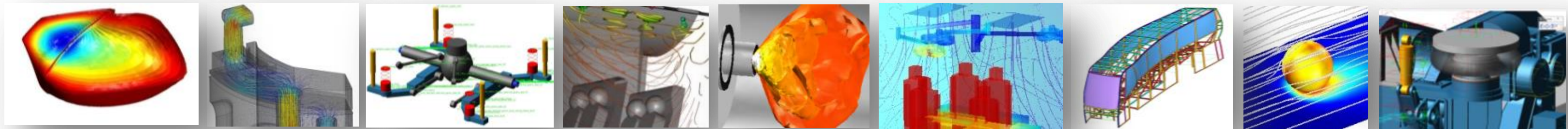
COMSOL CONFERENCE
2015 GRENOBLE

BE CAE & TEST

BE CAE & Test



A Comsol APP for thermal analysis of electronic devices

Giuseppe Petrone, Carmelo Barbagallo and Marco Scionti

BE CAE & TEST, Viale Africa 170 Sc. A, 95129 Catania (ITALY)

Grenoble, 14-16 October 2015

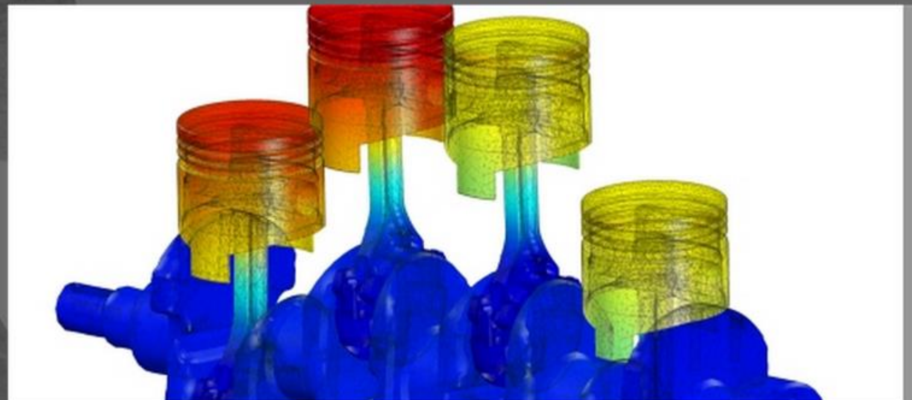
http://www.be-caetest.it

BE CAE & Test (http://www.be-caetest.it) provides consultancy services in several industrial sectors by using innovative **CAD/CAE modelling tools** and carrying out **experimental campaigns**

The company collaborates with **industrial partners** and **research centers** in several technologic fields

http://www.be-caetest.it/

Activities
Services
Partners
Customers
News
Contact us



Our team of engineers and researchers supports companies and individuals during their products and processes development by using advanced CAD/CAE tools and organizing accurate experimental tests.

The experience gained in experimental vibro-acoustics, FEM and Multibody numerical simulation and the use of Multiphysics packages make BE CAE & Test the ideal partner to guarantee reliability, innovation and competitiveness of your products and processes.

© 2015 BE CAE & Test S.r.l. | P.I. 05230570870

COMSOL Certified Consultants

COMSOL Certified Consultants use their extensive experience with COMSOL Multiphysics and our related products to deliver turnkey solutions for a wide range of modeling projects. They produce ready-to-run models and reports with an in-depth analysis of the simulation results.

https://www.comsol.it/certified-consultants

India

- ATOA Scientific Technologies Pvt. Ltd.
- Noumenon

Israel

- Rotem Industries Ltd.

Italy

- BE CAE & Test

Luxembourg (BeNeLux)

- Siegel Schleimer Ingénieurs-conseils s.à r.l.

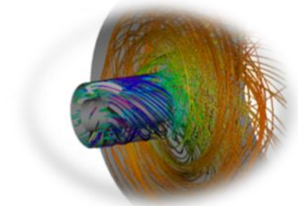
Our team of engineers and researchers supports companies and individuals during their products and processes development by using advanced CAD/CAE tools and organizing accurate experimental tests.

The experience gained in experimental vibro-acoustics, FEM and Multibody numerical simulation and the use of Multiphysics packages make BE CAE & Test the ideal partner to guarantee reliability, innovation and competitiveness of your products and processes.

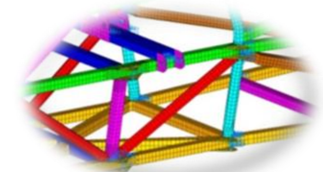
© 2015 BE CAE & Test S.r.l. | P.I. 05230570870

multiphysics

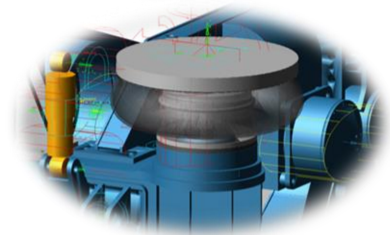
- **Fluid dynamics and thermal analyses**
  - Environmental energetics (HVAC, thermal comfort, IAQ)
  - Industrial energetics (Thermal design, energy conversion, reacting flows)



- **Structural analyses**
  - Linear and non-linear statics, dynamic and vibro-acustics analyses in industrial and civil applications

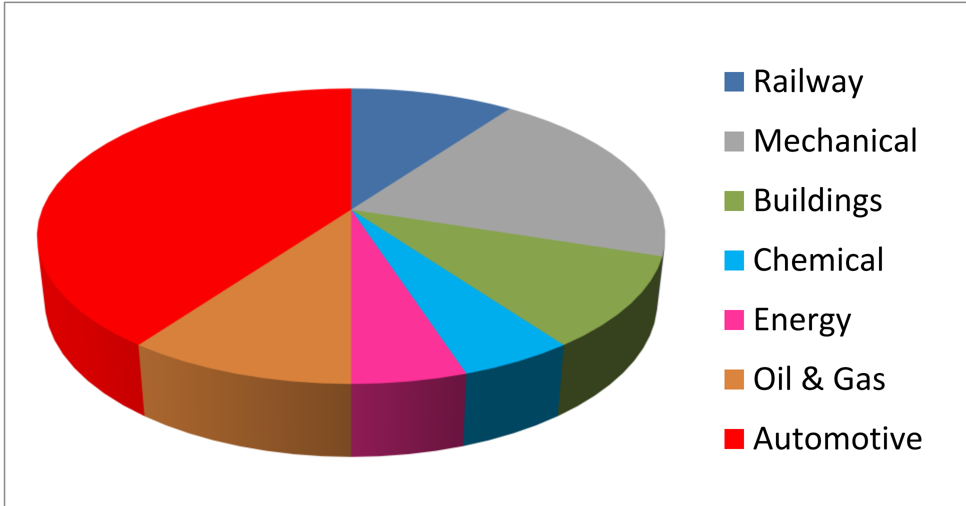


- **System dynamics and Multi-Body analyses**
  - Vehicle and rail dynamics (handling, ride comfort)
  - Kinematics, dynamics, rigid and flexible bodies analyses of mechanisms



- **Experimental testing**
  - Ride comfort (NVH), modal analyses
  - Human body vibrations (ISO standard)

BE CAE & Test / *Business areas and Customers*



BE CAE & Test collaborates with world-wide companies active in the fields of numerical simulations and experimental measurements.

➢ **Why thermal analysis of electronic devices?**

- Electronic devices produce a **very high rate** of specific **heat** (small dimensions)
- Exceeding in maximum safe operating temperature means strong reduction of **efficiency**, **reliability** and **lifetime**

Overheating is one of the main causes of failure for electronic equipment

Thermal design represents an unavoidable step in pre-production phase **in order to ensure reliability and performance of the electronic devices**

http://www.fludit.com/images/stories/Design/Cities-Made-From-Electronic-Components

Introduction / *Motivation*

➢ **Why thermal analysis of electronic devices?**

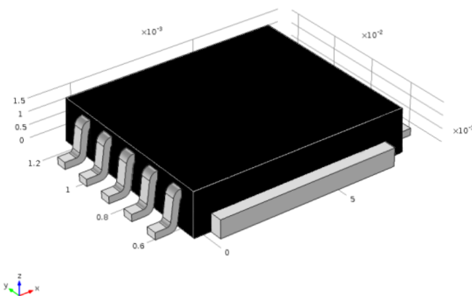
- Electronic devices produce a **very high rate** of specific **heat** (small dimensions)
- Exceeding in maximum safe operating temperature means strong reduction of **efficiency**, **reliability** and **lifetime**

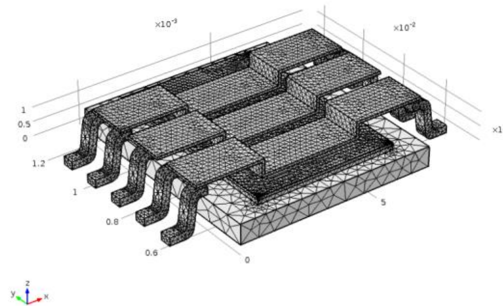
Overheating is one of the main causes of failure for electronic equipment

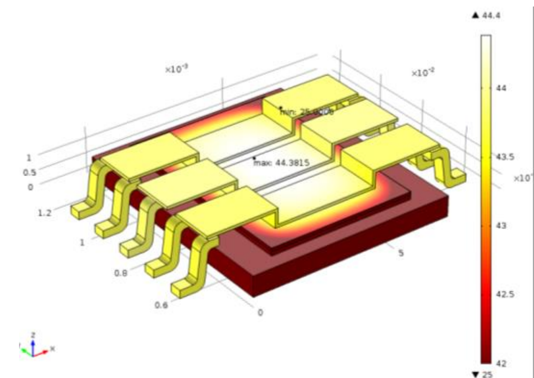
Thermal design represents an unavoidable step in pre-production phase **in order to ensure reliability and performance of the electronic devices**

http://www.fludit.com/images/stories/Design/Cities-Made-From-Electronic-Components

MODELLING & SIMULATION



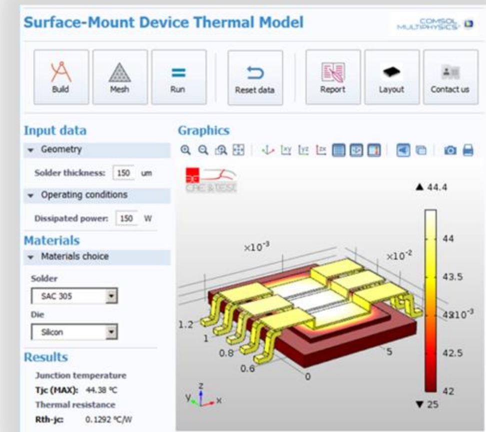




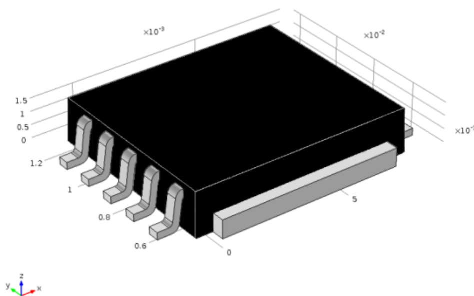
Introduction / *Motivation*

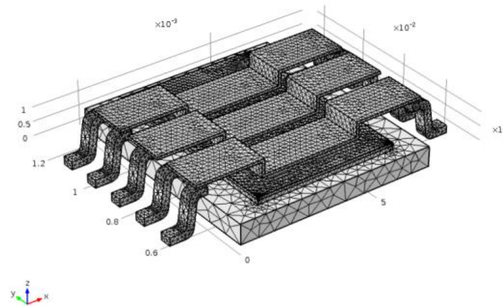
- Among the **new features** introduced in **Comsol Multiphysics**, the opportunity of building up **customized GUI** by exploiting the **Application Builder** is for sure one of the most promising

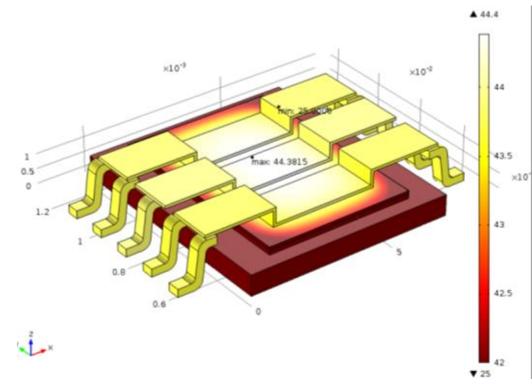
Arising from this concept, **BE CAE & Test built-up a Comsol APP** to analyse the thermal behavior of an electronic Surface-Mount Device (SMD)



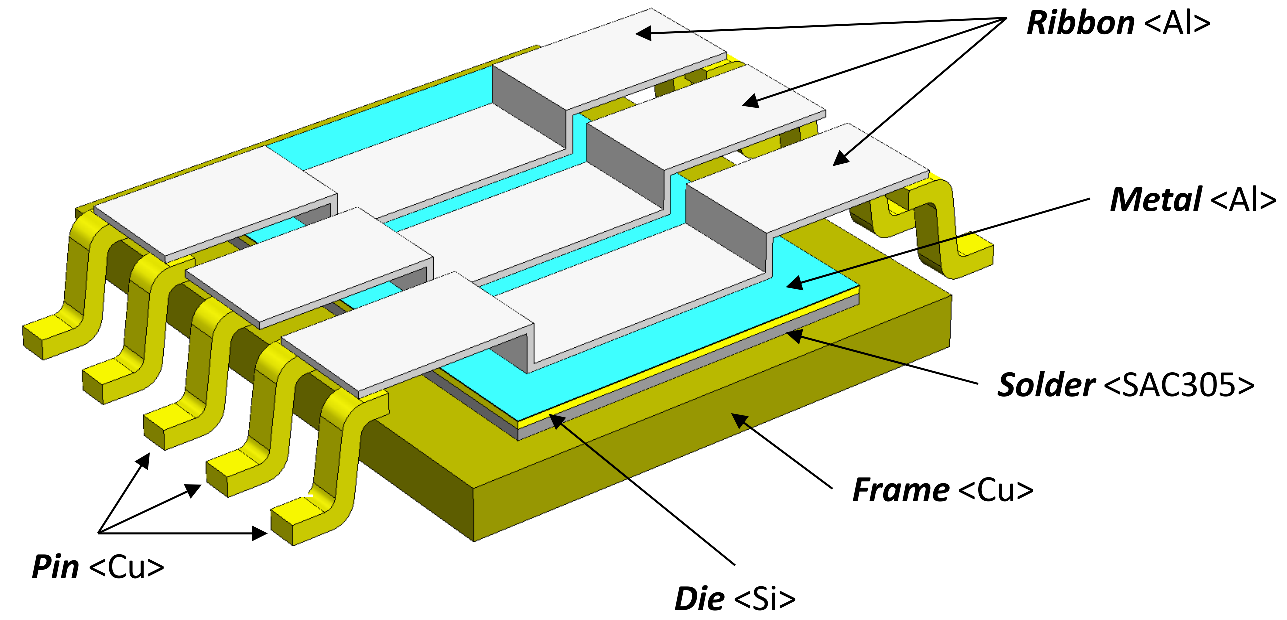
FROM MODEL TO APP

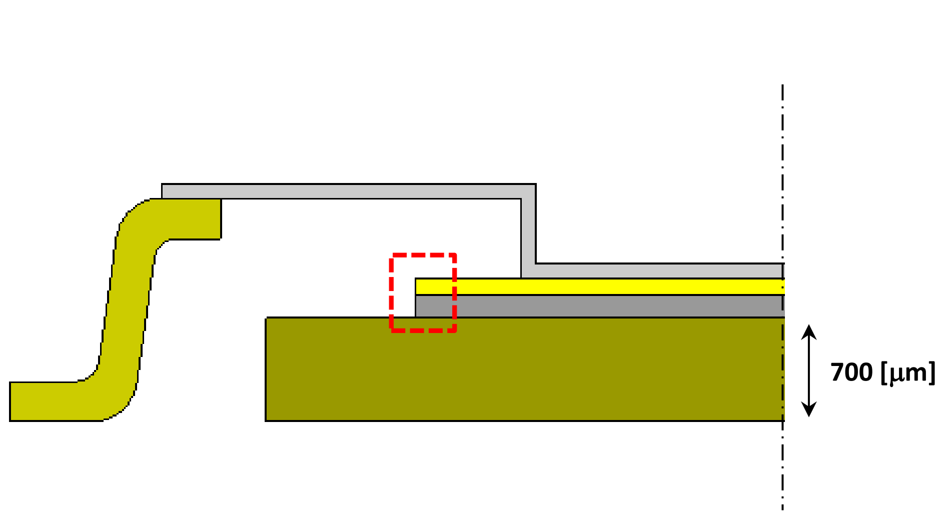


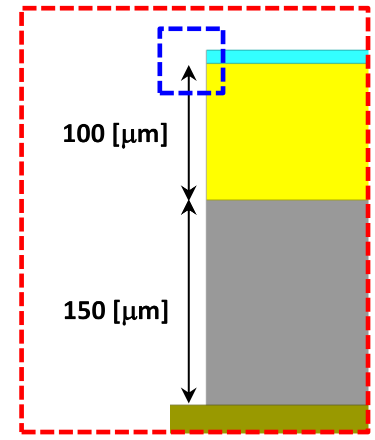


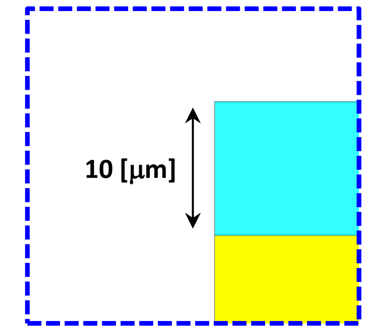


Surface –Mount Device / *Layout*









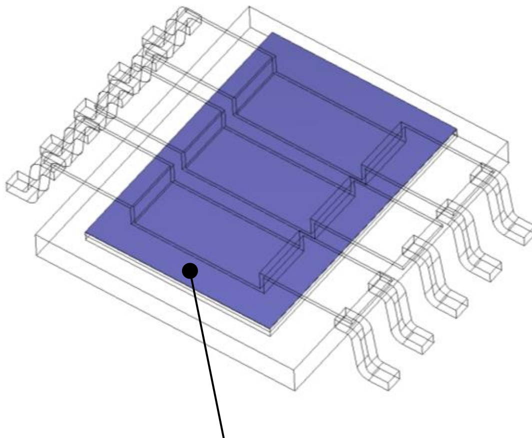
THERMAL ANALYSIS

Input: Dissipated thermal power
Frame temperature (corresponding to initial conditions)

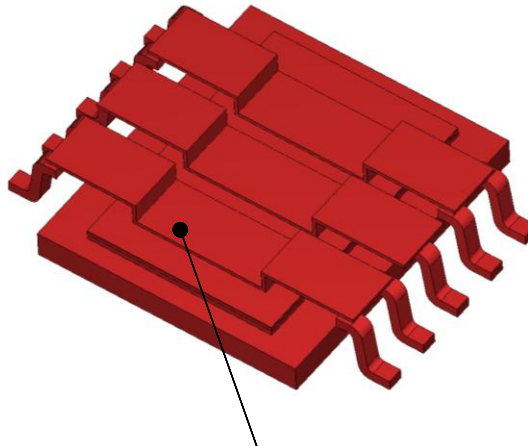
Output: **Temperature distribution**

Energy equation

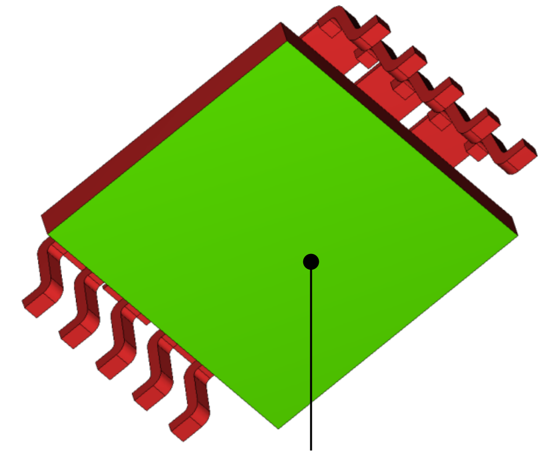
$$\rho C_p \frac{\partial T}{\partial t} = \nabla \cdot (k \nabla T) + Q$$



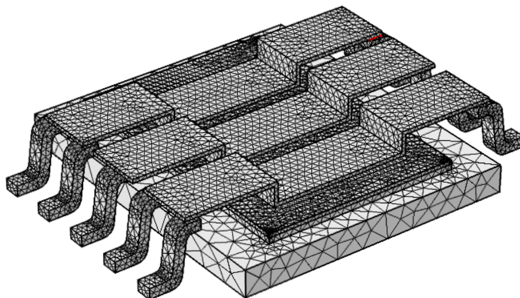
Heat source (Die ON)
P_{th} = 150 W



Insulation (package)
$-\boldsymbol{n} \cdot \boldsymbol{k}\nabla\boldsymbol{T} = \boldsymbol{0}$



Frame temperature
T_{ref} = 25 °C



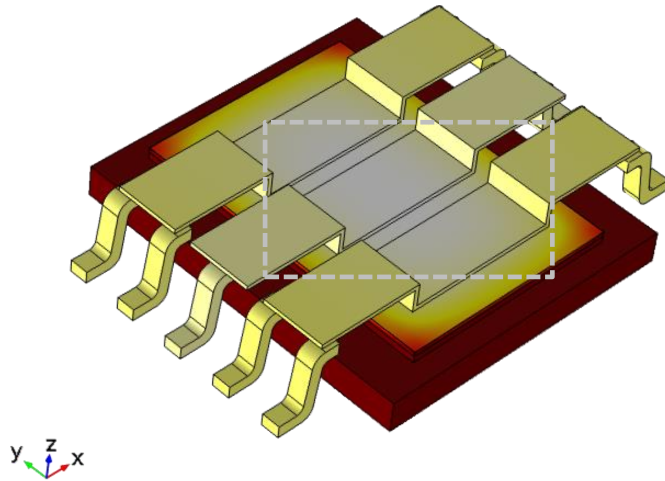
- Non-uniform and non-structured computational grids made of tetrahedral Lagrange elements of order 2 (~ 45,000 elements)
- Time-marching by using a Implicit Differential-Algebraic (IDA) solver based on a variable-order and variable-step-size Backward Differentiation Formulas (BDF)
- Direct solver (PARDISO) for linear systems
- Computational node : 2 x 64-bit dual-core @2,30 GHz - RAM 128 GB

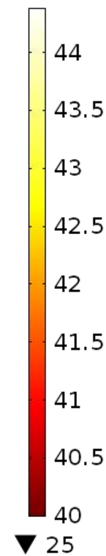
THERMAL ANALYSIS

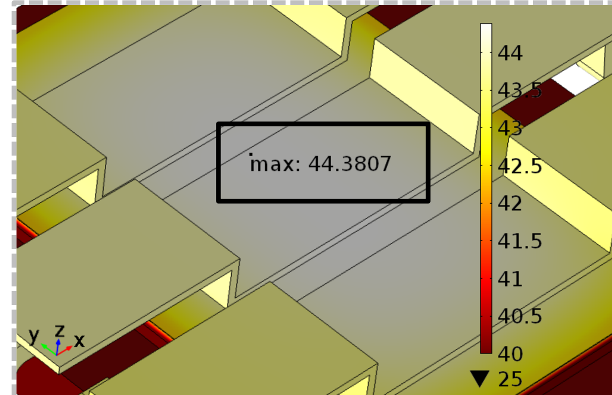
<u>Input:</u> Dissipated thermal power
Frame temperature (corresponding to initial conditions)

<u>Output:</u> **Temperature distribution**

Temperature [°C]





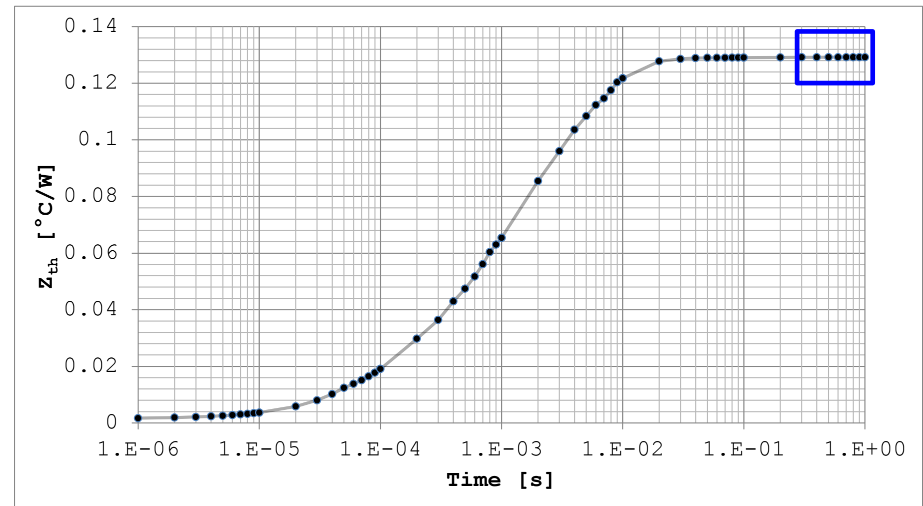


T_{jc} (MAX) = 44,4 [°C]

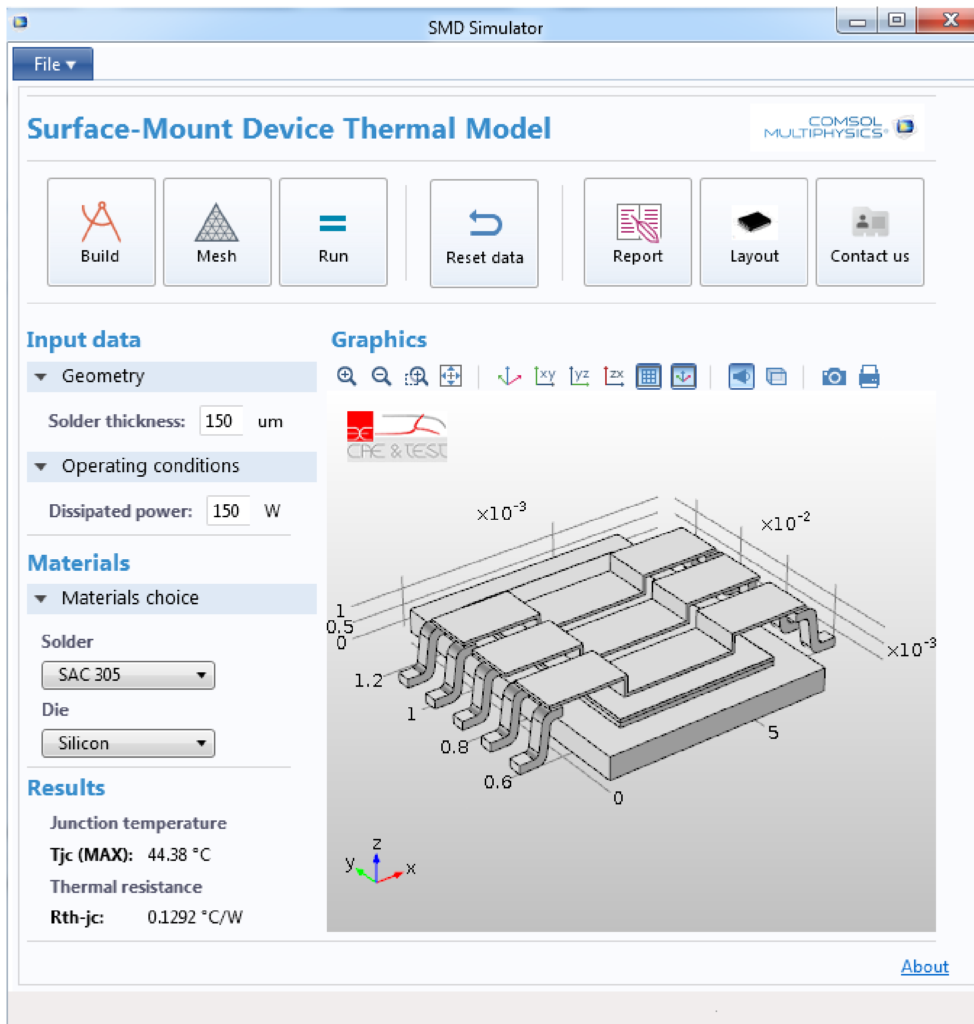
R_{th-jc} = 0,13 [°C/W]

Thermal Impedance

$$Z_{th} = \frac{T - T_{ref}}{P_{th}}$$

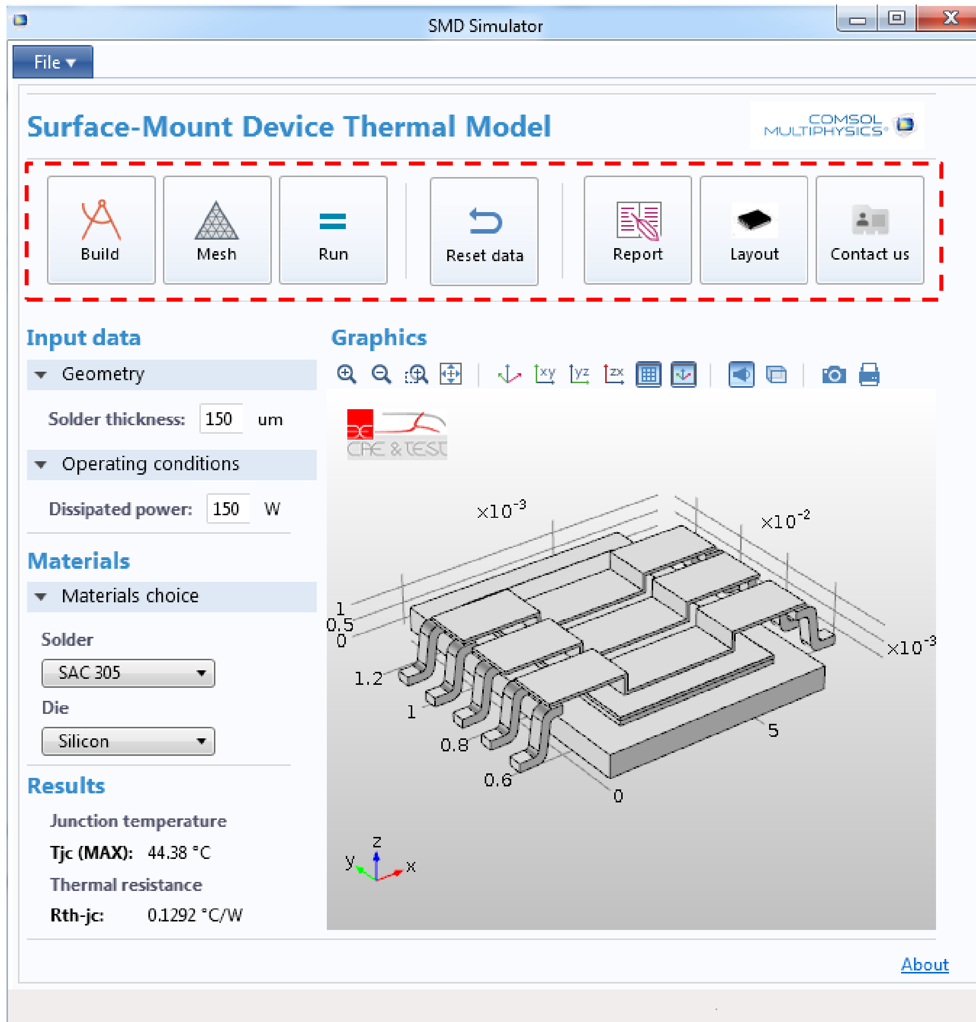


Building APP in COMSOL 5.1: "SMD Simulator / Thermal Model"



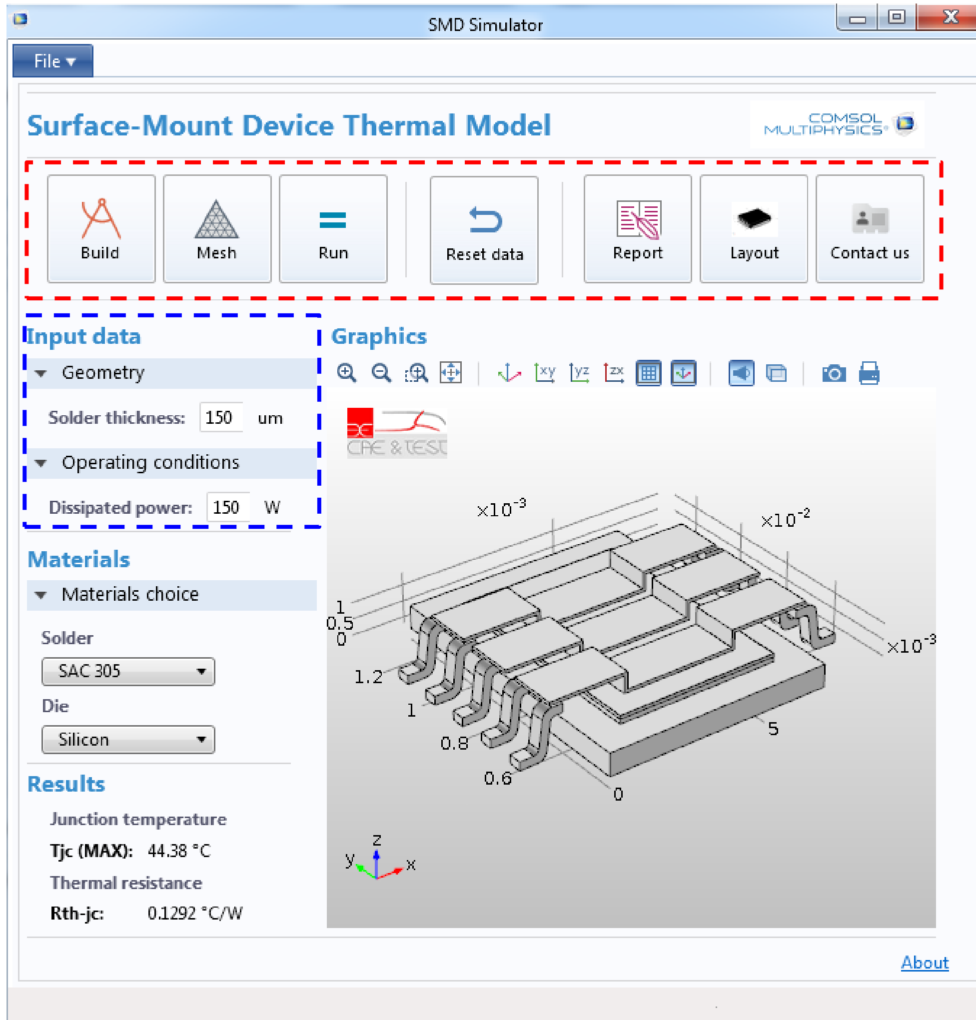
- **What is that?**
  - Customized GUI allowing users to carry-out parametrical simulations without build models
- **Which kind of «paramteric» analysis?**
  - **Geometrical**
  - **Constitutive**: materials, assumption (i.e. plasticity model in structural analysis, flow regime in fluid dynamics, …)
  - **Funcional**: any operational or working condition
  - **Derived value**: any value derived from FE dependent variable solved (i.e. a thermal flux from temperature solution in thermal analysis)
  - …
  - …

Building APP in COMSOL 5.1: "SMD Simulator / Thermal Model"



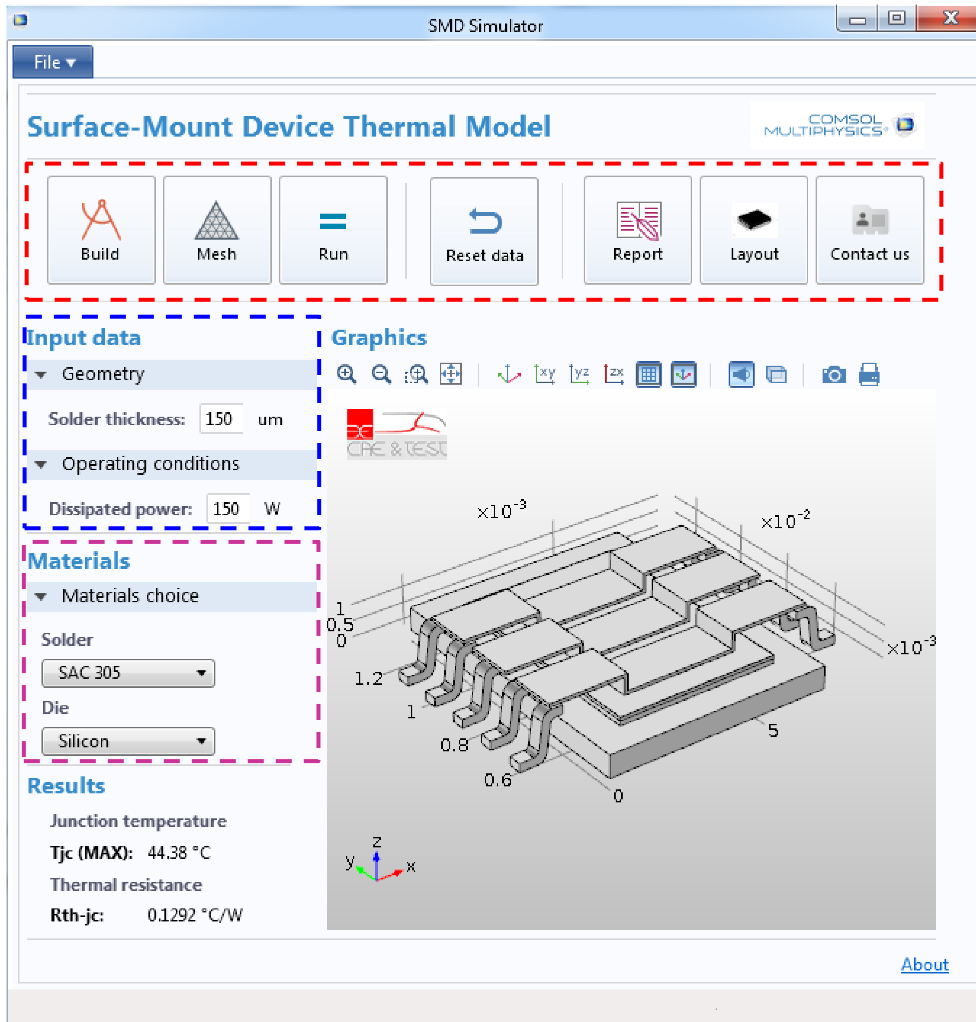
- **Action button**

Building APP in COMSOL 5.1: “SMD Simulator / Thermal Model”



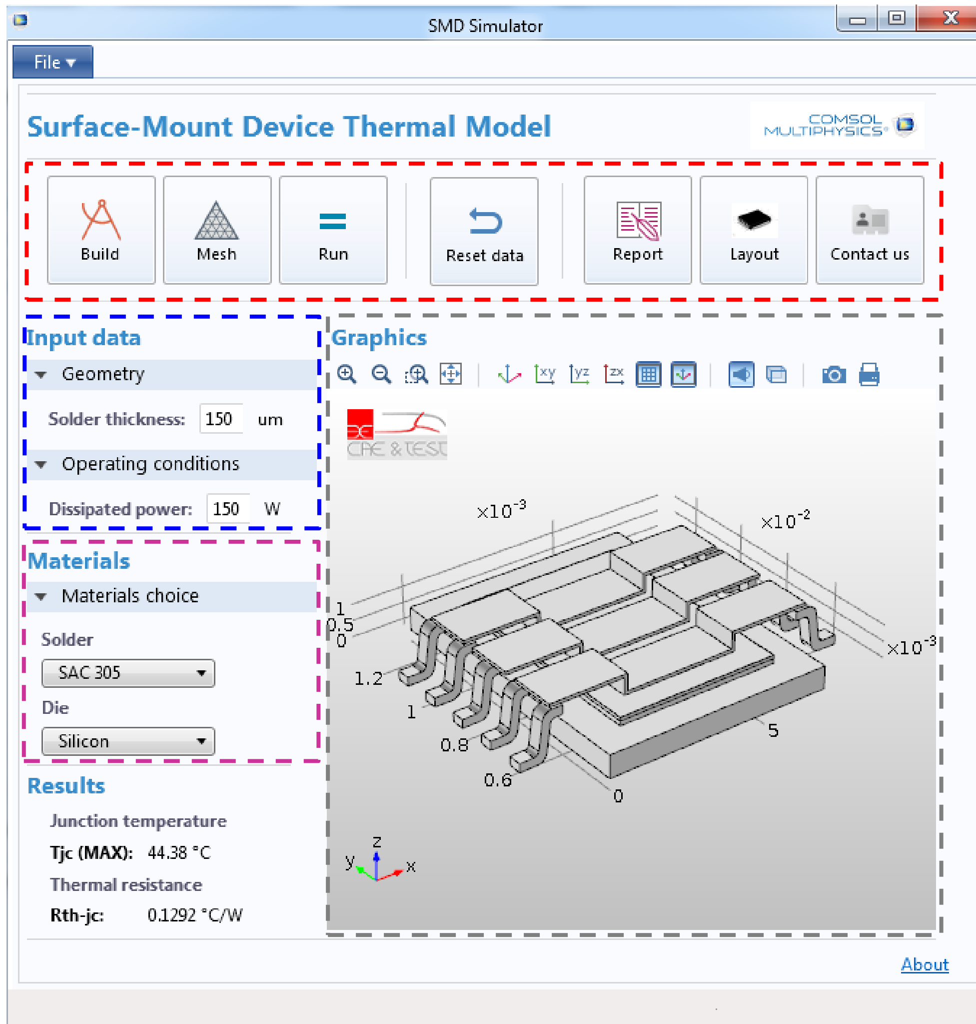
- **Action button**
- **Input field**

Building APP in COMSOL 5.1: “SMD Simulator / Thermal Model”



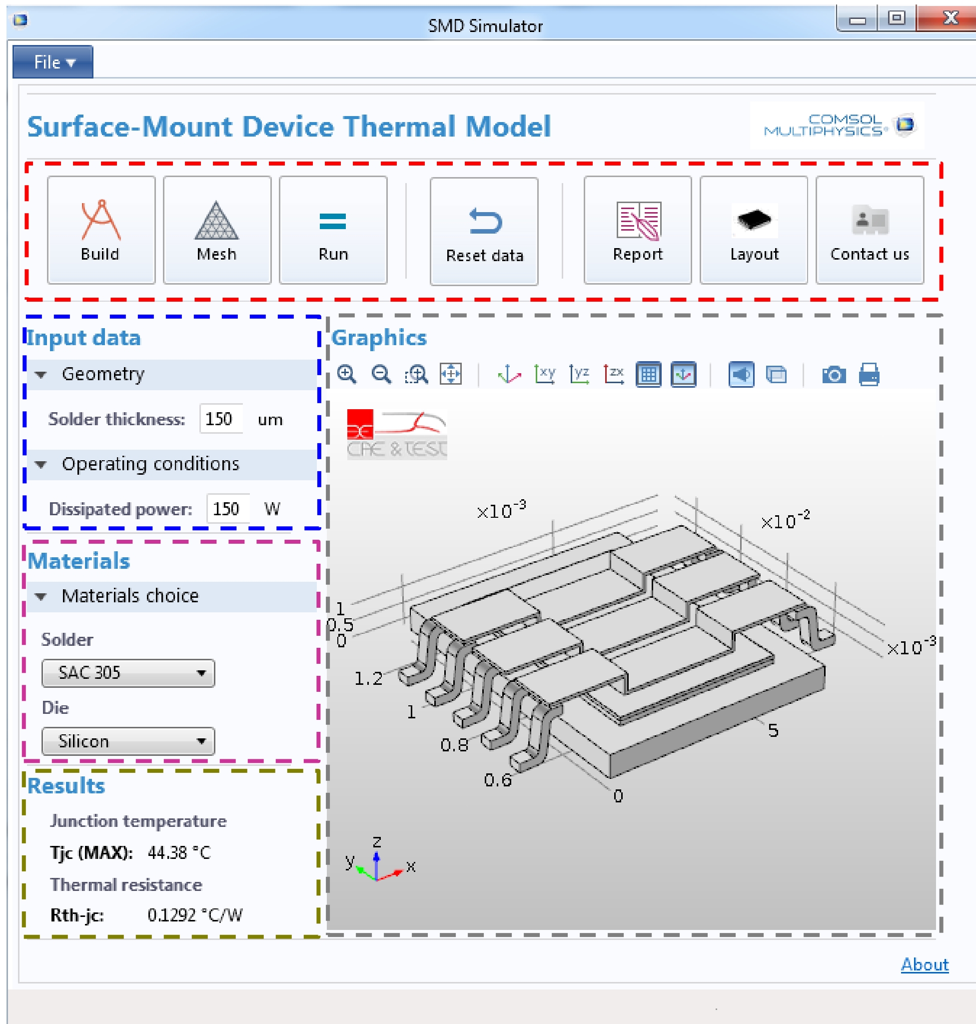
- Action button
- Input field
- Combo Box

Building APP in COMSOL 5.1: "SMD Simulator / Thermal Model"



- Action button
- Input field
- Combo Box
- Graphics

Building APP in COMSOL 5.1: “SMD Simulator / Thermal Model”



- Action button
- Input field
- Combo Box
- Graphics
- Data Display

THERMAL ANALYSIS / *APP*

Building APP in COMSOL 5.1: "SMD Simulator / Thermal Model"

- **Geometry - > Input field**

Parameters

Name	Expression	Value	Description
s_solder	150[um]	1.5E-4 m	Solder thickness
s_frame	7.0E-4[m]	7E-4 m	Frame thickness
P_max	150[W]	150 W	Dissipated power
T_ref	25[degC]	298.15 K	Reference temperature

Declaration of parameters

Building APP in COMSOL 5.1: "SMD Simulator / Thermal Model"

➢ **Geometry - > Input field**

Parametric design

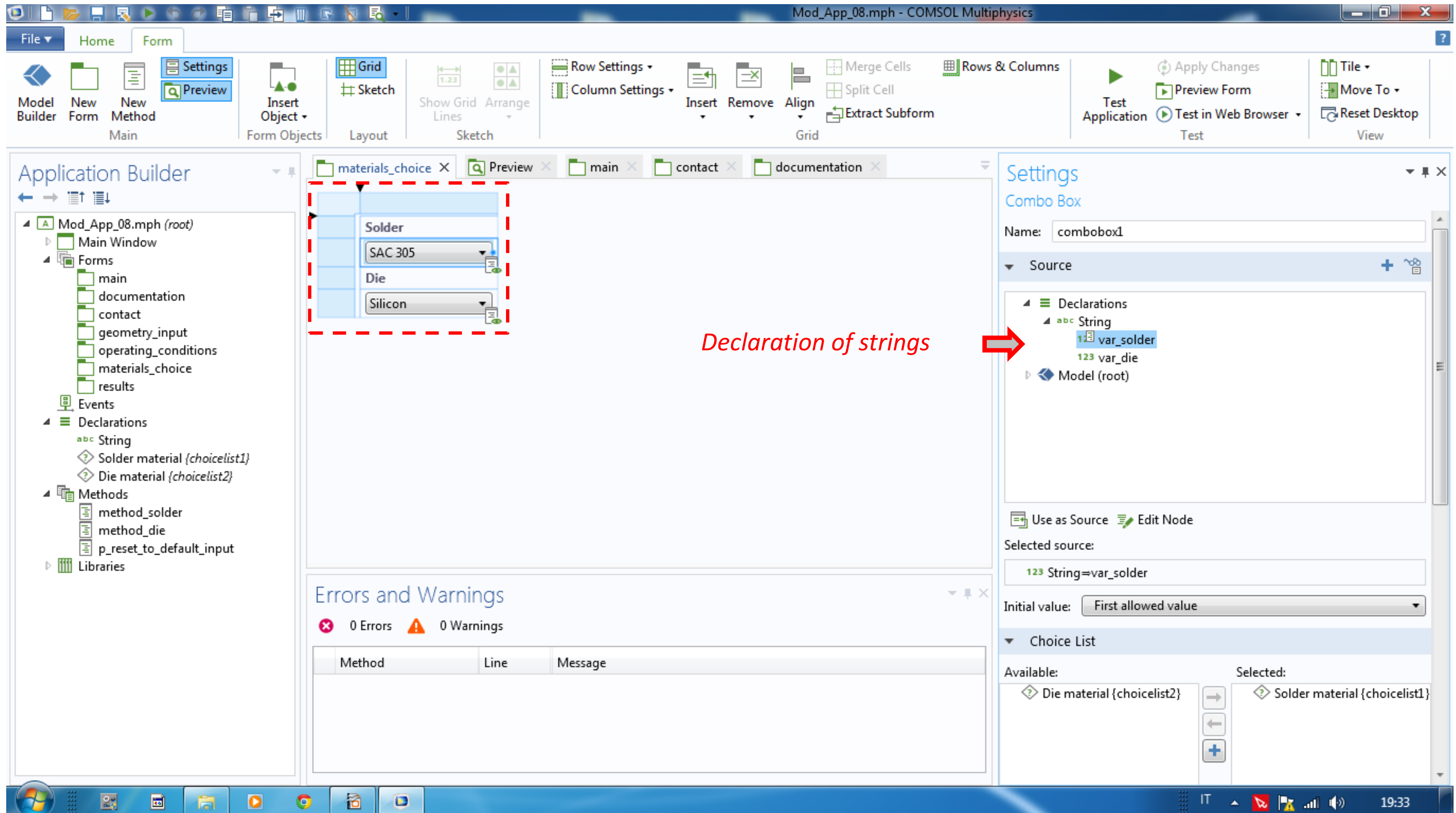
Building APP in COMSOL 5.1: "SMD Simulator / Thermal Model"

- **Constitutive / Materials -> Combo Box**

Global material / local link

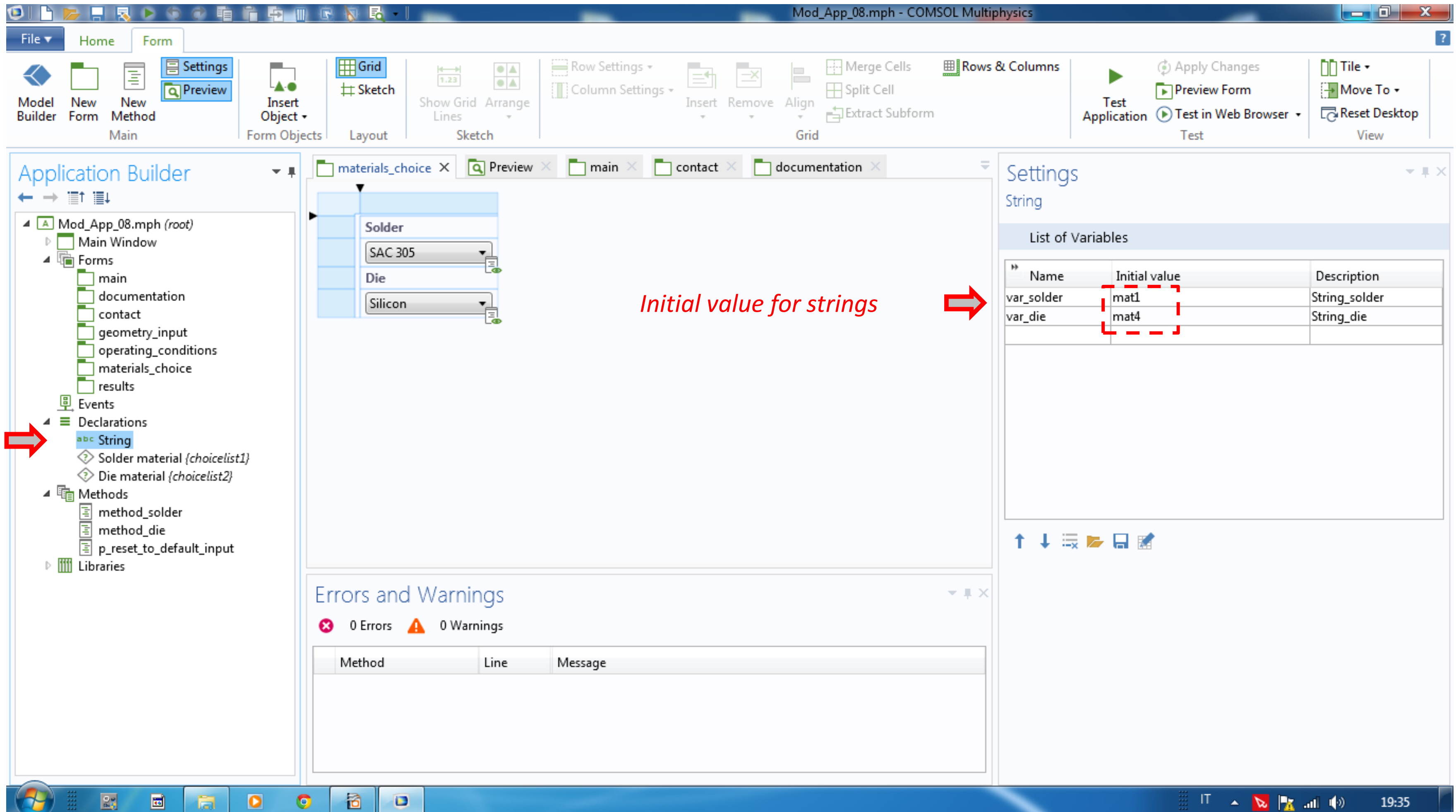
Building APP in COMSOL 5.1: "SMD Simulator / Thermal Model"

➢ **Constitutive / Materials -> Combo Box**



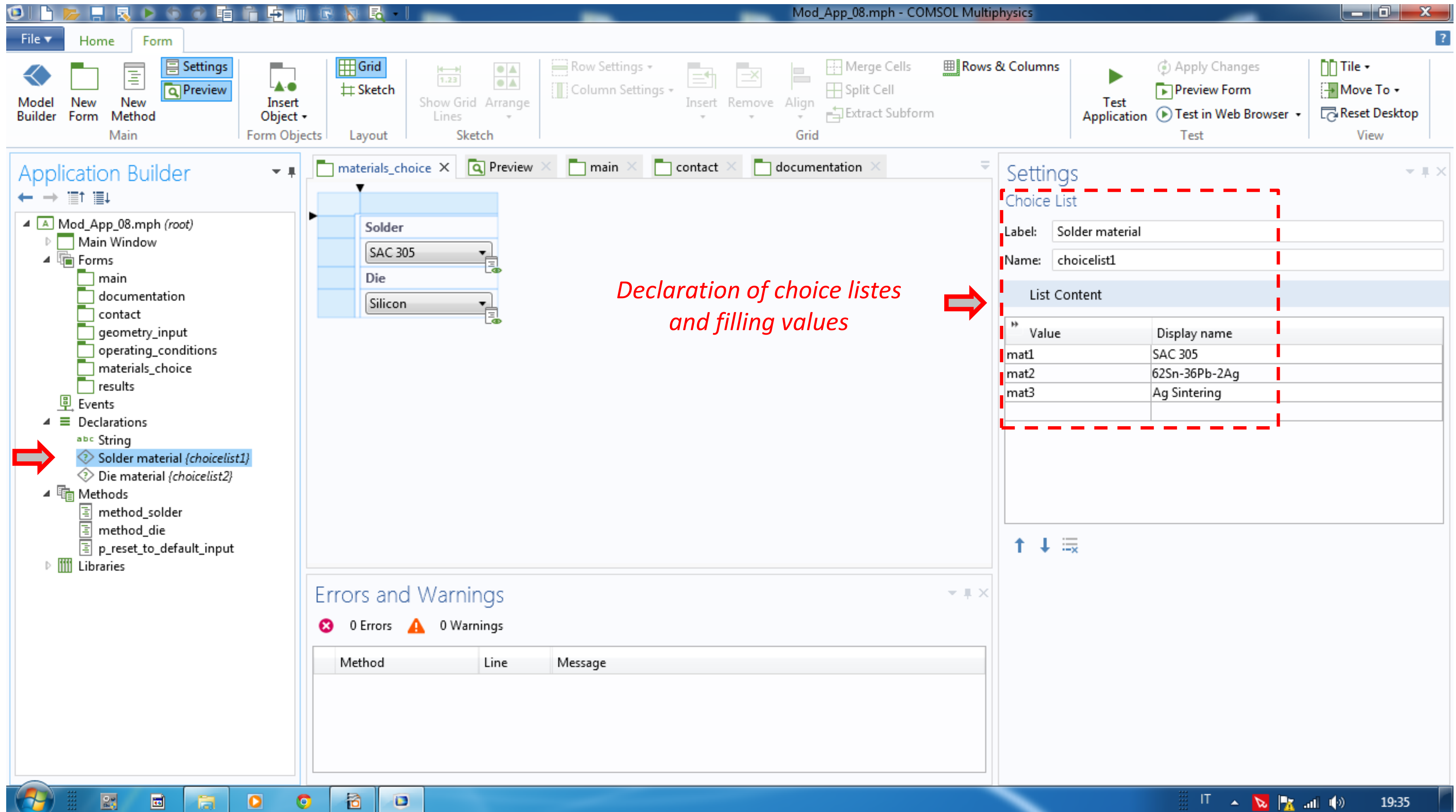
Building APP in COMSOL 5.1: “SMD Simulator / Thermal Model”

- **Constitutive / Materials -> Combo Box**



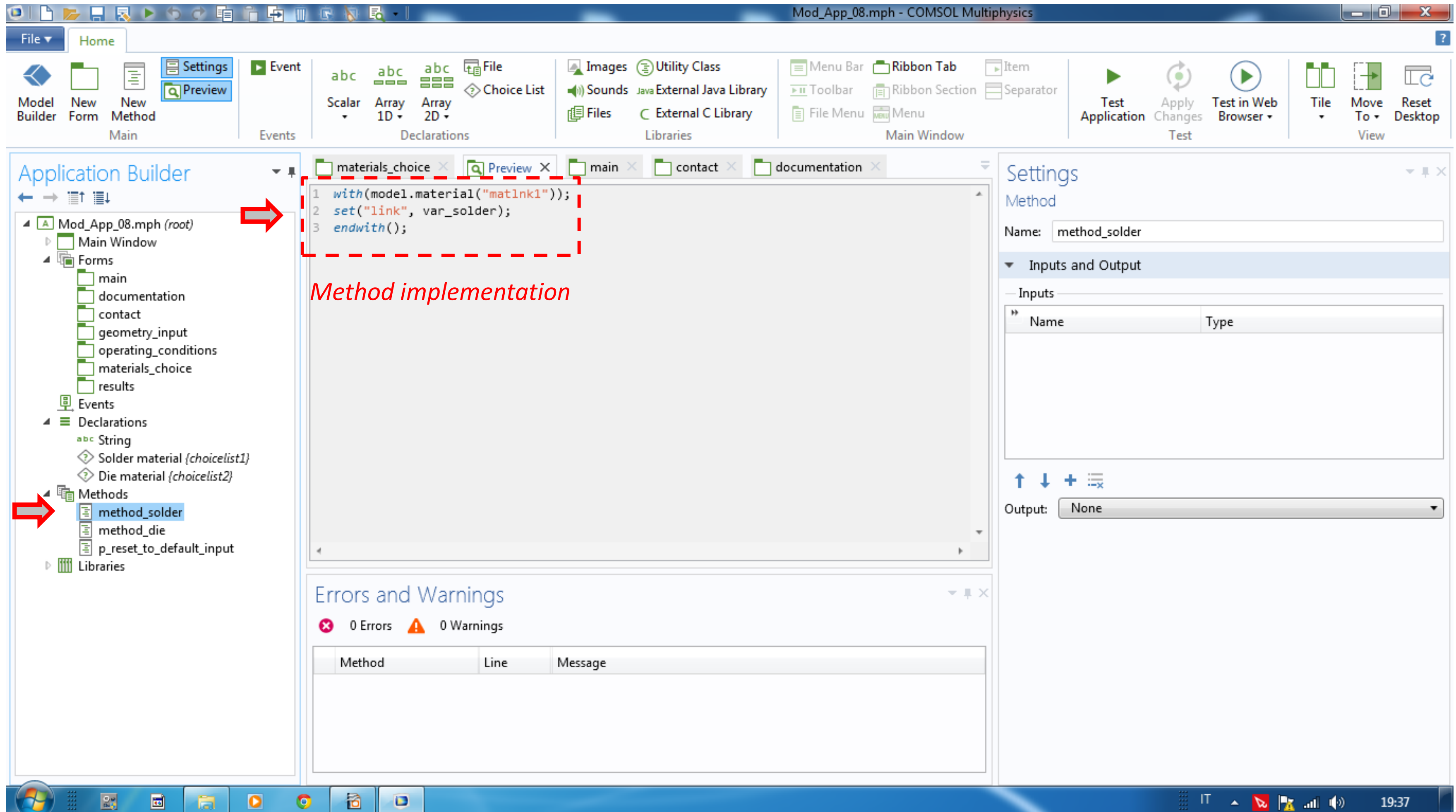
Building APP in COMSOL 5.1: “SMD Simulator / Thermal Model”

- **Constitutive / Materials -> Combo Box**



Building APP in COMSOL 5.1: “SMD Simulator / Thermal Model”

- **Constitutive / Materials -> Combo Box**



Building APP in COMSOL 5.1: “SMD Simulator / Thermal Model”

➢ **Derived values -> Probe / Global variable / Data Display**

Probe assuming a global variable value

Building APP in COMSOL 5.1: "SMD Simulator / Thermal Model"

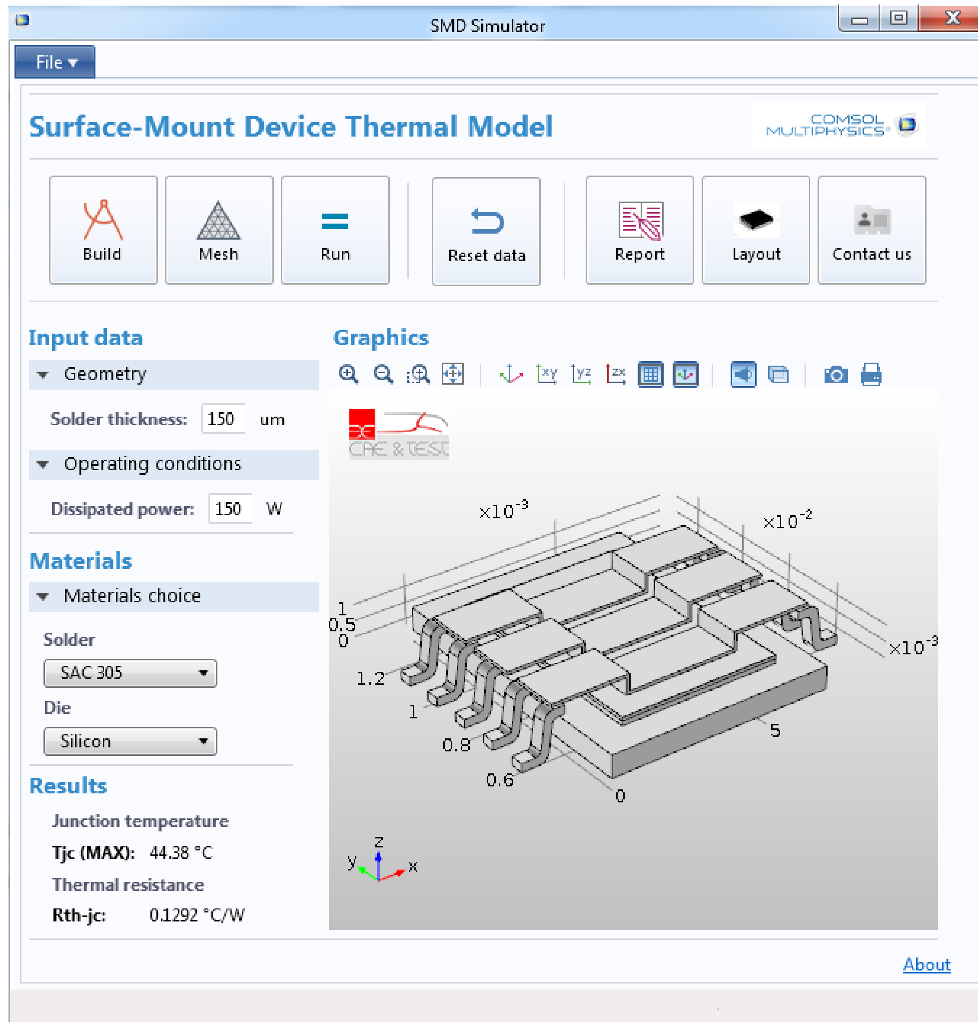
➢ **Derived values -> Probe / Global variable / Data Display**

Variable value depends in this case by another probe value

Name	Expression	Unit	Description
Rth	(root.comp1.dom1-T_r...	K/W	

(root.comp1.dom1-T_ref)/P_max

Building APP in COMSOL 5.1: “SMD Simulator / Thermal Model”



- **How to use it?**

COMSOL SERVER / *App launching*

Launching APP in COMSOL SERVER

App User

PC, Tablet, Smartphone

App platoform: COMSOL Server

COMSOL Multiphisycs User

COMSOL Server User

One-time user User

Web browser

App

App Developper

Remote App using

on Developper resource

Activities
Services
Partners
News
Contact us

Our team of engineers and researchers supports companies and individuals during their products and processes development by using advanced CAD/CAE tools and organizing accurate experimental tests.

The experience gained in experimental vibro-acoustics, FEM and Multibody numerical simulation and the use of Multiphysics packages make BE CAE & Test the ideal partner to guarantee reliability, innovation and competitiveness of your products and processes.

© 2015 BE CAE & Test S.r.l. | P.I. 05230570870

BE CAE & TEST S.r.l.

Viale Africa 170, Sc.A
95129 Catania (Italy)

Phone +39 095 216 64 26

URL: http://www.be-caetest.it
E-mail: info@be-caetest.it
PEC: info@pec.be-caetest.it

https://www.comsol.it/certified-consultants/bus