Hochschule für Technik, Wirtschaft und Kultur Leipzig
Leipzig University of Applied Sciences

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Simulation of Printing Processes in Education using Open-Source FEM Software

Holger Zellmer

Introduction

Why should students learn numerical simulation methods?

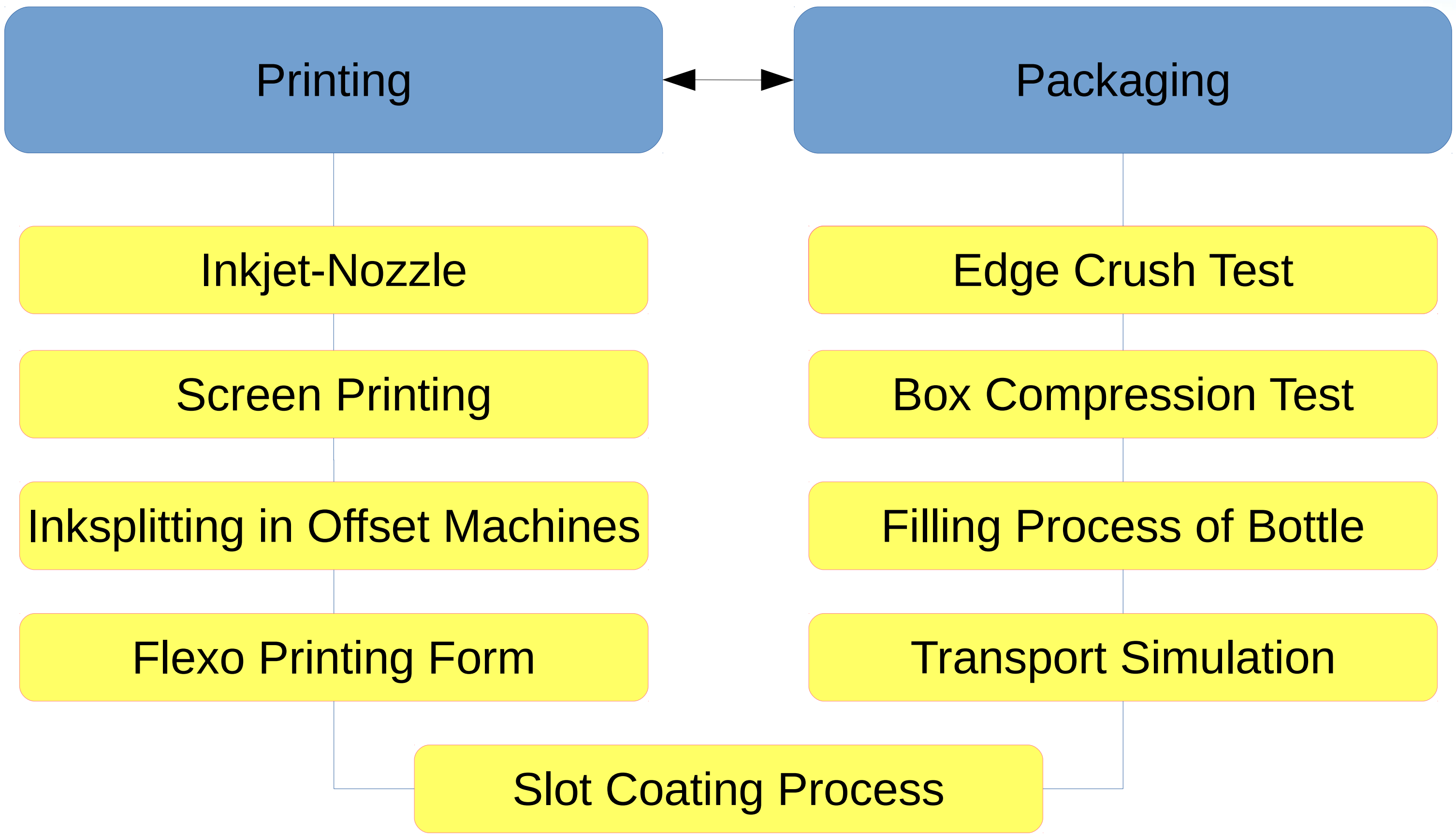
→ helps to think like an engineer

→ helps understanding basic effects by easily changing physical parameters or properties in a system

→ learn new methods

→ get information on physical properties or values where in situ measurement is not possible

Some print-related Projects in Student Education



The Software

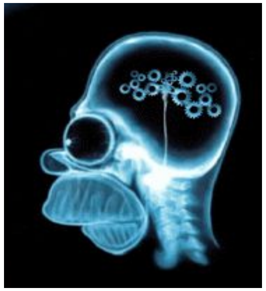
Preprocessor

Create a CAD Model

Create and define Bodies and Boundaries

Create a mesh of finite elements

Processor



Assign physical properties to bodies e.g. density, viscosity

Assign boundary-conditions e.g. force, velocity, temperature

Assign physical model e.g. Navier-Stokes flow solution, heat equation

Solve the equations

Postprocessor

View the results

Extract data

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The Software

Commercial Solutions

Many good commercial software solutions are on the marked, mainly for windows based systems.

Although some distributors offer university discounts, the software ist still very expensive.

Preprocessor

AutoCAD

Processor
Postprocessor

ANSYS

Processor
Postcrozessor

COMSOL MULTIPHYSICS®

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The Software

Open Source Solutions

For numerical simulation there is a variety of free software available.

Development in user community or European research projects

+ High performance
- Little less convenience
+ Students can use the software at home

Linux based
(can be easily installed with bootmanager parallel to win)

Preprocessors

SALOME 6

GMSH

Netgen

Processors

OpenFOAM

Code_Aster

Elmer

Postprocessor

ParaView
Parallel Visualization Application

The Training: Building a Model

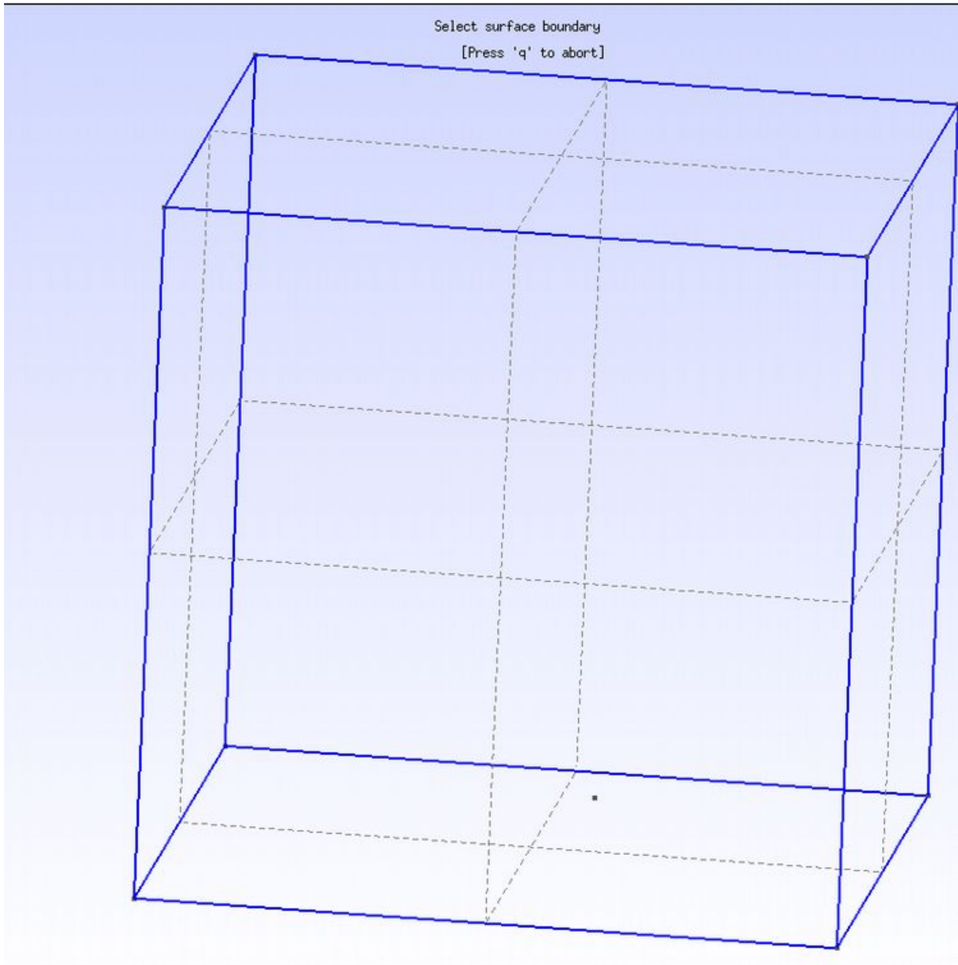
Create a model step by step

Points → lines → surfaces → volumes

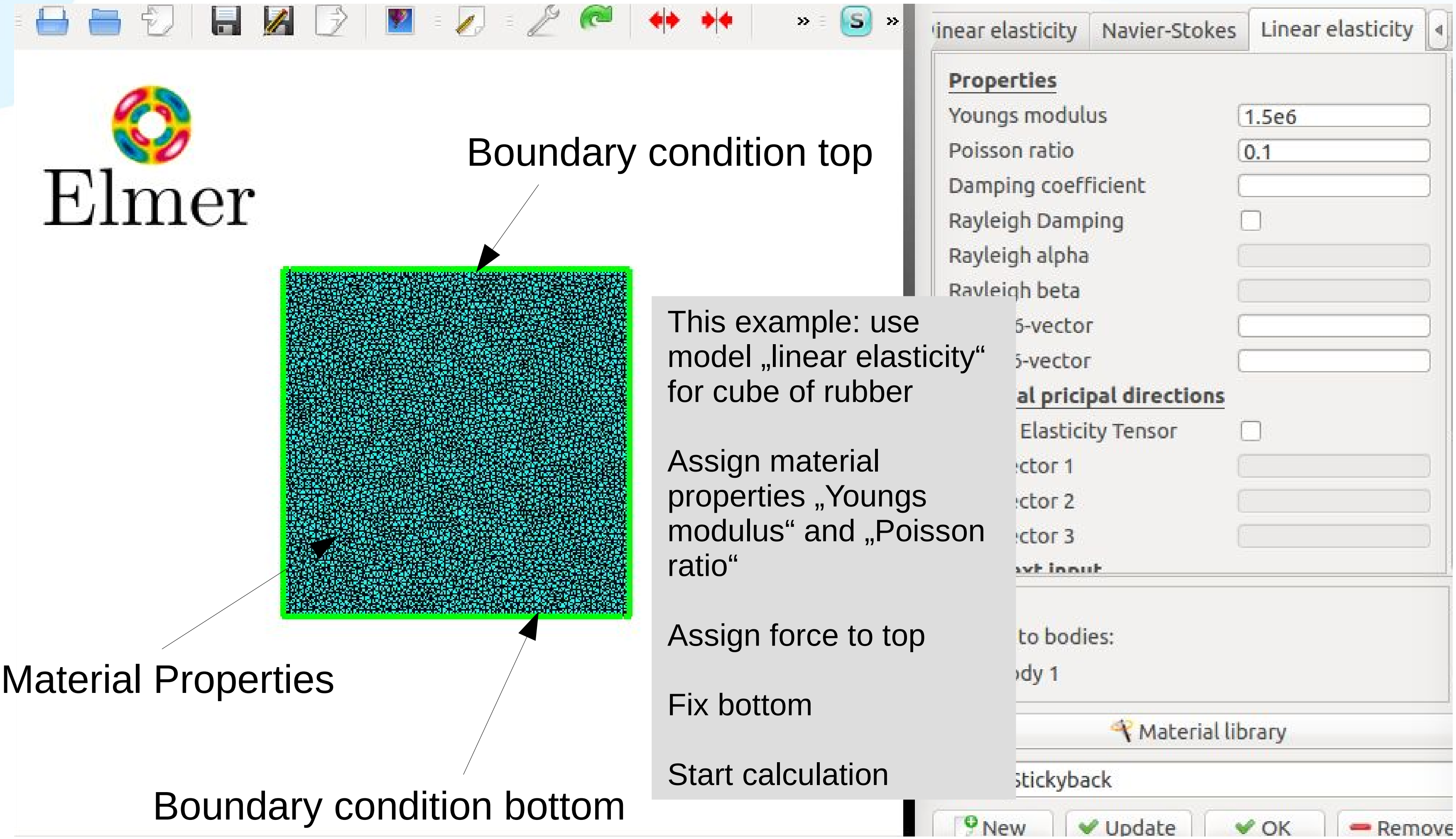
Learn to think in 3D

Use symmetries to make it simple

First example: create a cube of rubber and apply a force to it



Applying the Physics



This example: use model „linear elasticity" for cube of rubber

Assign material properties „Youngs modulus" and „Poisson ratio"

Assign force to top

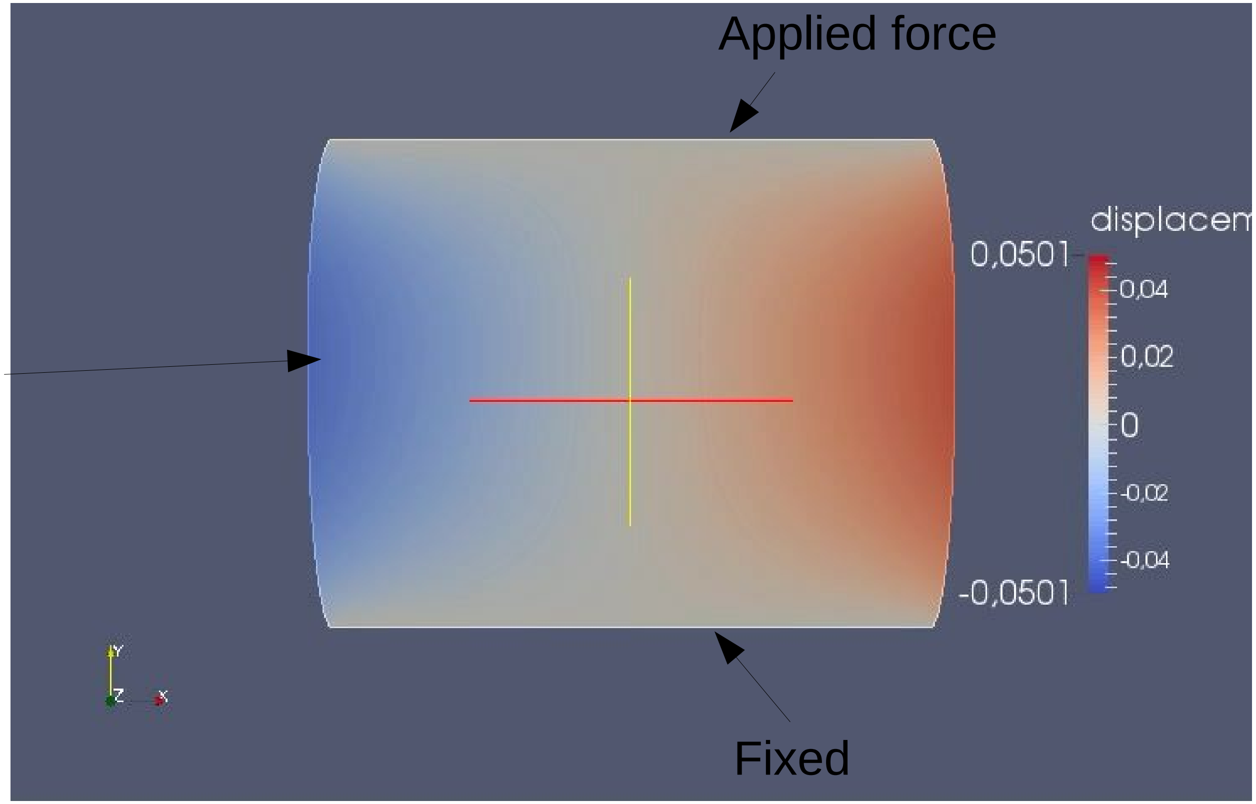
Fix bottom

Start calculation

Viewing the Results

ParaView
Parallel Visualization Application

Lateral deformation displayed as colormap



The Project

Based on the training and test cases a real world application is simulated:

Flexography:

- Compare digital dots to flat top dots

- Compare a compressible submount (plate mounting foam tape) to incompressible rigid submount (plate mounting tape)

- calculate the dot size for 5% an 10% dot coverage

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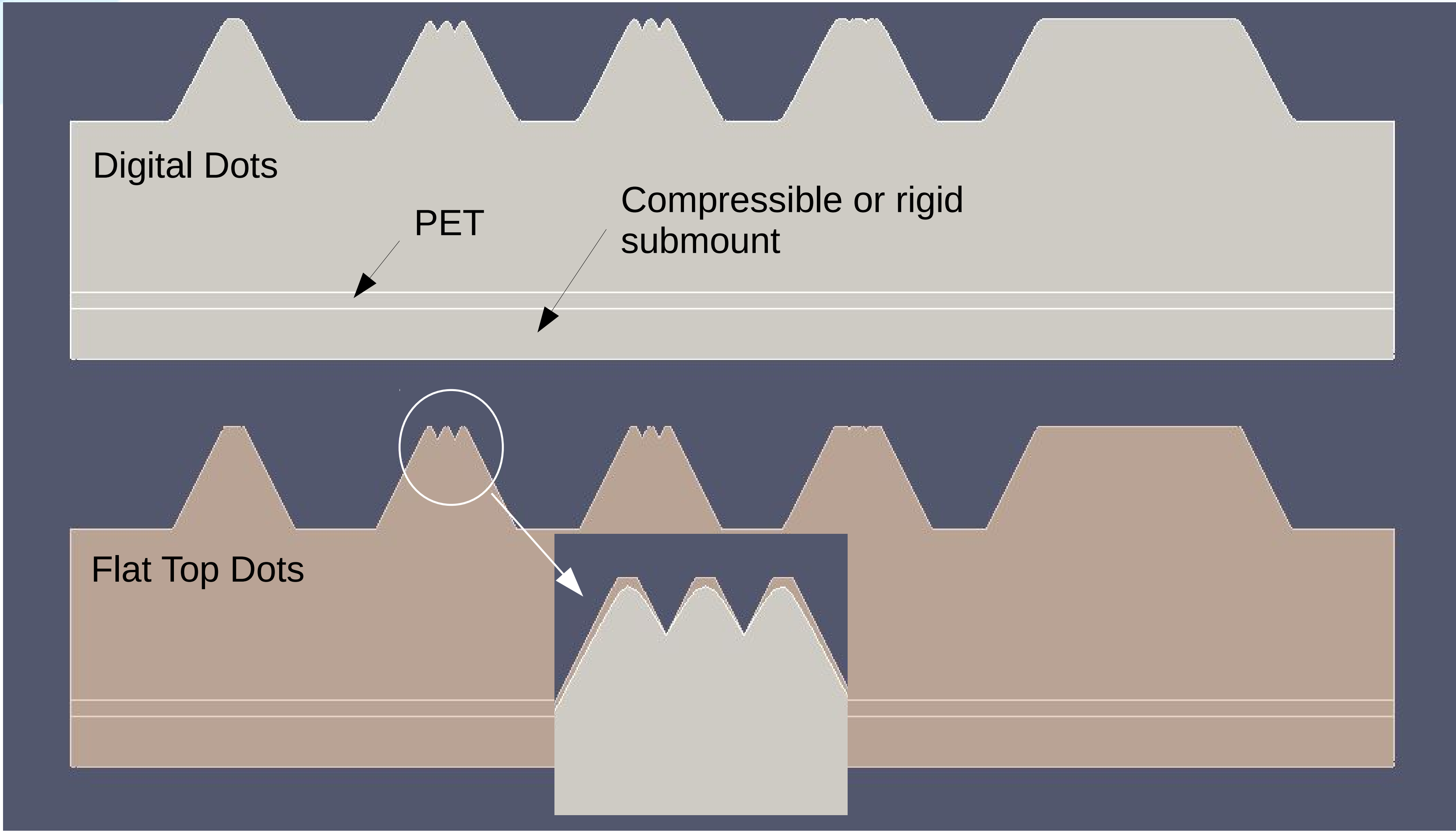
The Project: CAD Model



The Project: Material parameters

Material parameters are obtained in the materials lab

Zwick Universalprüfmaschine

- Youngs modulus
- Poisson ratio

```
Material 1
  Name = "Fotopolymer"
  Poisson ratio = 0.45
  Youngs modulus = 4.68E6
End

Material 2
  Name = "PET"
  Poisson ratio = 0.35
  Youngs modulus = 2800E6
End

Material 3
  Name = "Foam Tape"
  Poisson ratio = 0.1
  Youngs modulus = 1.65E6
End
```

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The Project: Simulation

Use four possible combinations:

digital dot	↔	flat top dot
compressible	↔	incompressible submount

Change the infeed from 0 to 100 µm

Calculate contact forces

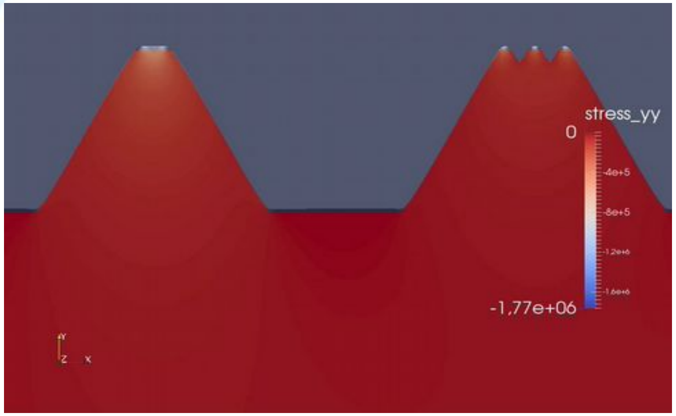
Calcutale strain and stress in the fotopolymer

Calculate contact area
→ calculate dot gain

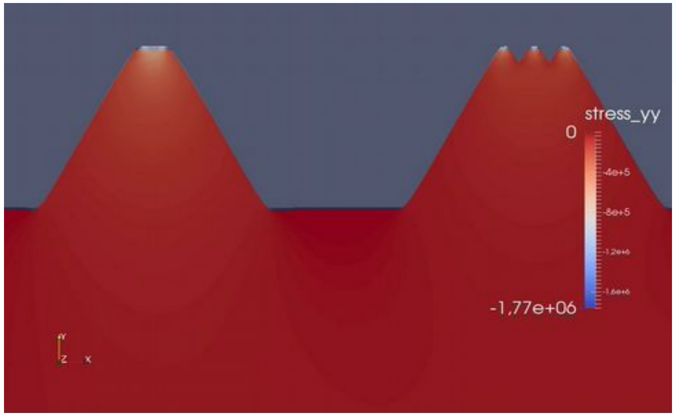
Note: all calculations are in SI units (m kg s)

Stress Analysis

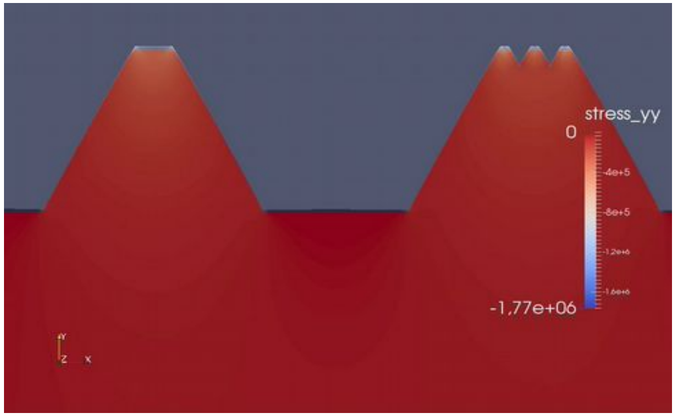
Digital Dot Compressible Submount



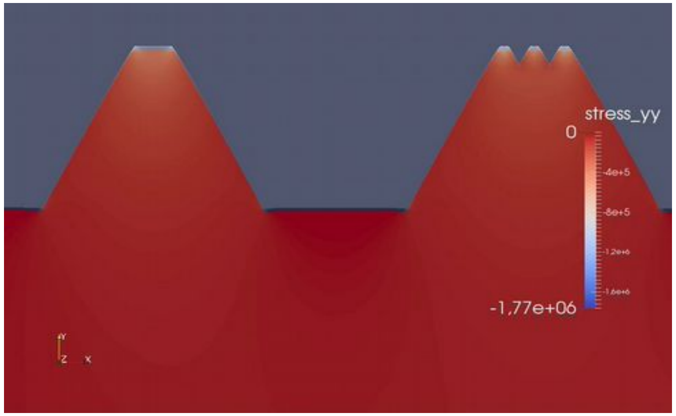
Digital Dot Incompressible Submount



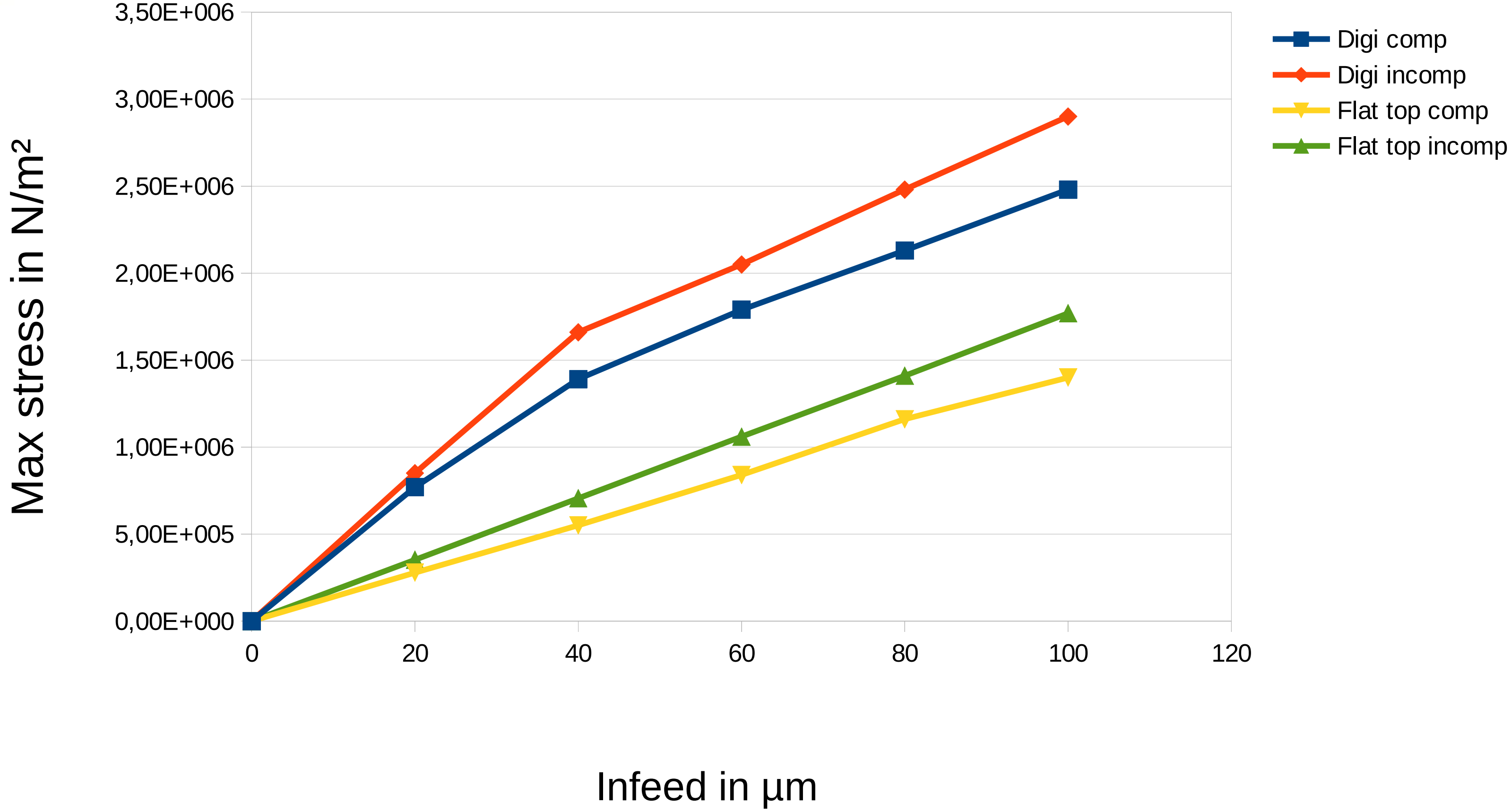
Flat Top Dot Compressible Submount



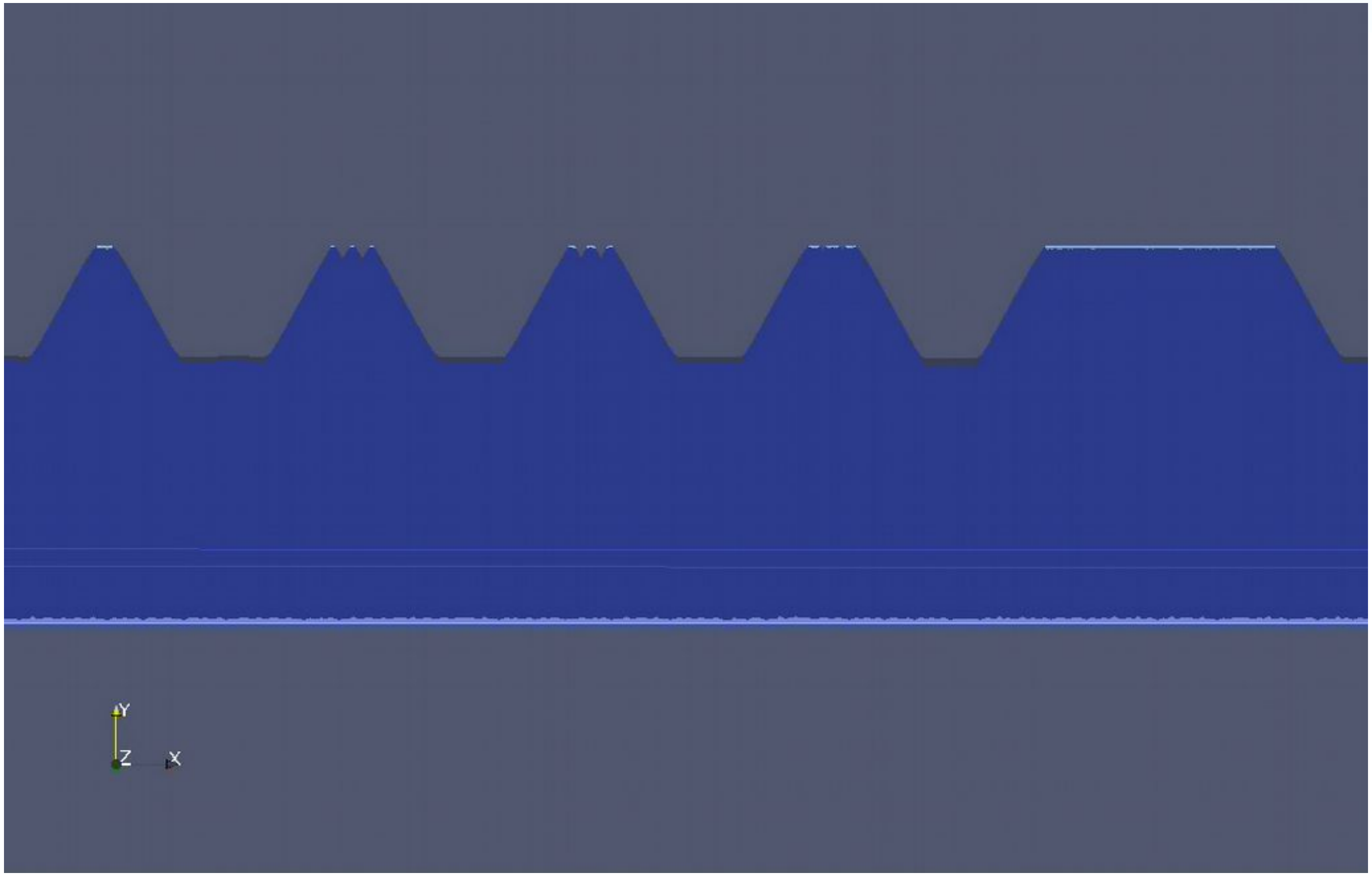
Flat Top Dot Incompressible Submount



Stress Analysis: Maximum Stress

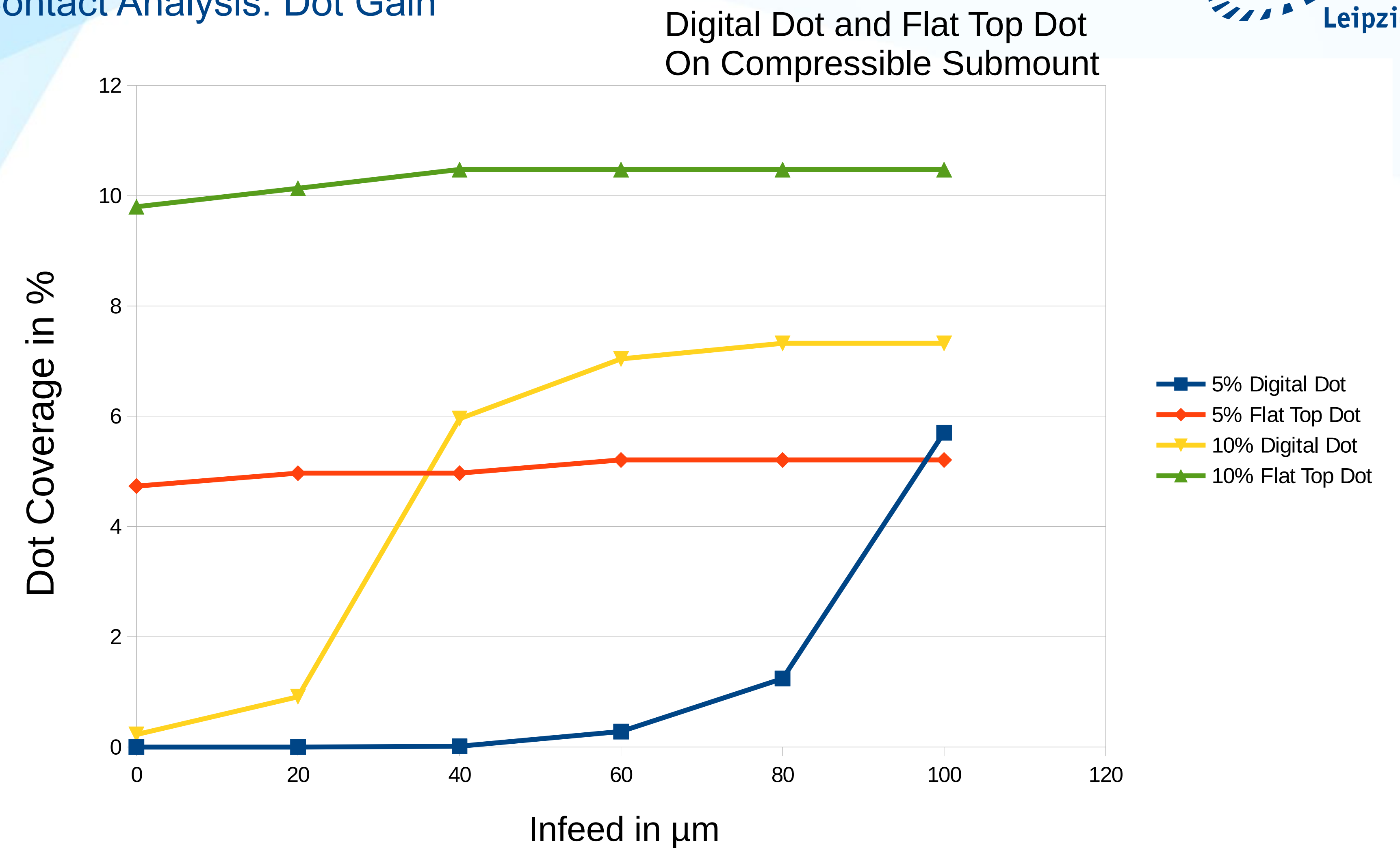


Contact Analysis



Digital Dot Compressible Submount

Contact Analysis: Dot Gain



Summary

Open source software works

Open source software can be used in predicting effects in printing

Students can use the software

Further effects and more physics can be added
→ ink behaviour
→ compression of the substrate (e.g. corrugated board)

For further Questions:

holger.zellmer@htwk-leipzig.de