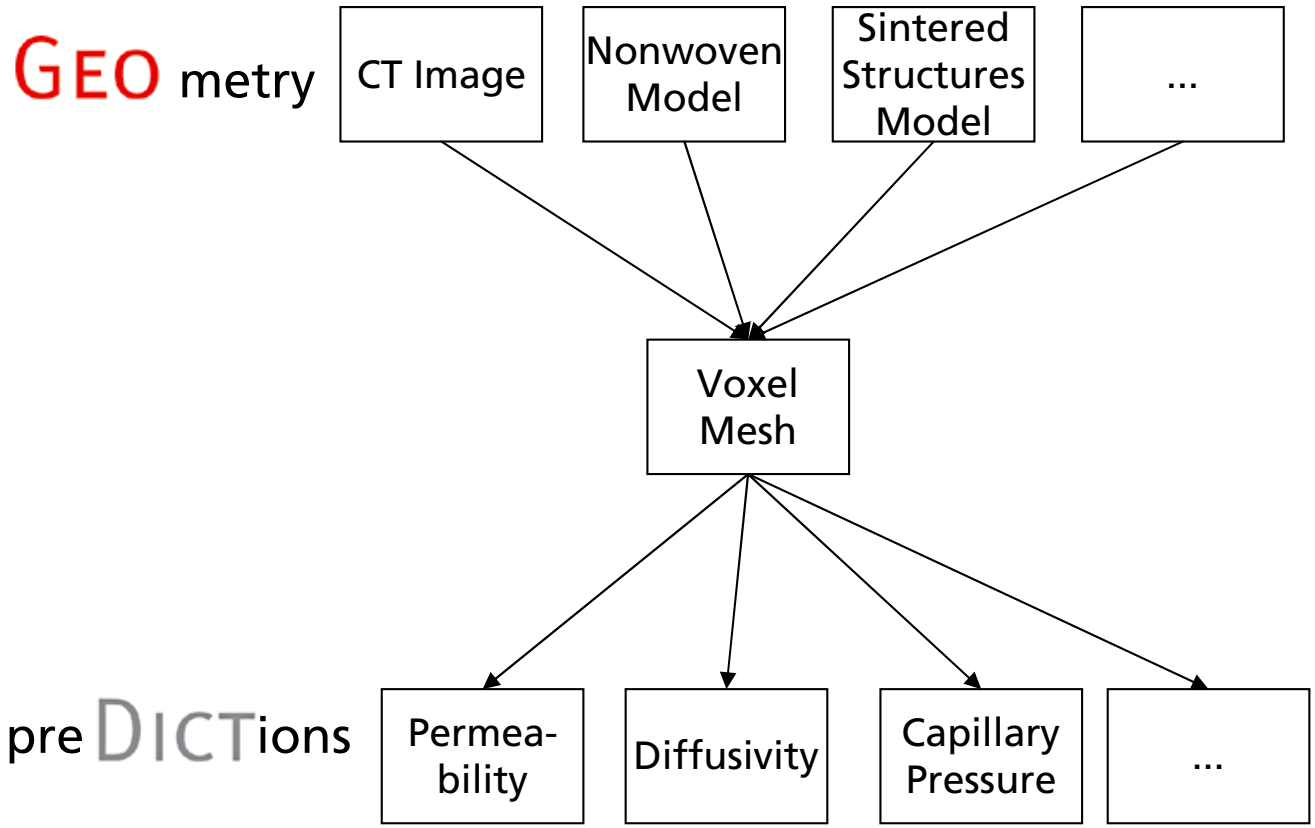
Fraunhofer ITWM

Computer Aided Material Engineering with GeoDict



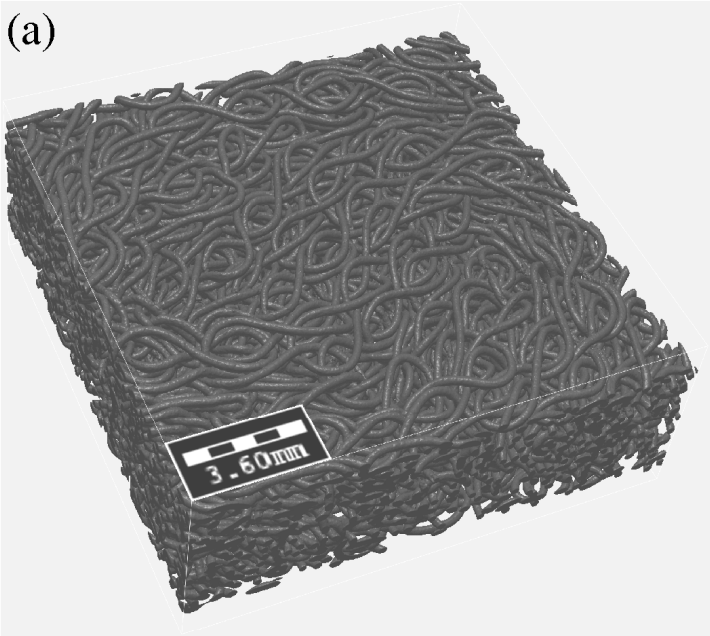
Fraunhofer ITWM

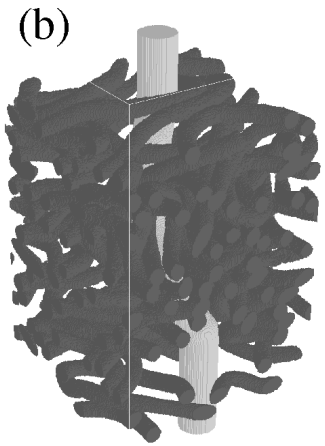
The GeoDict Software

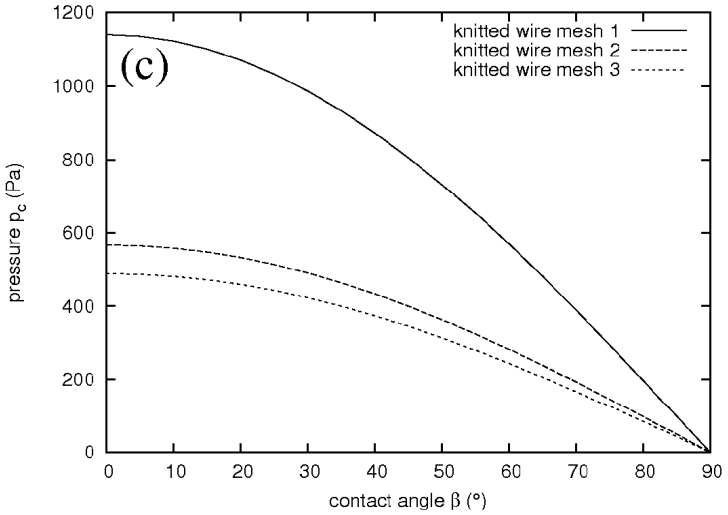


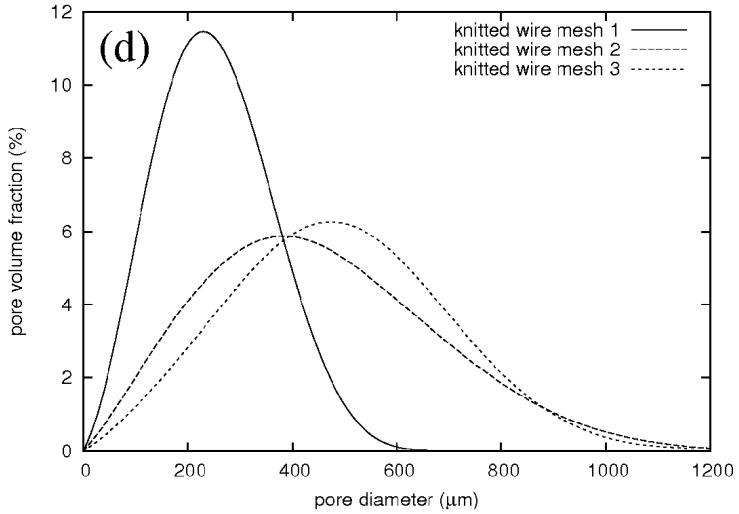
Fraunhofer ITWM

Knitted Wire Meshes: Geometry-Based Property Analyses









(a): CT-scan of a knitted wire mesh.

(b): Largest through pore.

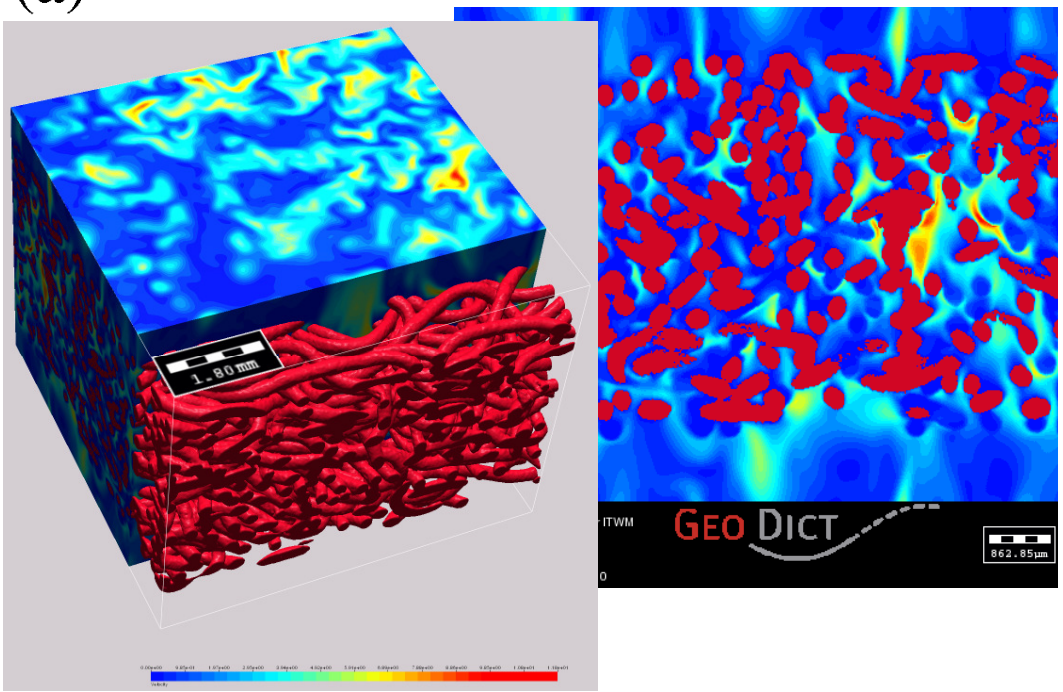
(c): Bubble point pressure in dependency of the contact angle.

(d): Pore size distribution.

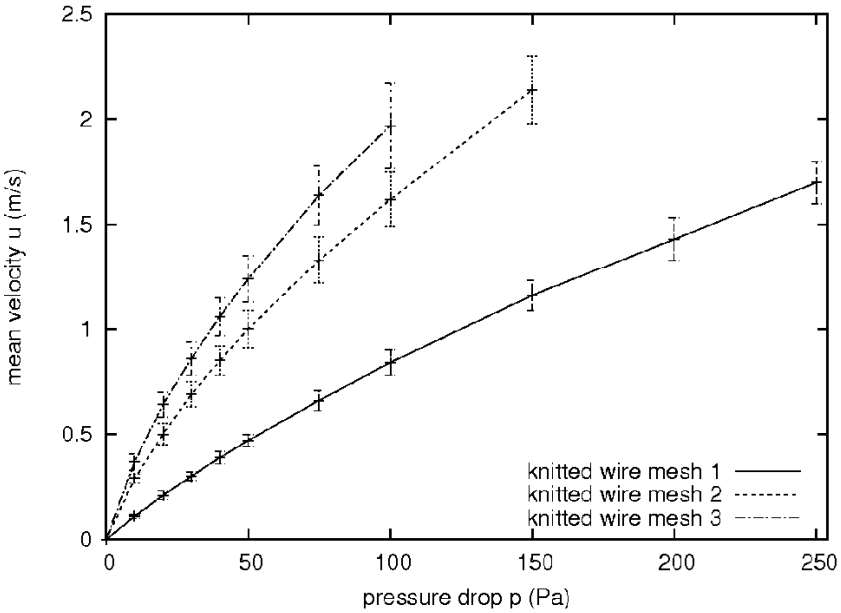
Fraunhofer ITWM

Knitted Wire Meshes: Partial-Differential-Equation-Based Property Analyses

(a)



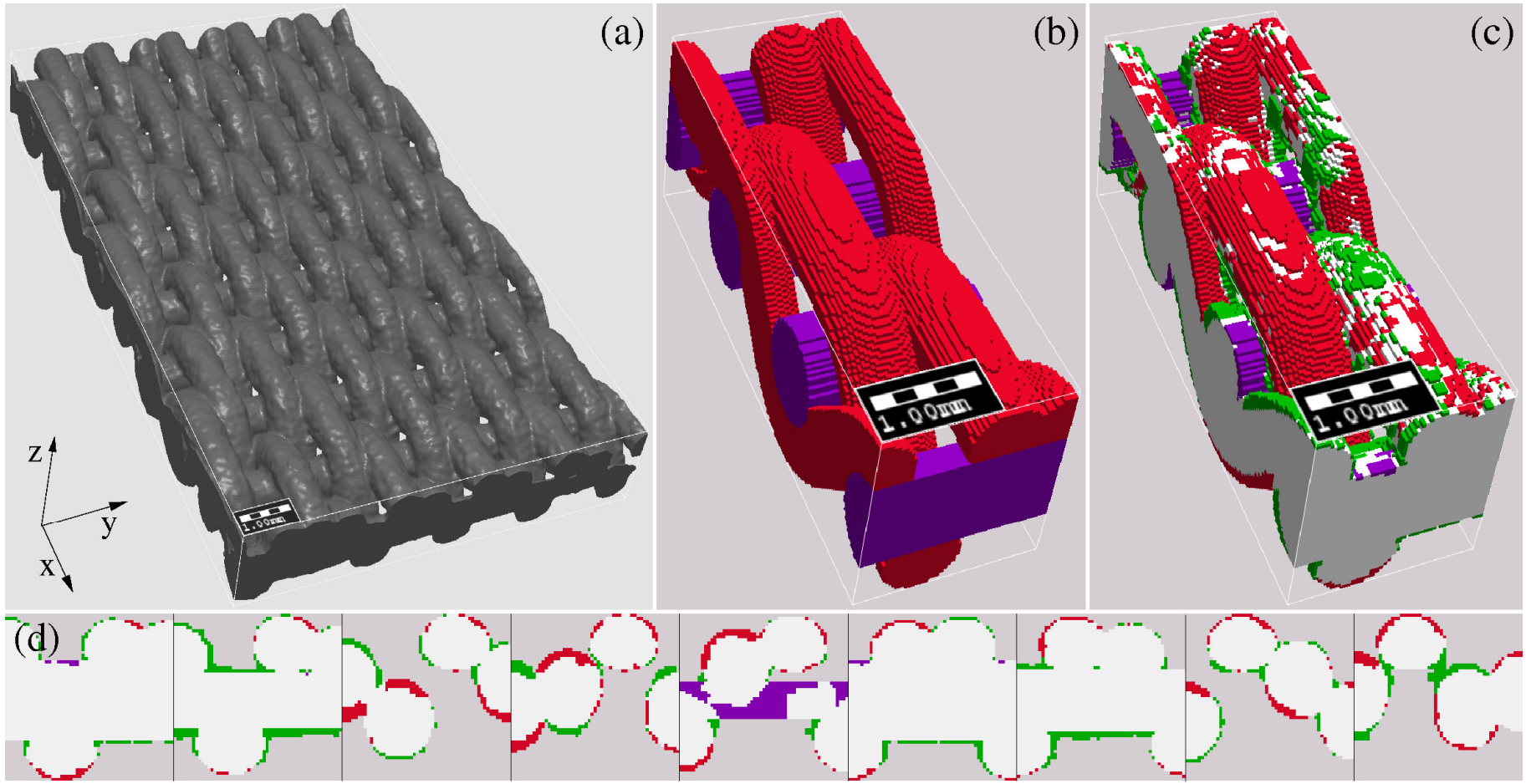
(b)



(a): Visualisation of the flow field in a CT-scan of a knitted wire mesh.
(b): Velocity dependent pressure drop of three knitted wire meshes.

Fraunhofer ITWM

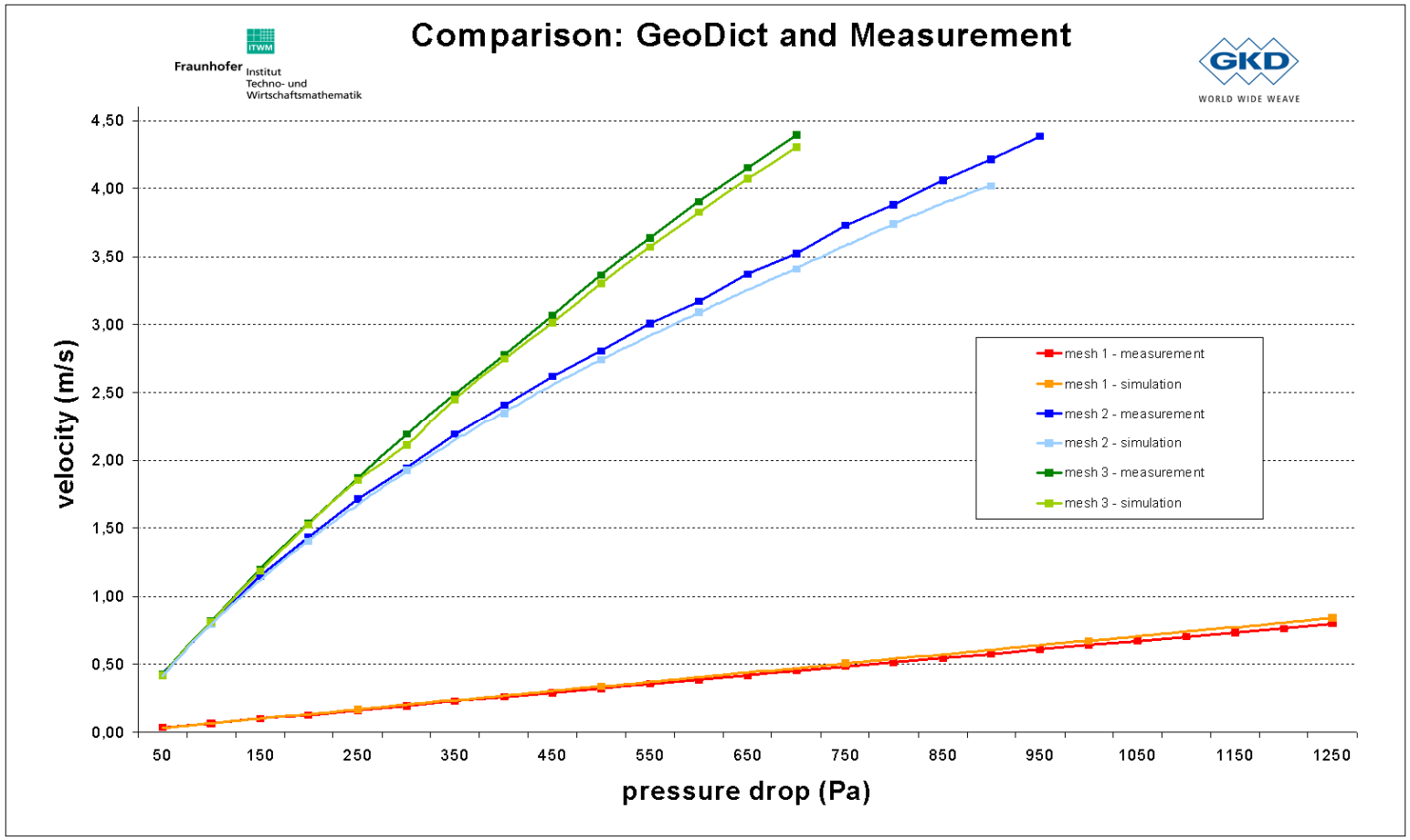
Woven Metal Wire Meshes: Geometric Validation



(a): CT of a twill Dutch-weave. (b): Geometry model.
(c)-(d): Geometric validation.

Fraunhofer ITWM

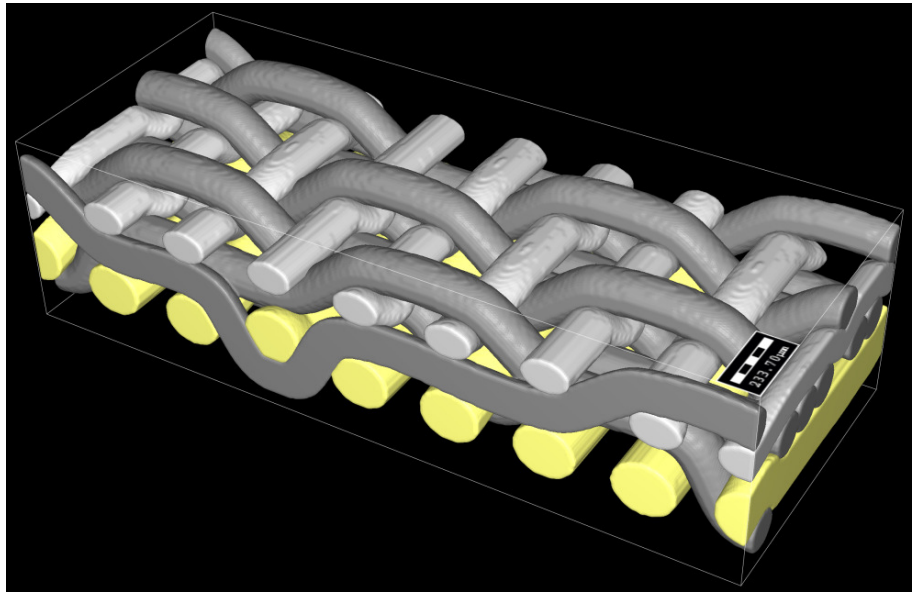
Woven Metal Wire Meshes: Measurement and Simulation

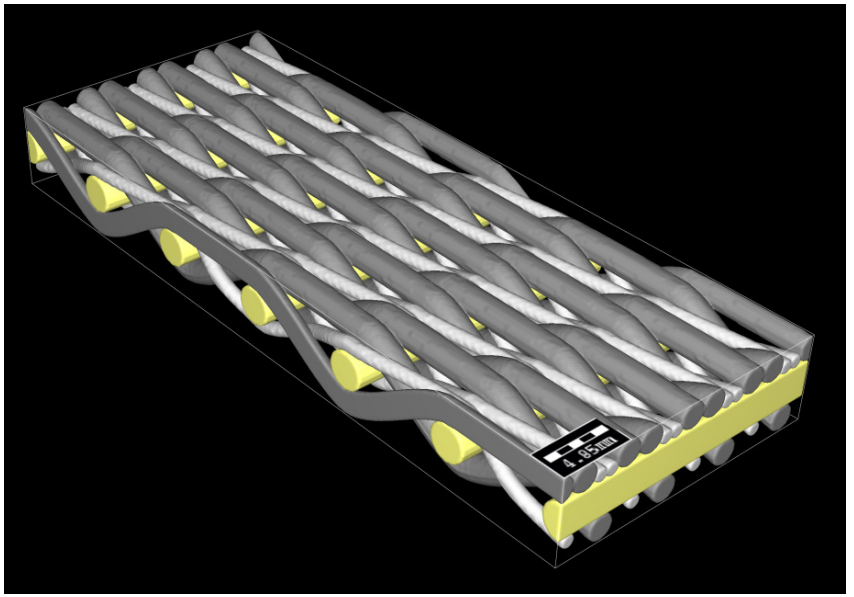


Velocity dependent pressure drop: Comparison between measurements and simulations on corresponding geometry models.

Fraunhofer ITWM

Woven Metal Wire Meshes: Complex weave models





Left: Model of a two-layer weave based on a CT-scan.
Right: Model of a complex one-layer twill Dutch-weave.

Summary Part I

Models:

- CT Images

- Fibrous nonwovens
- Woven structures
- Sintered structures
- Sphere packings

- Layered structures

Properties:

- Pore size distribution
- Surface area

- (Knudsen) Diffusivity
- Permeability
- Electric conductivity
- Heat conductivity

- Capillary pressure curve
- Bubble point
- Relative (= saturation dependent) permeability
- Relative (= saturation dependent) diffusivity

- Filter efficiency and life time

Fraunhofer ITWM

Summary Part II

Knitted Wire Meshes:

- property analyses on CT-scans

Woven Metal Meshes:

- model validation based on CT-scans

Thank You !

GEO DICT

Geometry generator,
property predictor and
virtual material designer

www.geodict.com

Fraunhofer ITWM