Improving The Design Process Of A MEMS-IR-Emitter

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SHORT FACTS - „CiS Forschungsinstitut“

- ➔ Research institution in Erfurt, Thuringia, Germany
- ➔ Independent - non-profit - close to business

16,5 MIO. € TOTAL OUTPUT IN 2022

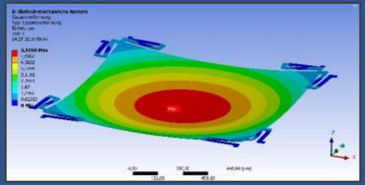
- ➔ ~120 Employees
- ➔ 52 % Public research projects
- ➔ 48 % Industrial contract research and manufacturing
- ➔ No basic funding, only project funding

→ MOEMS Development and Prototyping

TECHNOLOGICAL EXPERTISE

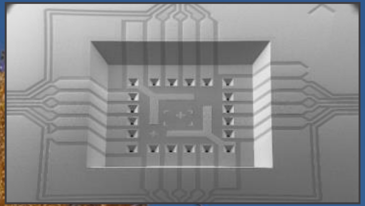
In MEMS and MOEMS sensors

Simulation & Design



Wafer Technology & Manufacturing

Packaging & Assembly



Test & Analytics

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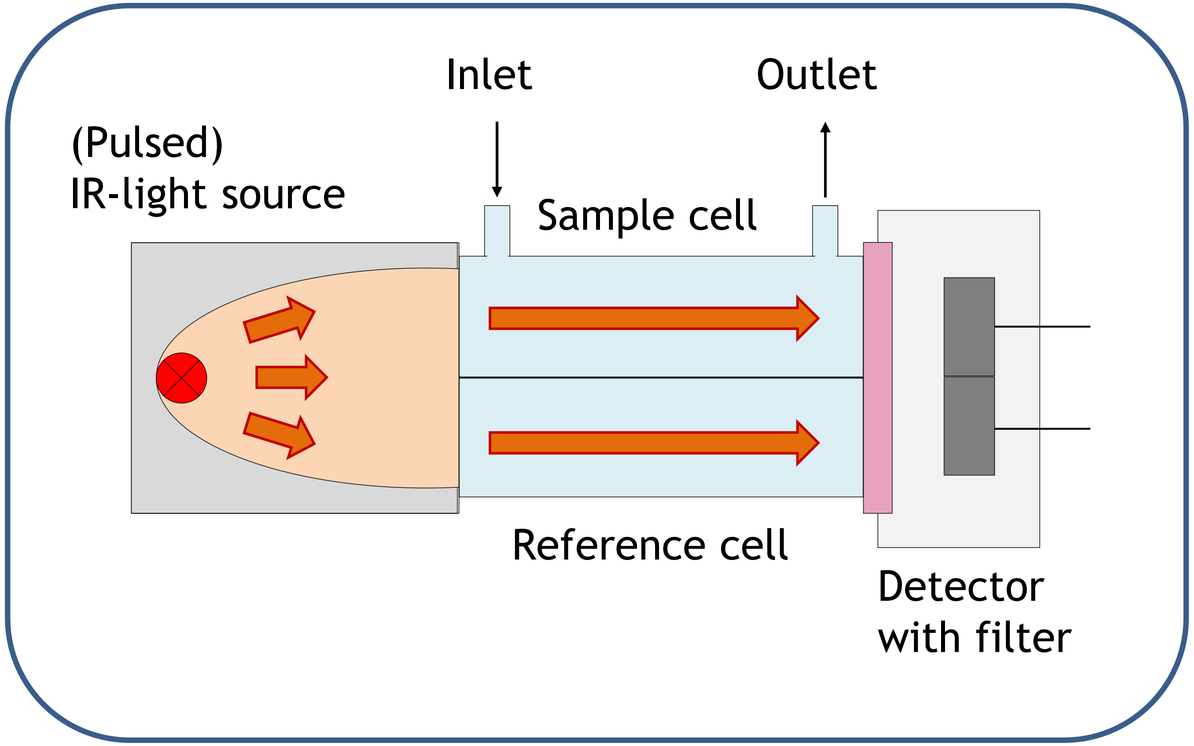
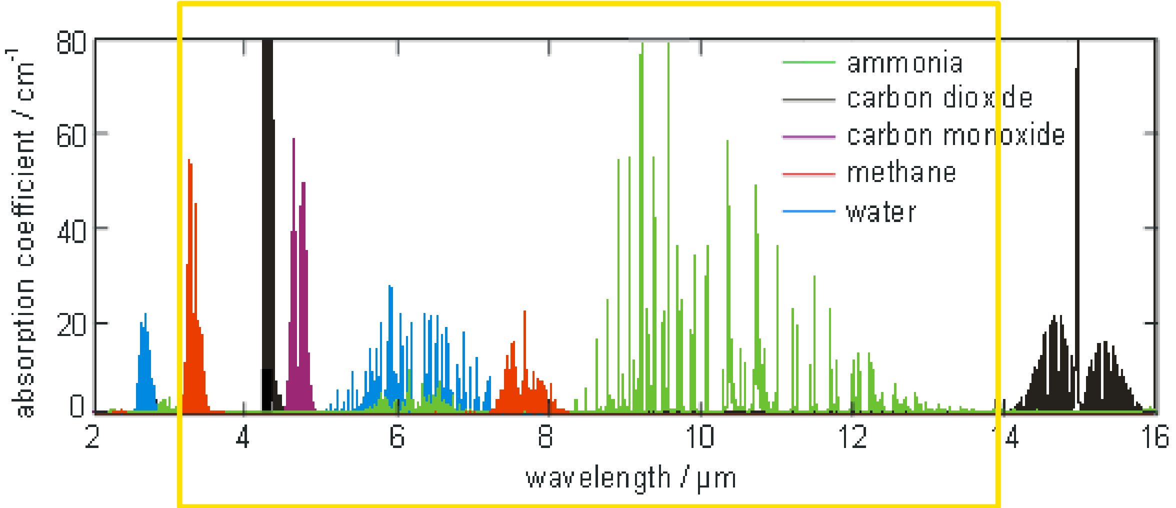
Background: IR-MEMS-Technology And Fabrication

Background: IR-Emitter-Technology

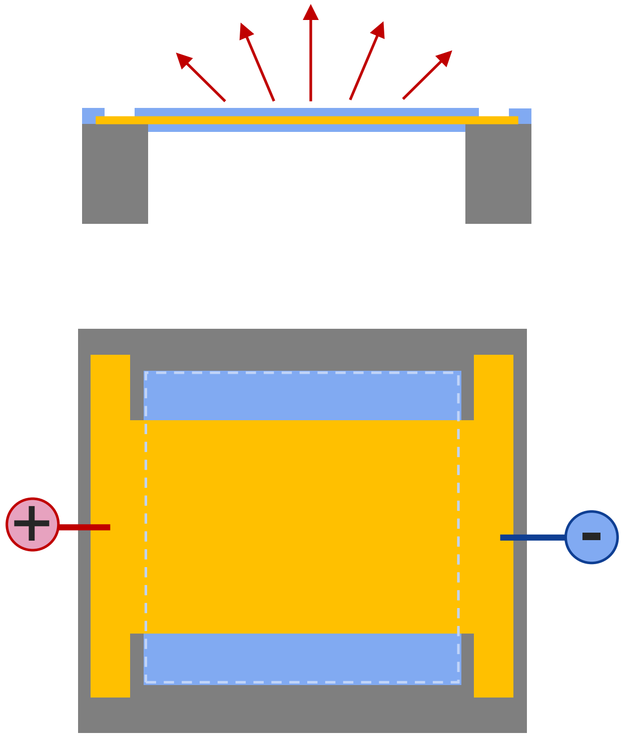
Nondispersive Infrared Gassensor



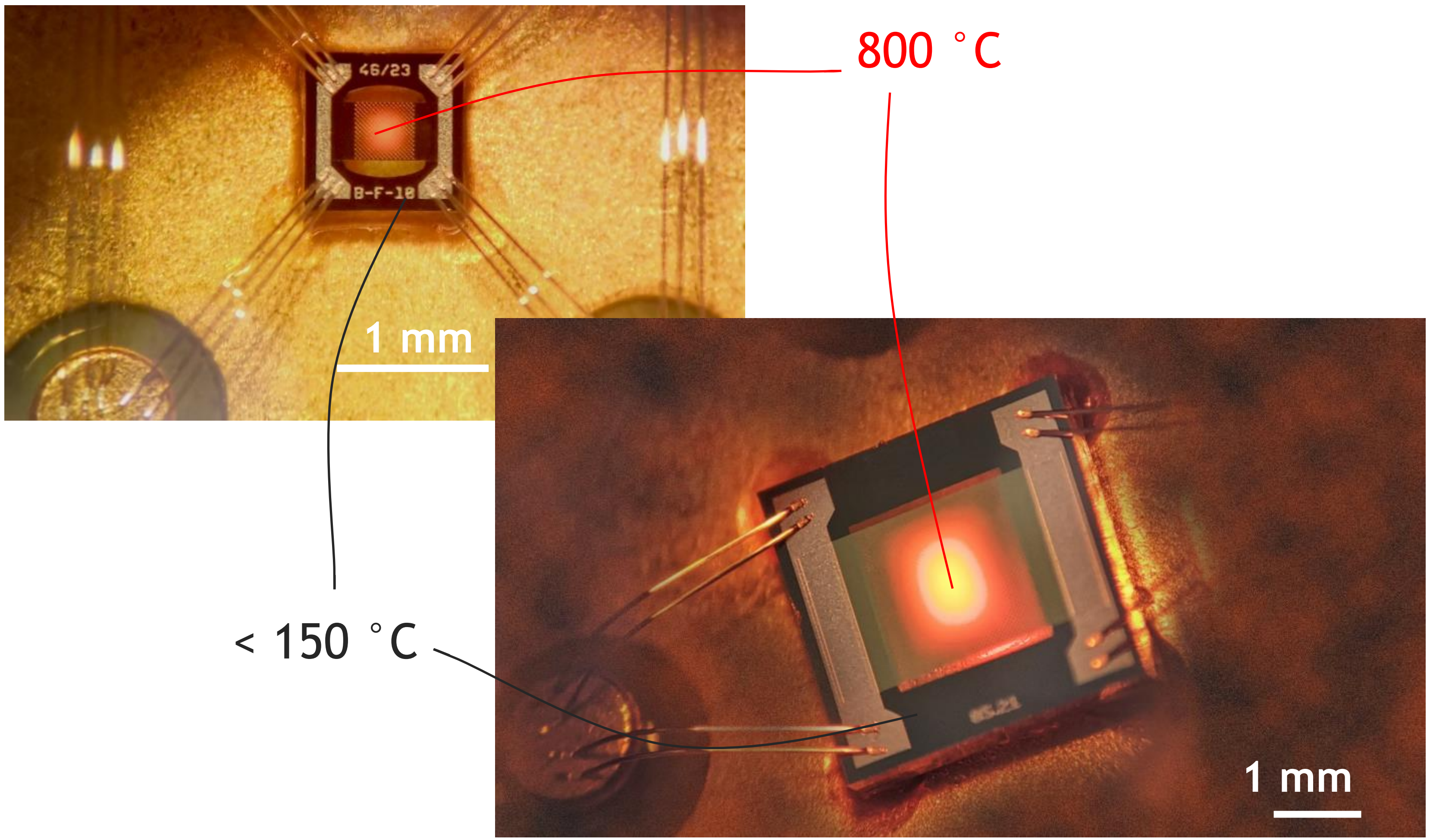


Rogalski, Antoni & Chrzanowski, K. (2014). Infrared Devices And Techniques (Revision). Metrology and Measurement Systems. 21. 10.2478/mms-2014-0057

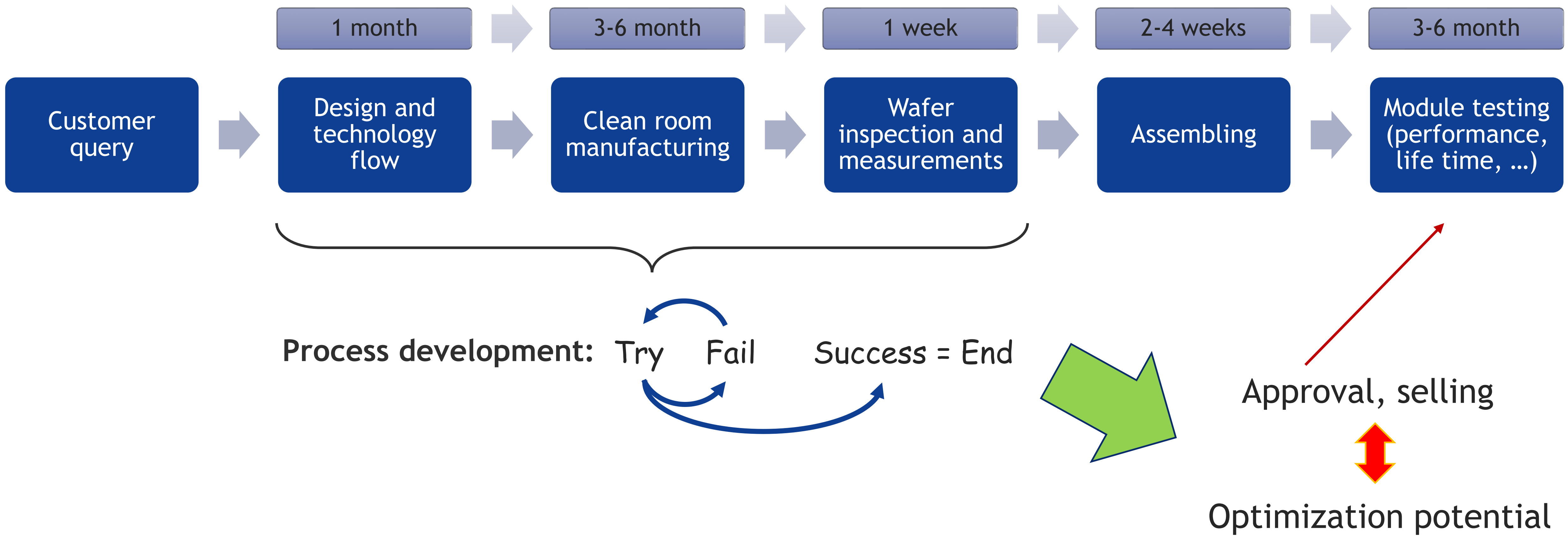
Background: IR-Emitter-Technology



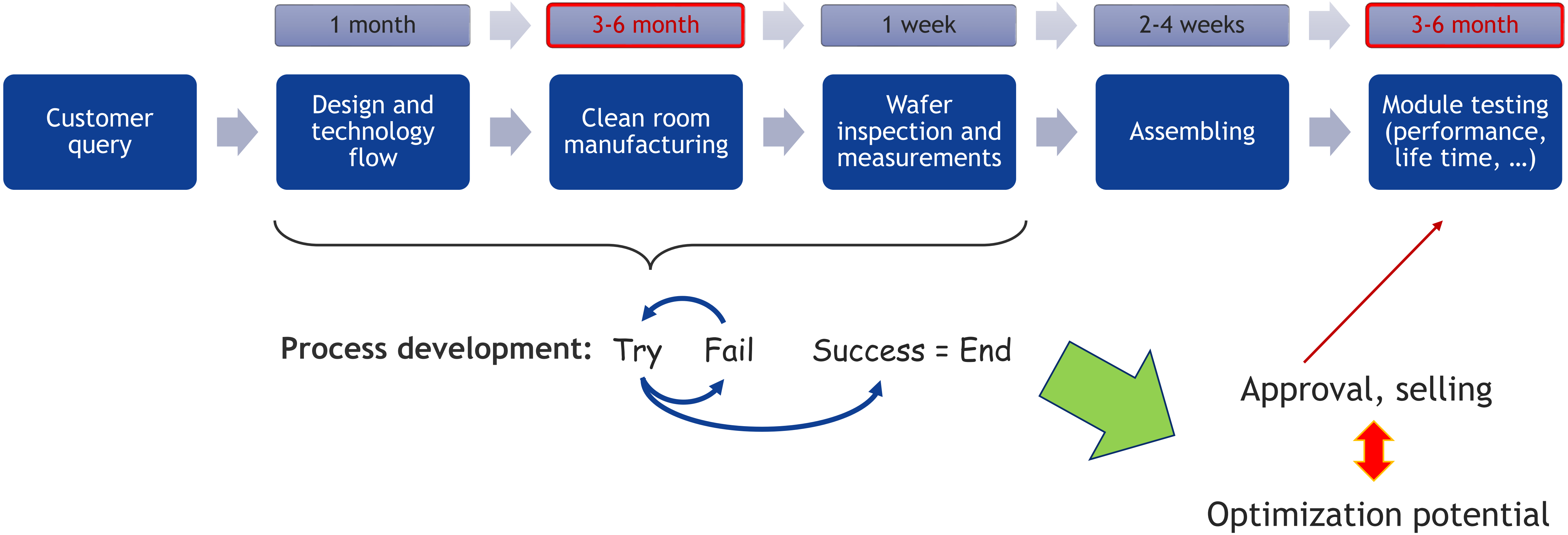
Ohmic Resistor



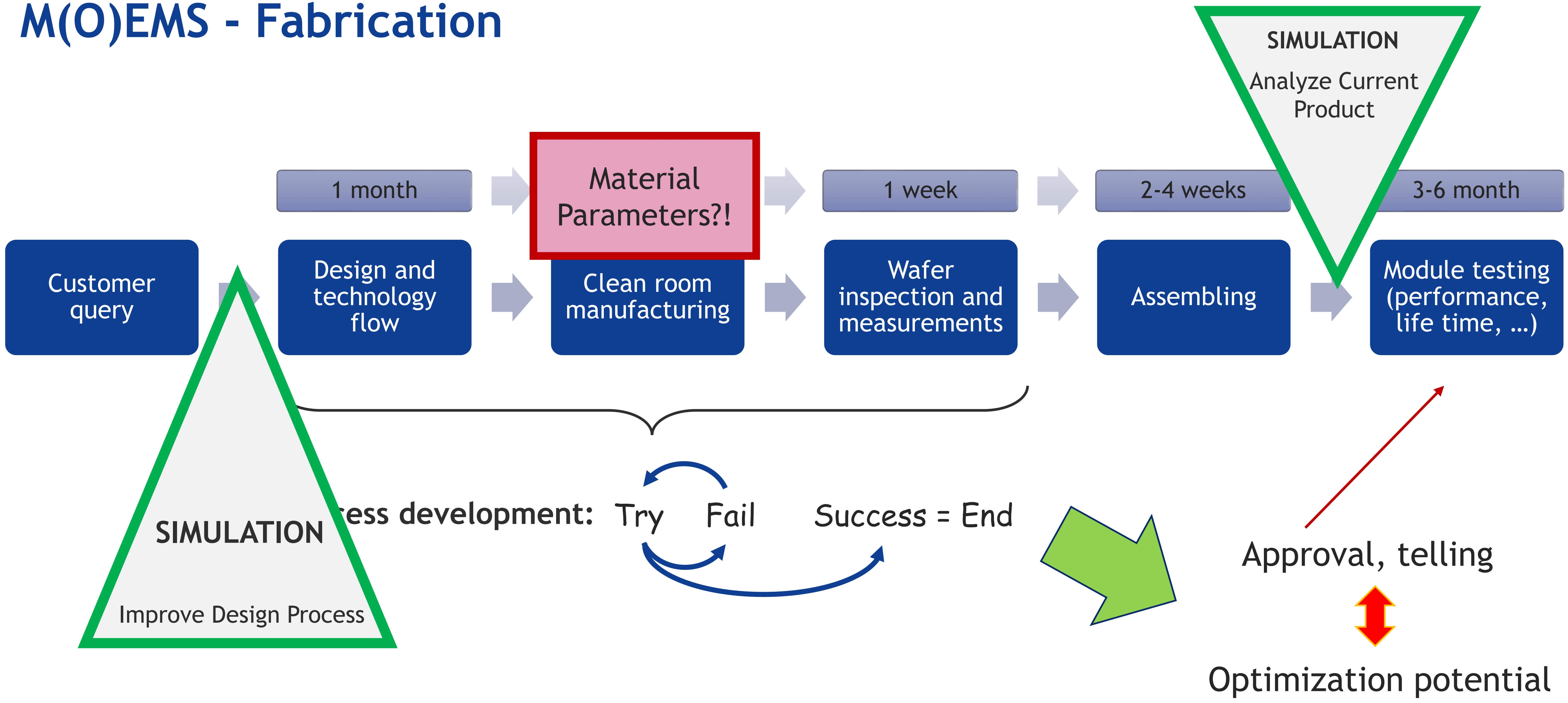
M(O)EMS - Fabrication



M(O)EMS - Fabrication



M(O)EMS - Fabrication



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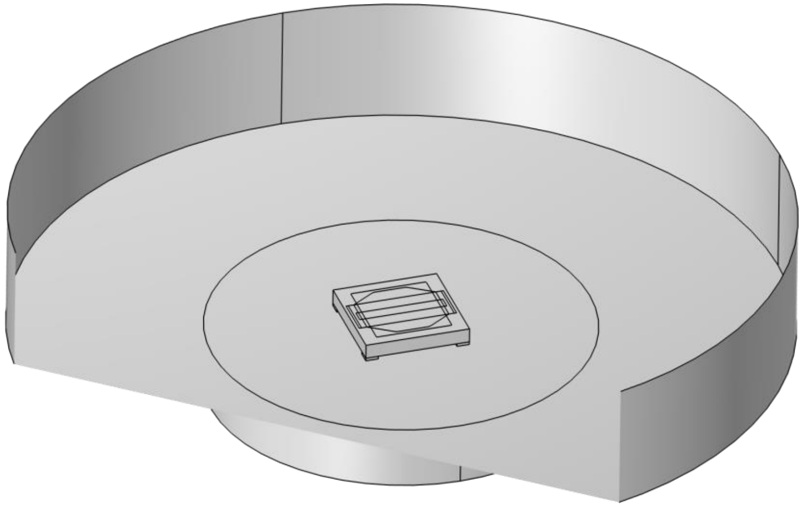


Building The Model

Challenge: Material Parameters Of **Our** Thin Layers

The Inverse Problem

- forward calculation:
  obtain the device characteristic
- inverse calculation:
  obtain the material parameters

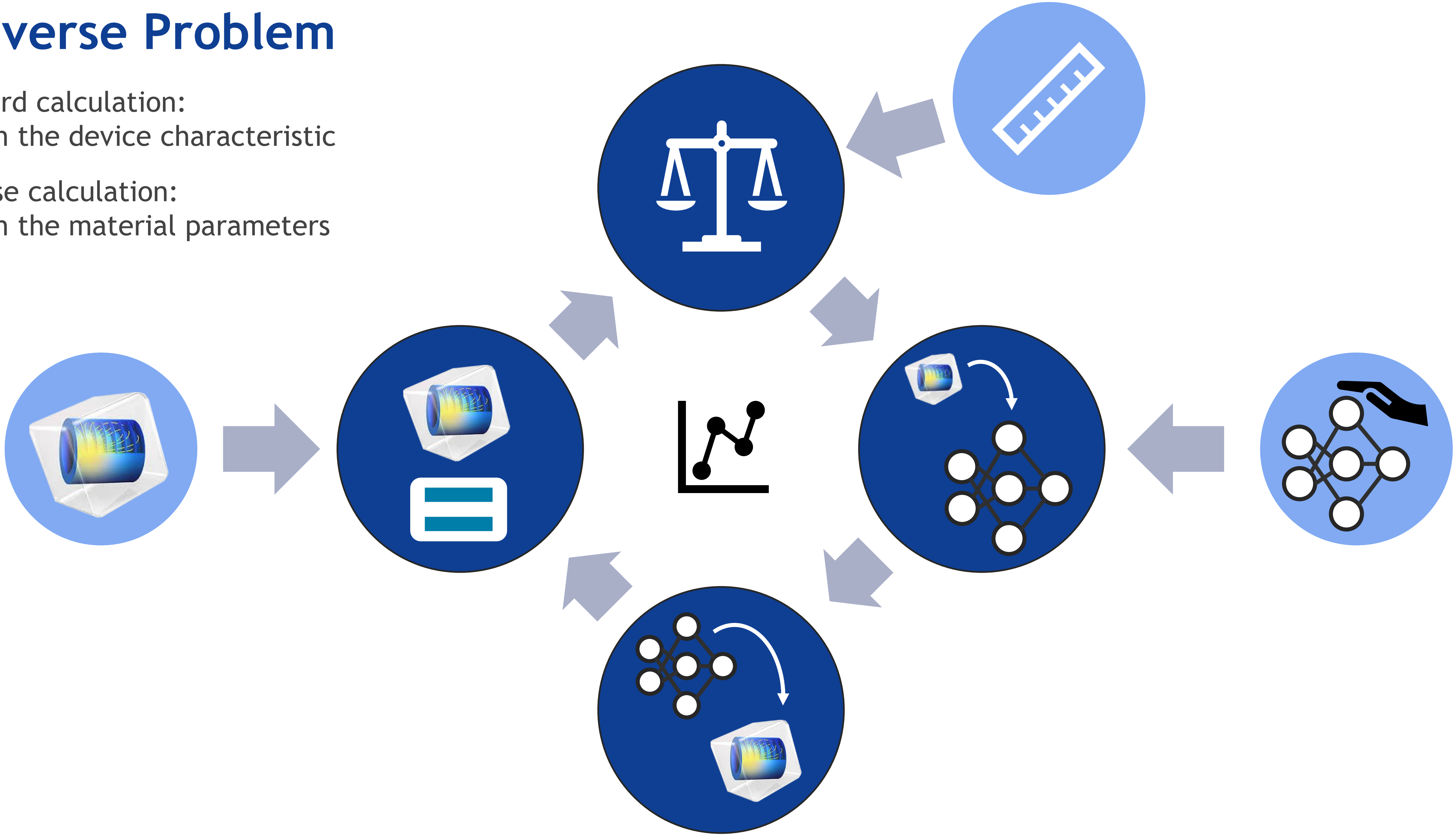
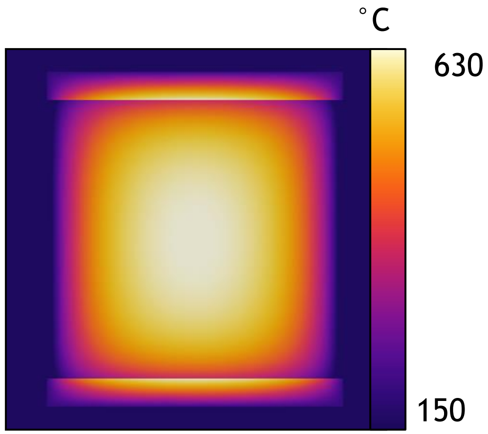
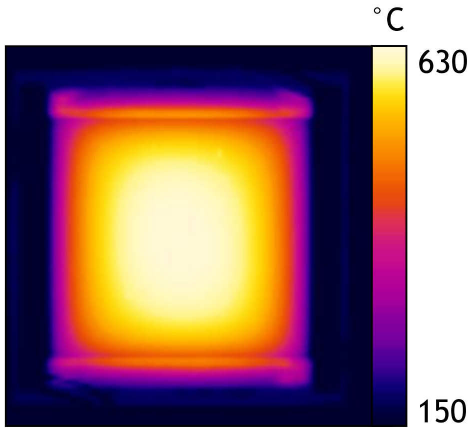


Image Source: Comsol Multiphysics Logo
https://doc.comsol.com/6.2/docserver/#!/com.comsol.help.comsol/html_COMSOL_MultiphysicsInstallationGuide.html

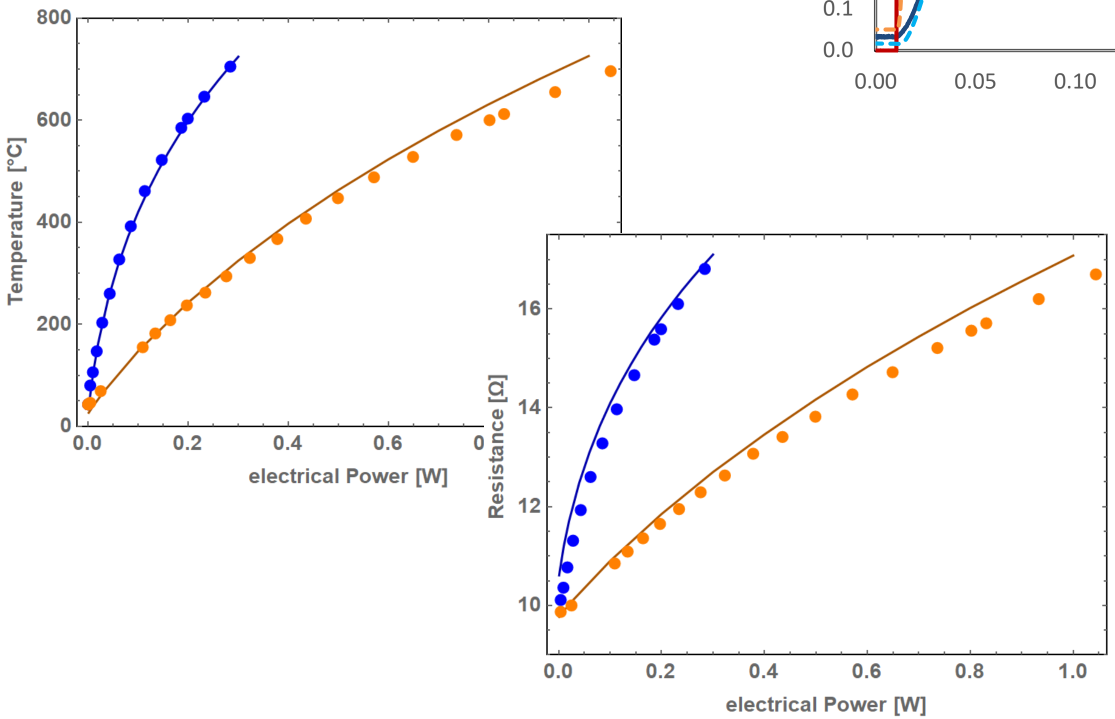
The Inverse Problem - Result

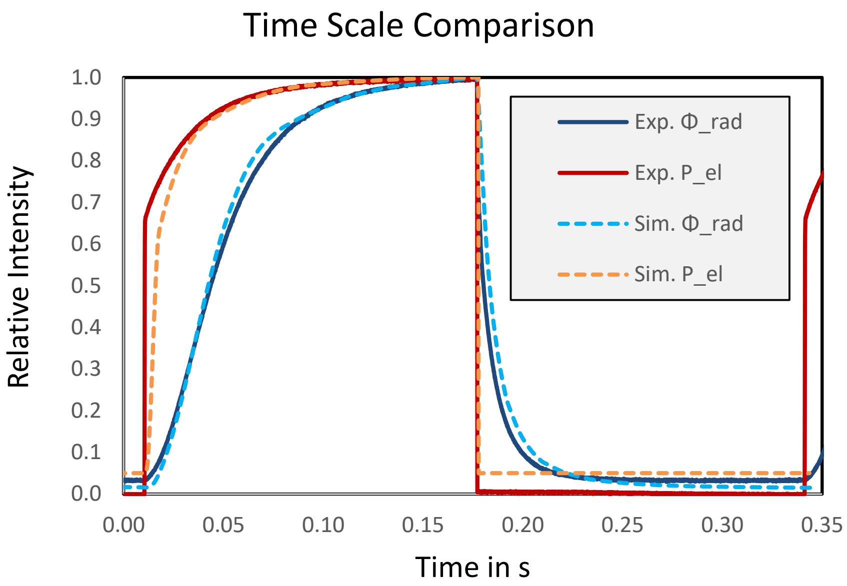


Simulation



Heat camera image





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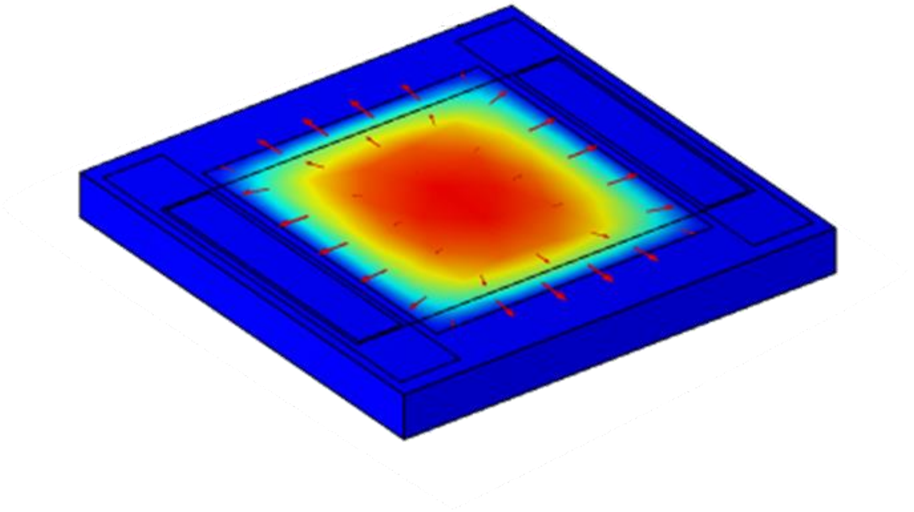
Using The Model In Design Processes



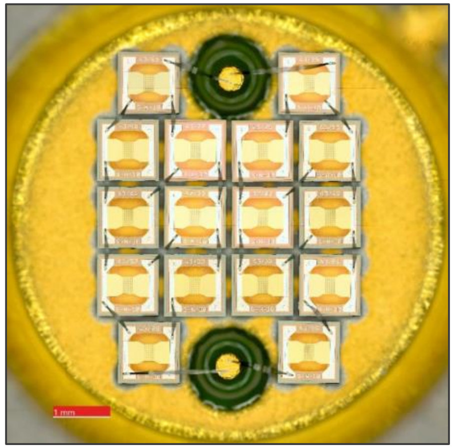
First Design Task

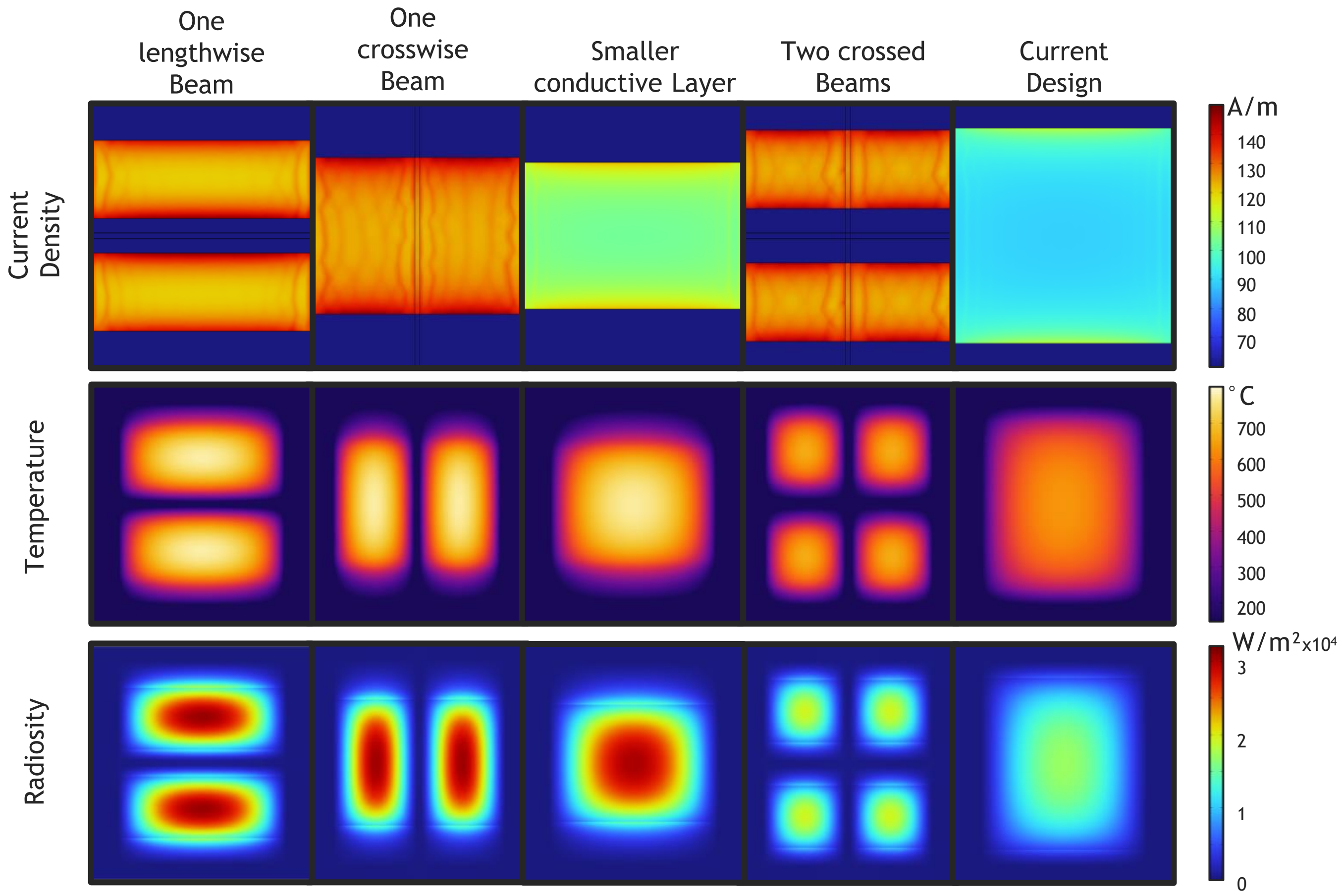
- Either bright or fast

  → Fast

- Big discrete parameter studies

  → Good prediction, what is worth to manufacture

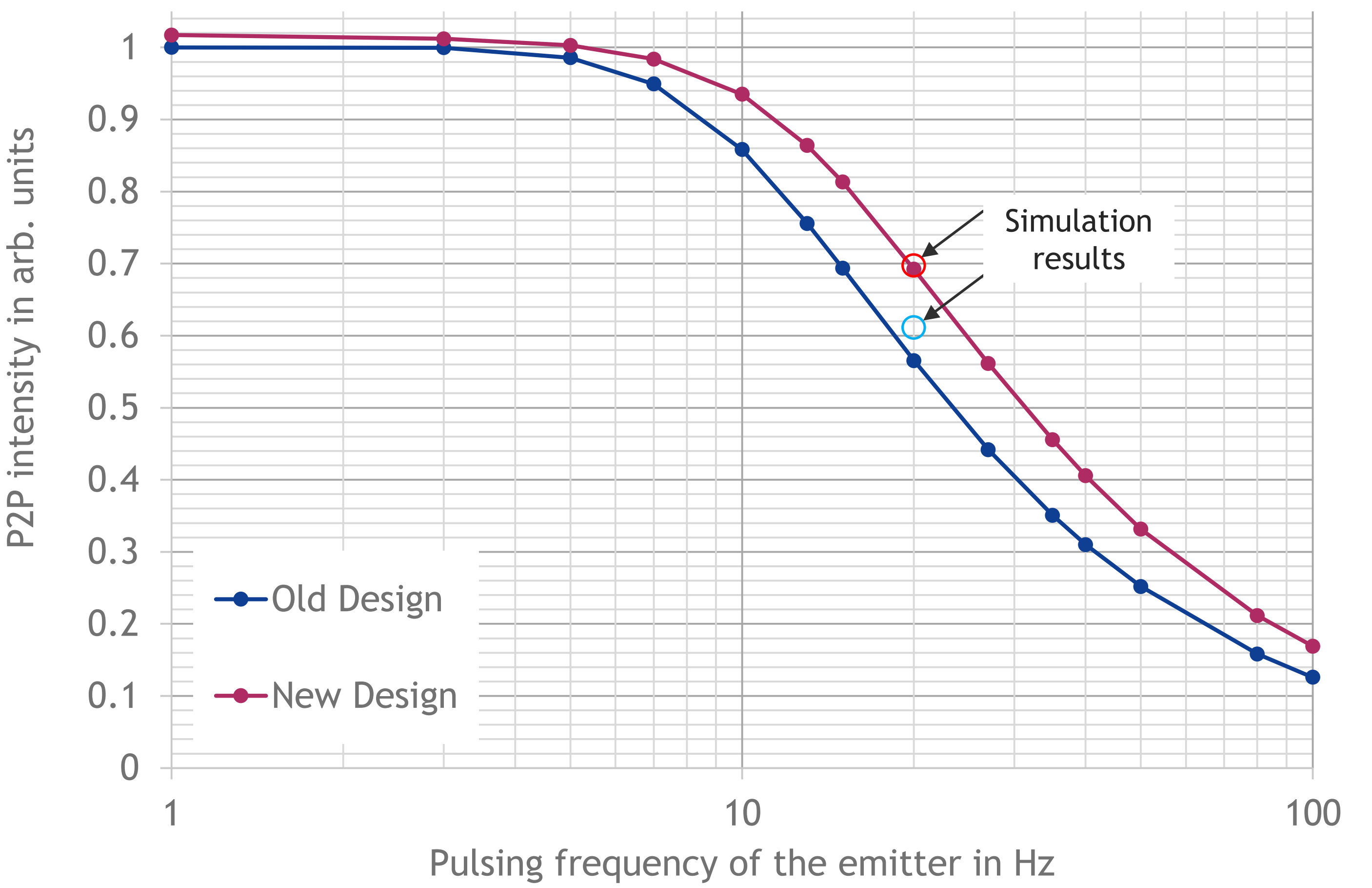


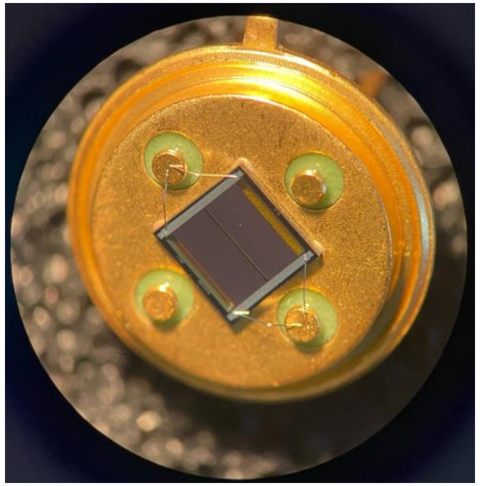


Helping In Design

- Same life time in simulation

Measurements with fabricated chip





Helping In Design

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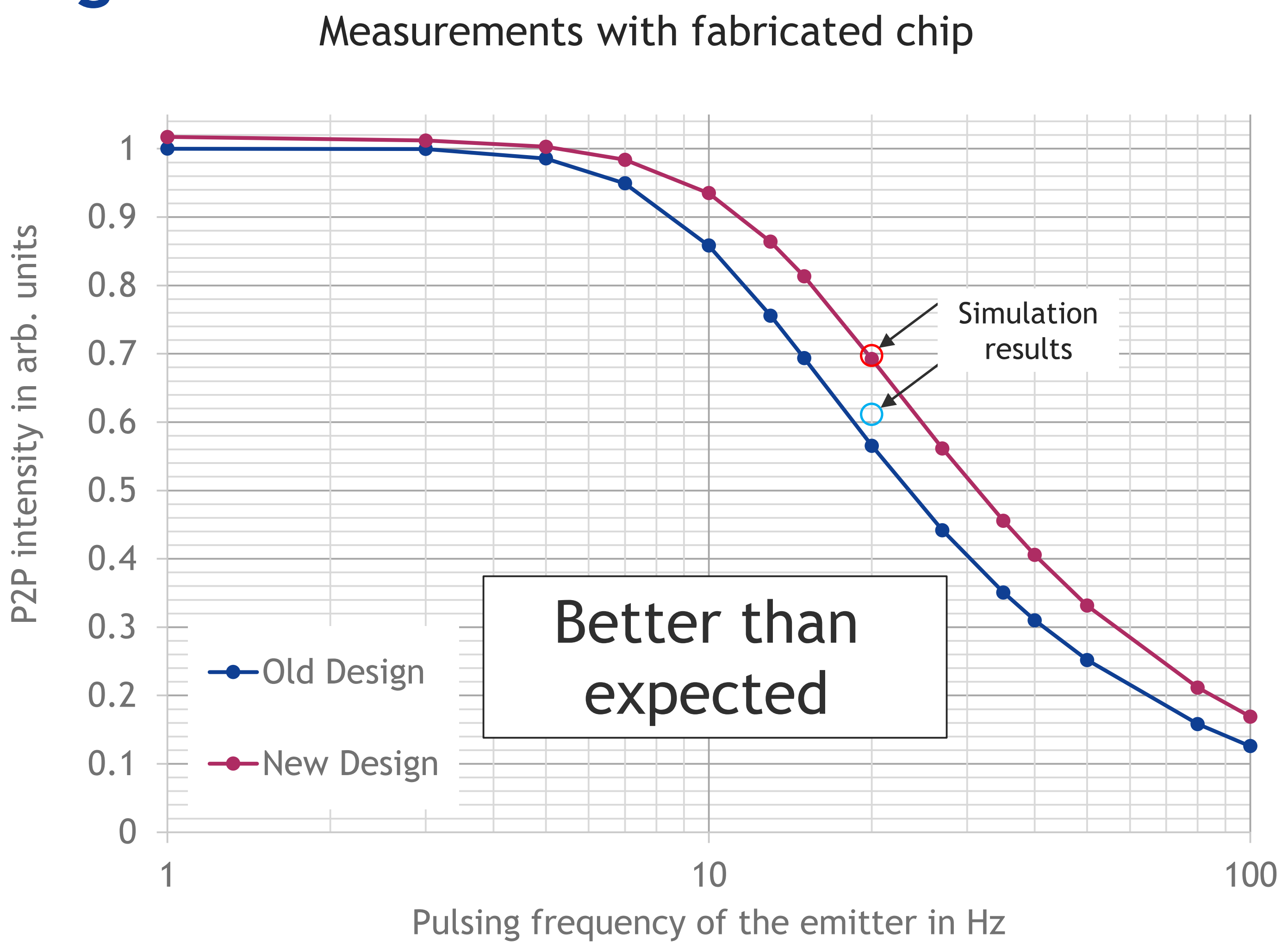
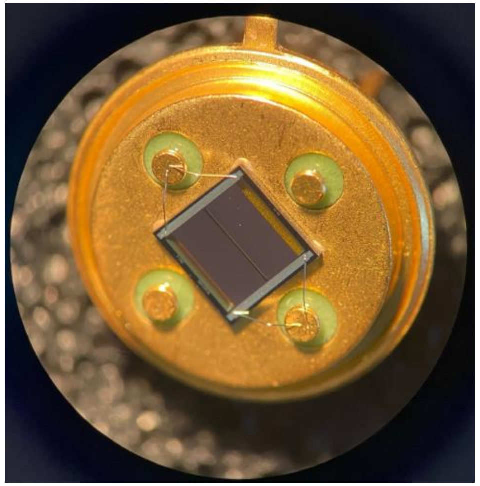
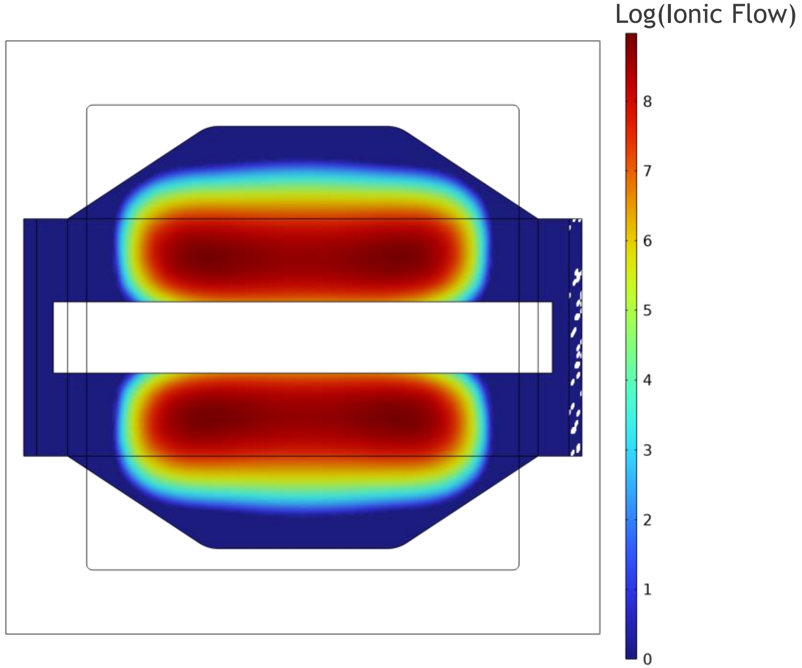


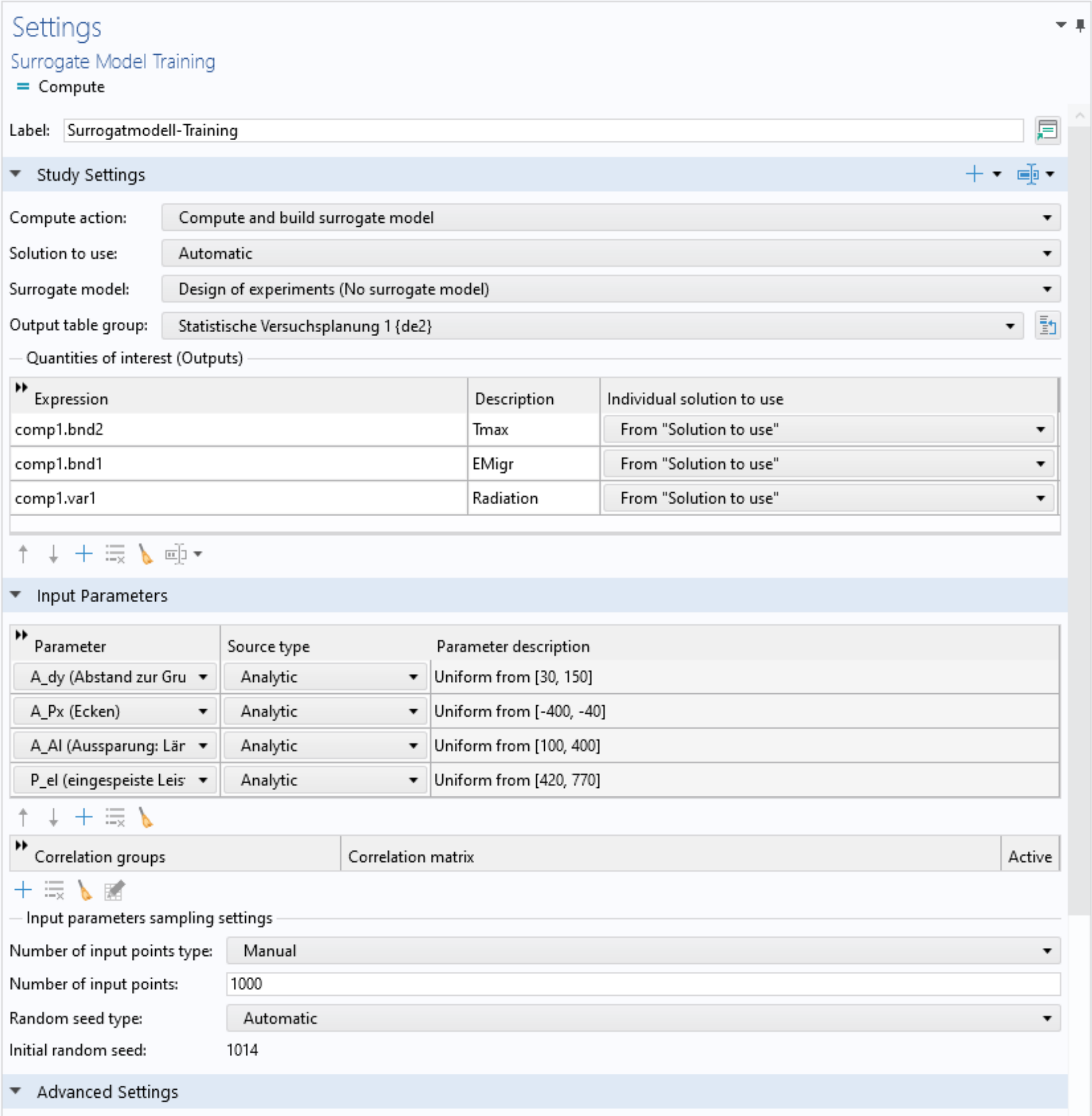


Improve Design Process With Surrogate Modelling

- 3 geometrical parameters + applied electrical power
- In parameter study only discrete combinations

→ Surrogate Modelling





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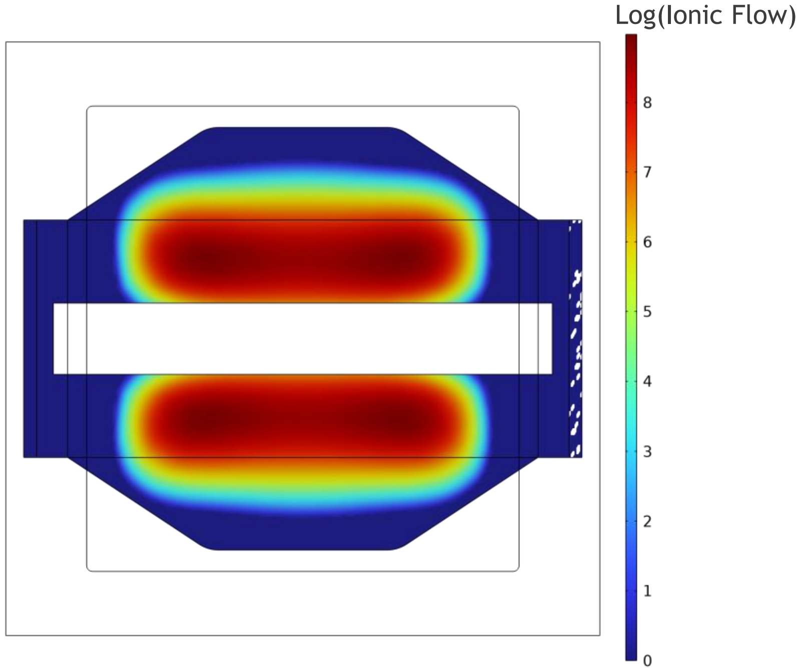
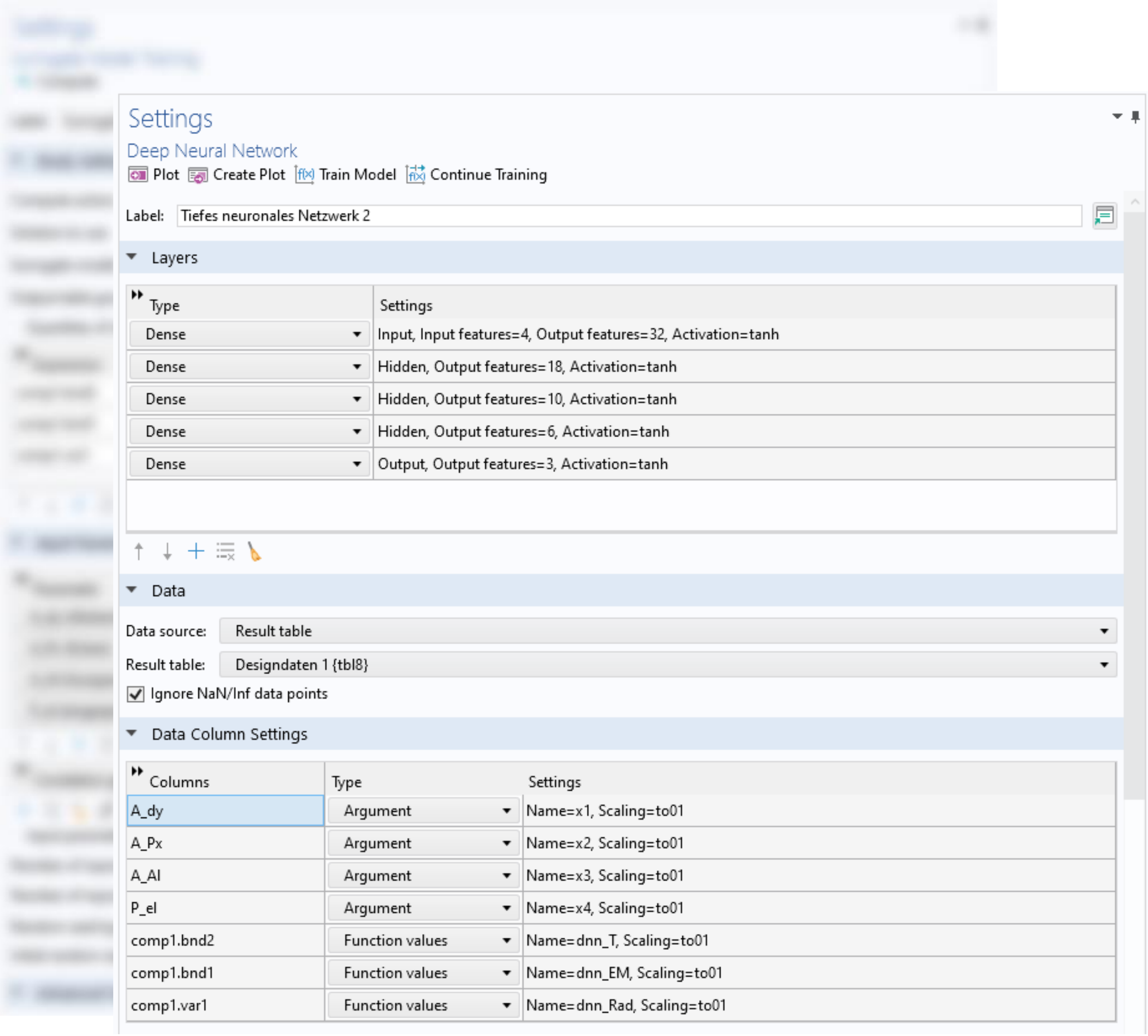
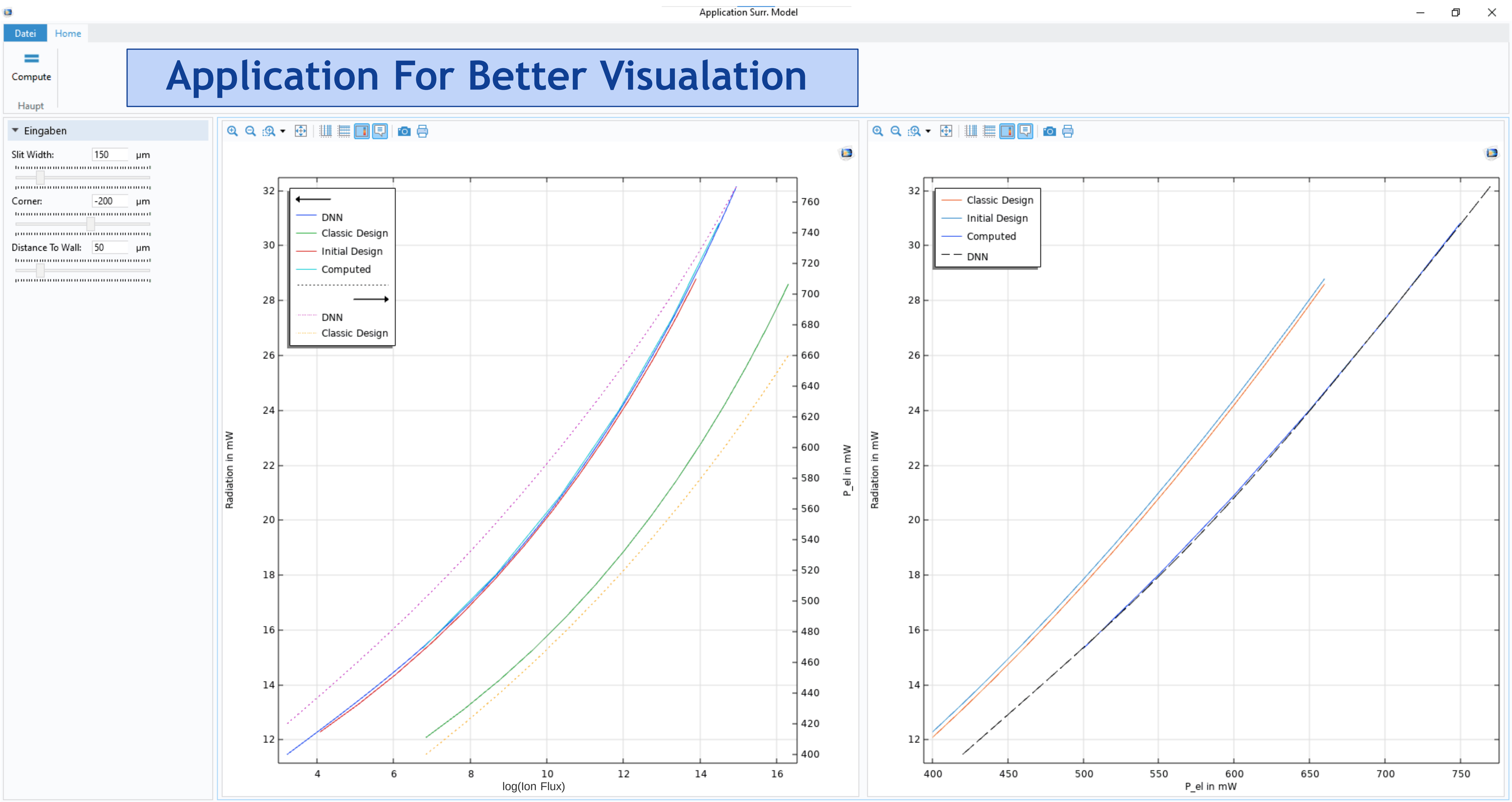




Application For Better Visualation



Conclusion

- Model building of existing technology without knowing exact material parameters
- New evaluation of current designs

  → Life time prediction
- Developing new designs

  → Better preselection of design worth manufacturing

  → Surrogate Modelling allows steplessly adjustable parameters

Thank you for your attention!

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tschildhauer@cismst.de

QSolid
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LinkedIn Profil

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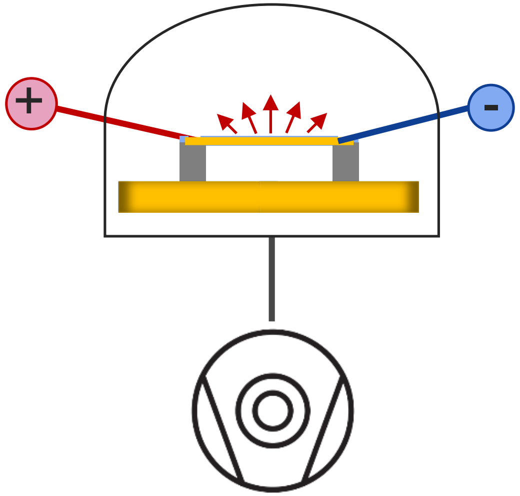
Verification experiment

Unknown parameters:
- Temperature dependent resistance
- Temperature dependenent thermal conductivity

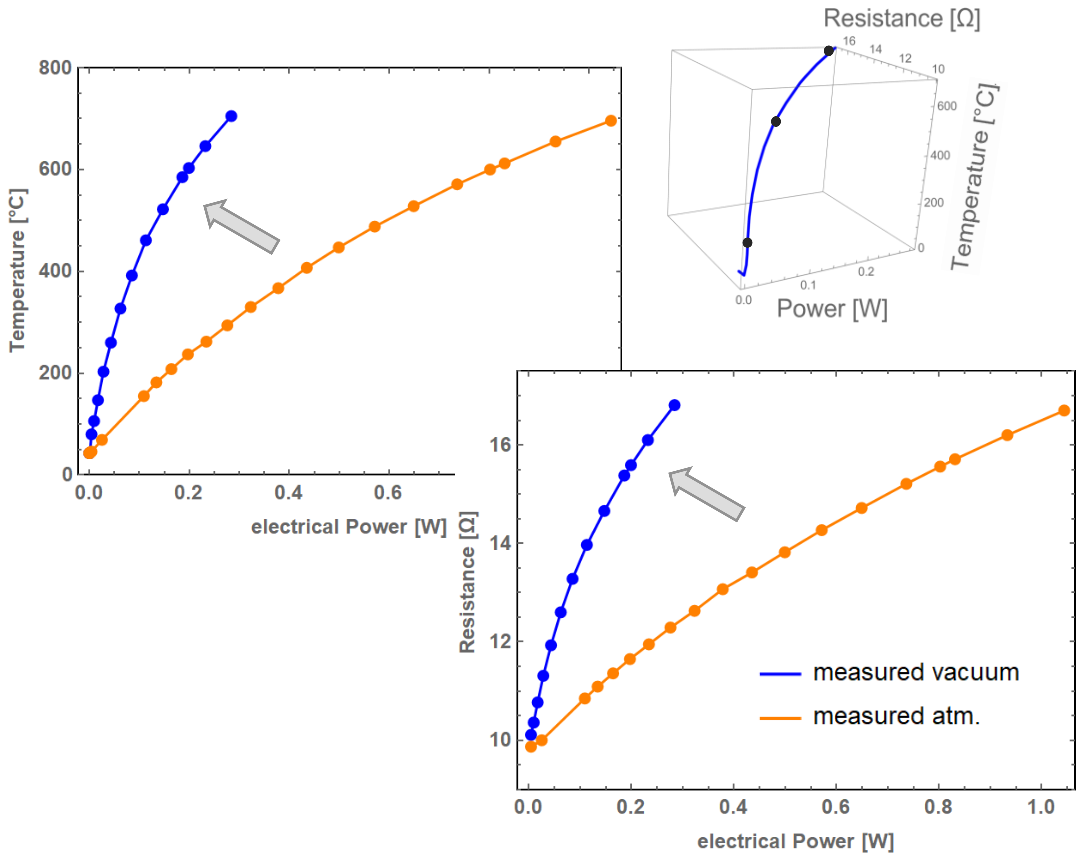
Vacuum container

Source measure unit

Turbo pump

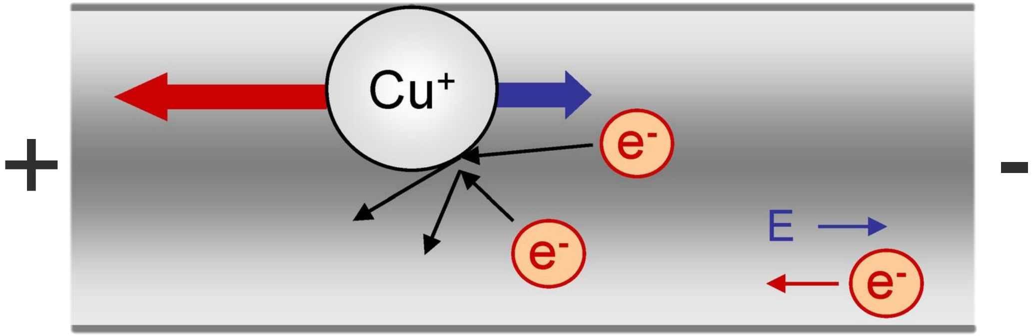


Remove influence of thermal conduction and convection by air



Life Time Modeling

- Dominant failure mechanism is Electromigration

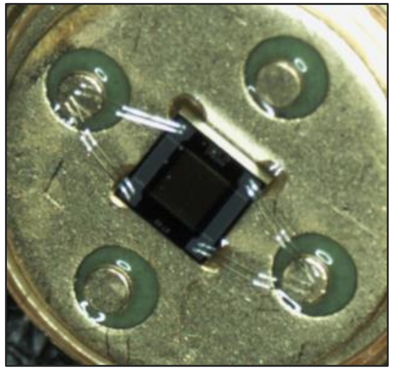


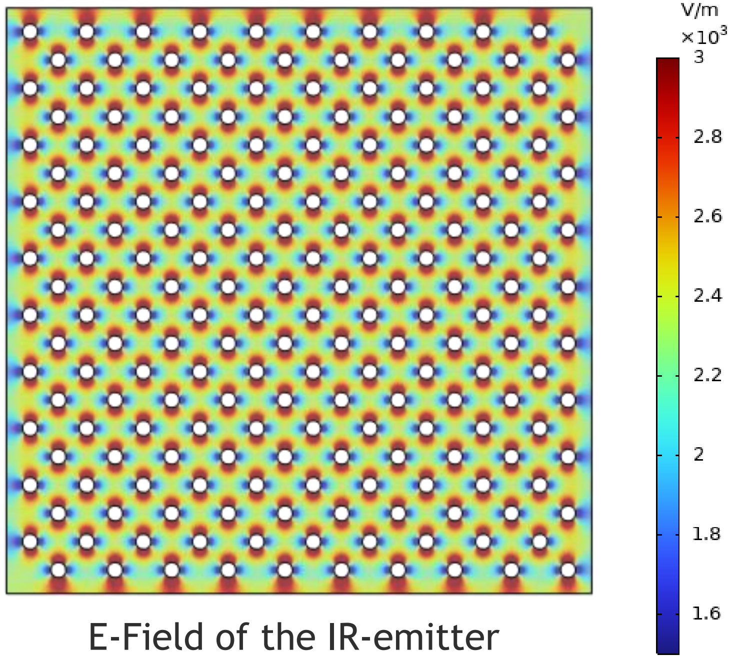
https://commons.wikimedia.org/wiki/File:Electromigration.png
Authour: Linear 77, Source: Own work

$$J_{max} = K \cdot \frac{kT}{E} \cdot \exp\left(\frac{E_A}{kT}\right)$$

- *K* - summarized material properties, *k* - Boltzmann constant, *T* - Temperature, E_A - Activation energy, *E* - Electric Field

Analyzing current design
with perforated conductive layer





E-Field of the IR-emitter