

BITS F415: Introduction to MEMS

Experiment 1: Introduction to COMSOL

August 31, 2021

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Report date

Sep 9, 2021 1:10:05 PM

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1 Global Definitions

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GLOBAL SETTINGS

Name	Cantilever.mph
Version	COMSOL Multiphysics 5.5 (Build: 359)

USED PRODUCTS

COMSOL Multiphysics
CAD Import Module

2 Component 1

2.1 DEFINITIONS

2.1.1 Coordinate Systems

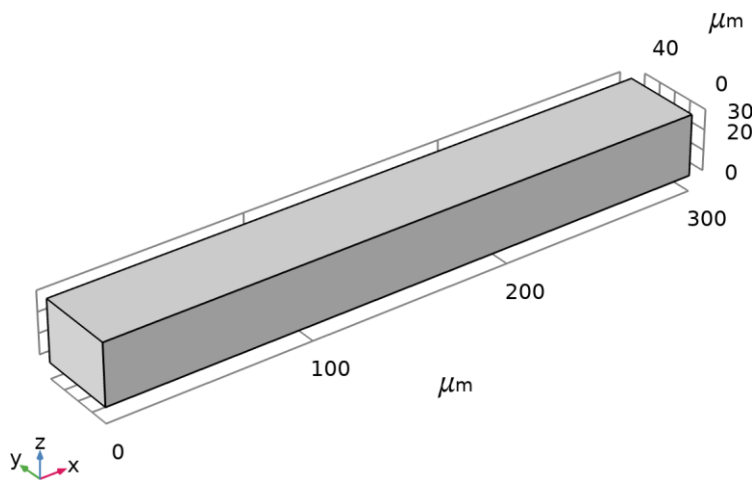
Boundary System 1

Coordinate system type	Boundary system
Tag	sys1

COORDINATE NAMES

First	Second	Third
t1	t2	n

2.2 GEOMETRY 1



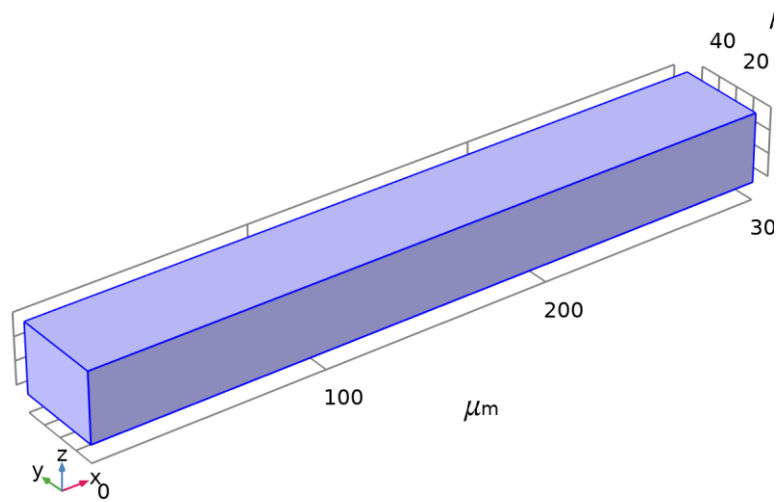
Geometry 1

UNITS

Length unit	μm
Angular unit	deg

2.3 MATERIALS

2.3.1 Silicon

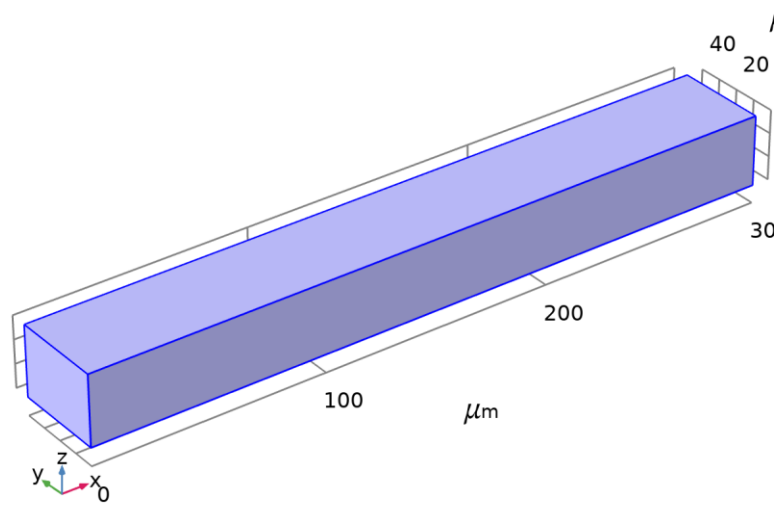


Silicon

SELECTION

Geometric entity level	Domain
Selection	Geometry geom1: Dimension 3: All domains

2.4 SOLID MECHANICS



Solid Mechanics

EQUATIONS

$$0 = \nabla \cdot \mathbf{S} + \mathbf{F}_V$$

FEATURES

Linear Elastic Material 1
Free 1
Initial Values 1
Fixed Constraint 1
Boundary Load 1

2.4.1 Linear Elastic Material 1

EQUATIONS

$$0 = \nabla \cdot \mathbf{S} + \mathbf{F}_V$$

$$\mathbf{S} = \mathbf{S}_{ad} + \mathbf{C} : \boldsymbol{\epsilon}_{el}, \quad \boldsymbol{\epsilon}_{el} = \boldsymbol{\epsilon} - \boldsymbol{\epsilon}_{inel}$$

$$\boldsymbol{\epsilon}_{inel} = \boldsymbol{\epsilon}_0 + \boldsymbol{\epsilon}_{ext} + \boldsymbol{\epsilon}_{th} + \boldsymbol{\epsilon}_{hs} + \boldsymbol{\epsilon}_{pl} + \boldsymbol{\epsilon}_{cr} + \boldsymbol{\epsilon}_{vp}$$

$$\mathbf{S}_{ad} = \mathbf{S}_0 + \mathbf{S}_{ext} + \mathbf{S}_q$$

$$\boldsymbol{\epsilon} = \frac{1}{2} \left[(\nabla \mathbf{u})^T + \nabla \mathbf{u} \right]$$

$$\mathbf{C} = \mathbf{C}(E, \nu)$$

2.4.2 Fixed Constraint 1

EQUATIONS

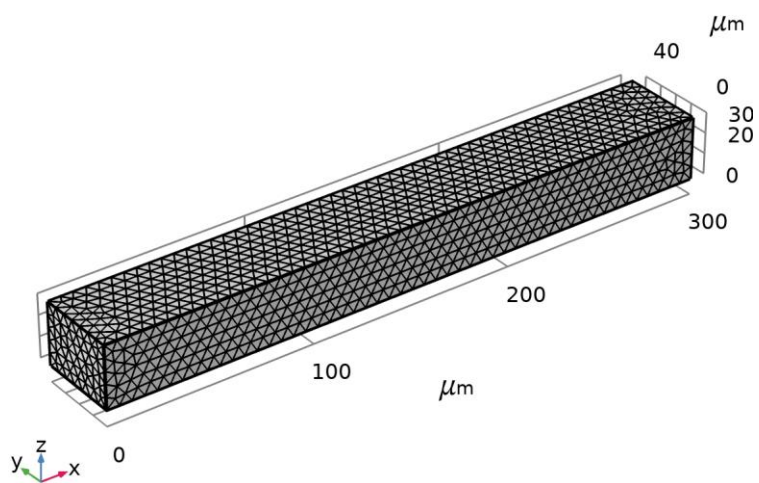
$$\mathbf{u} = \mathbf{0}$$

2.4.3 Boundary Load 1

EQUATIONS

$$\mathbf{S} \cdot \mathbf{n} = \mathbf{F}_A$$

2.5 MESH 1



Mesh 1

3 Study 1

COMPUTATION INFORMATION

Computation time	16 s
CPU	Intel64 Family 6 Model 158 Stepping 10, 6 cores
Operating system	Windows 10

3.1 STATIONARY

STUDY SETTINGS

Description	Value
Include geometric nonlinearity	Off

PHYSICS AND VARIABLES SELECTION

Physics interface	Discretization
Solid Mechanics (solid)	physics

MESH SELECTION

Geometry	Mesh
Geometry 1 (geom1)	mesh1

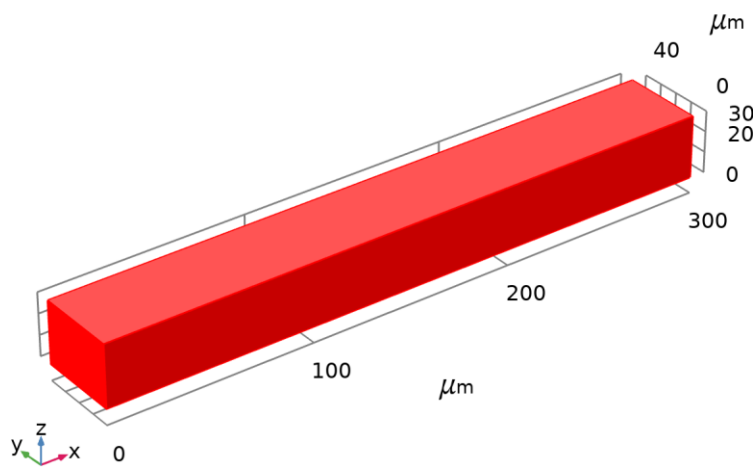
4 Results

4.1 DATASETS

4.1.1 Study 1/Solution 1

SOLUTION

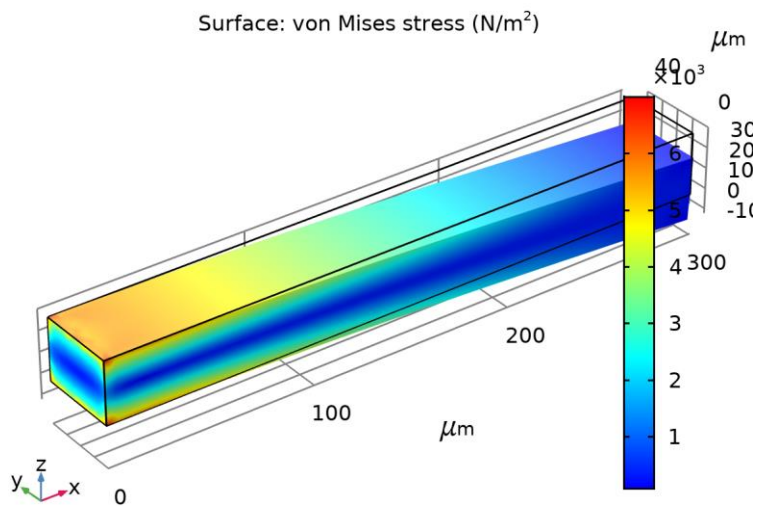
Description	Value
Solution	Solution 1
Component	Save Point Geometry 1



Dataset: Study 1/Solution 1

4.2 PLOT GROUPS

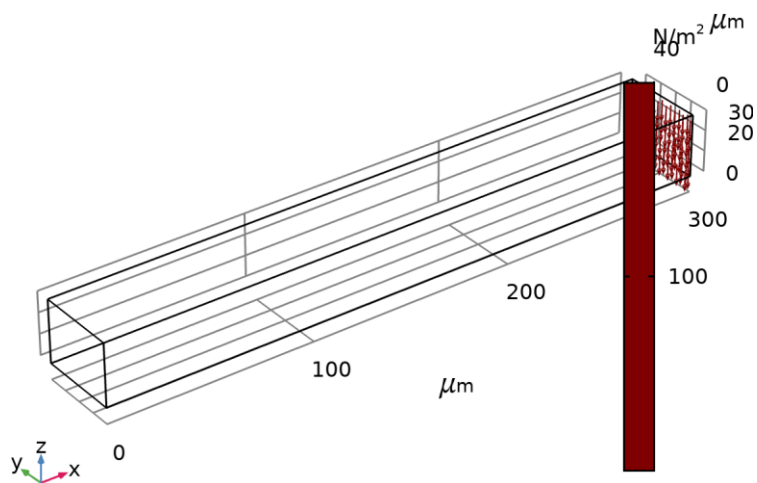
4.2.1 Stress (solid)



Surface: von Mises stress (N/m^2)

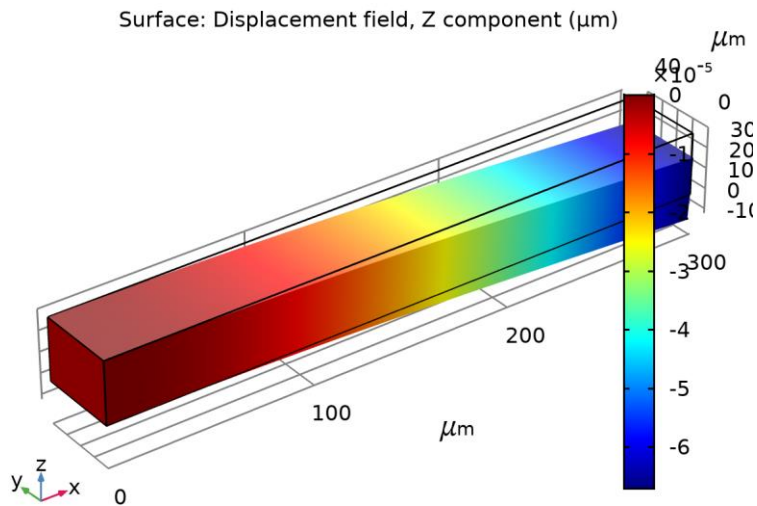
4.3 APPLIED LOADS (SOLID)

4.3.1 Boundary Loads (solid)



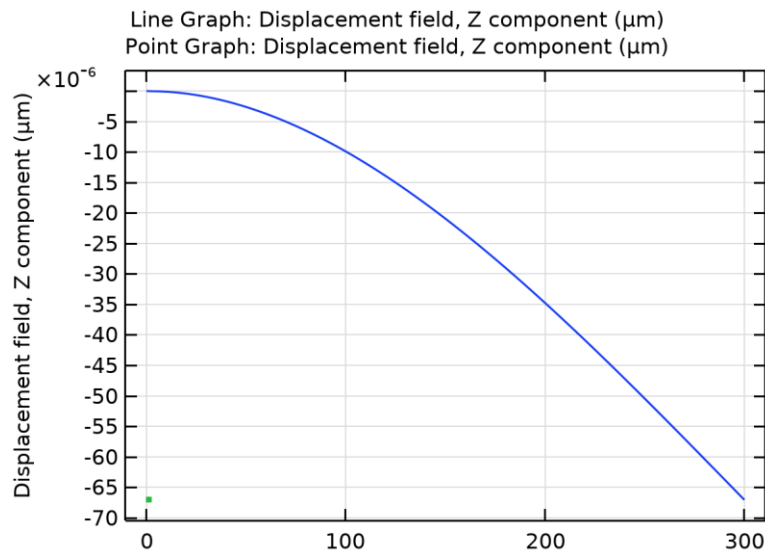
4.4 PLOT GROUPS

4.4.1 3D Plot Group 3



Surface: Displacement field, Z component (μm)

4.4.2 1D Plot Group 4



Line Graph: Displacement field, Z component (μm) Point Graph: Displacement field, Z component (μm)

4.5 EVALUATION GROUPS

4.5.1 Evaluation Group 1

FEATURES

Feature	Column
Point Evaluation 1	Displacement field, Z component (μm), Point: 6

RESULTS

Displacement field, Z component (μm), Point: 6
-6.7070E-5

4.6 CONVERGENCE STUDY

MESH TYPE	DOMAIN ELEMENTS	POINT DISPLACEMENT (μm)
EXTREMELY COURSE	12	-6.02E-05
COURSE	85	-6.62E-05
NORMAL	244	-6.68E-05
FINE	342	-6.69E-05
EXTREMELY FINE	26464	-6.71E-05

