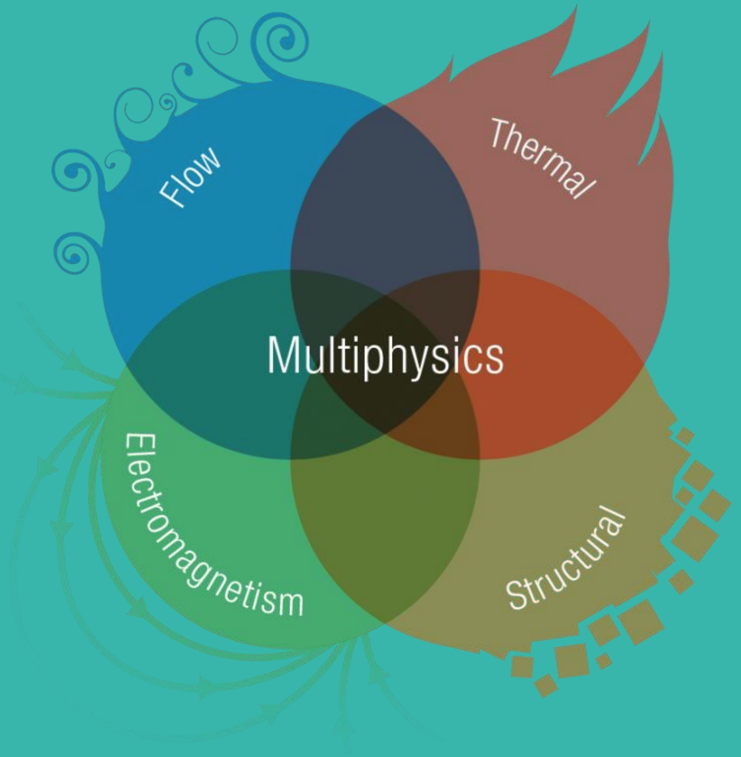


The role of simulation-driven engineering in semicon challenges

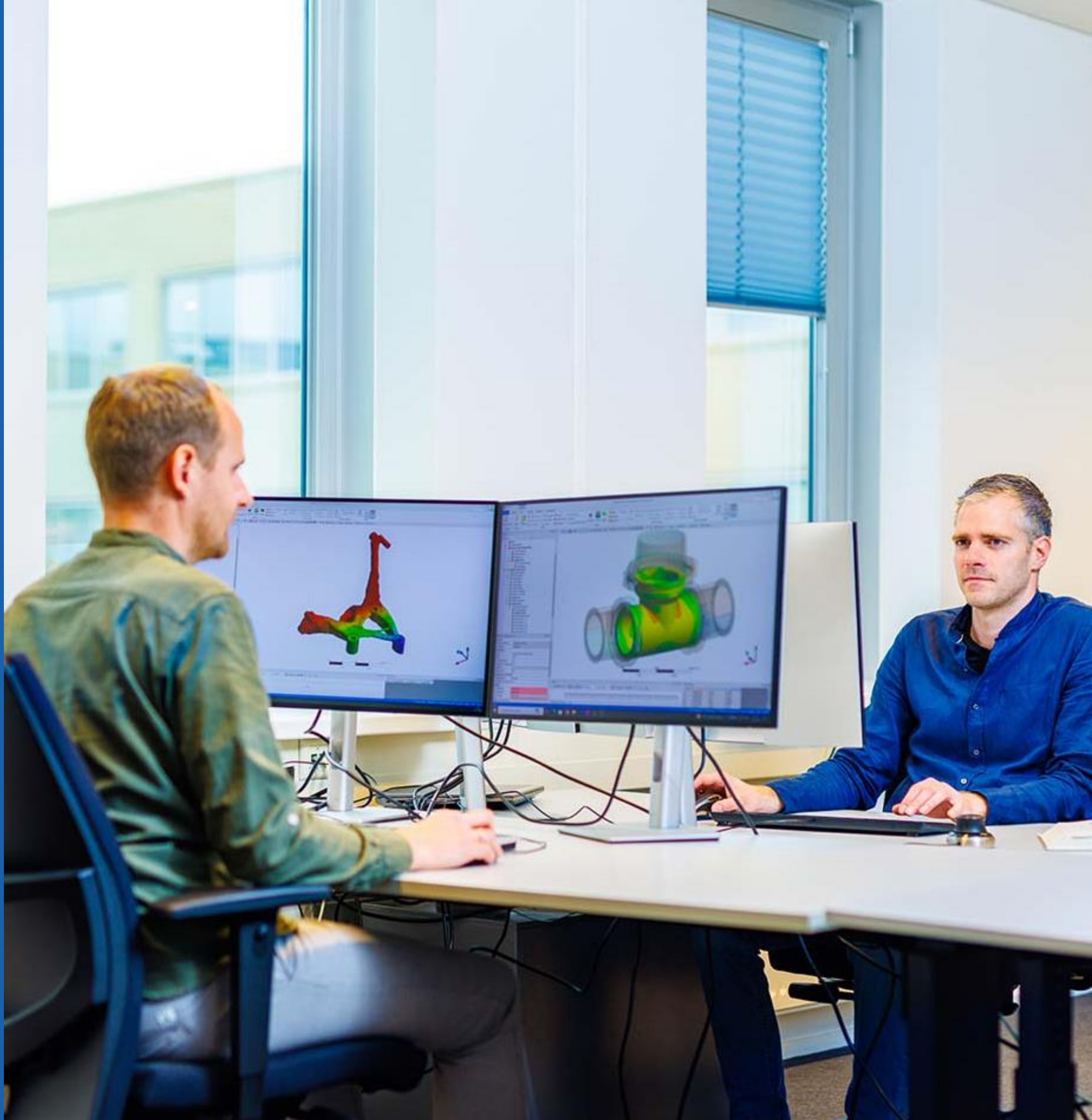
JOOST MULDER - MANAGING DIRECTOR

DEMCON | MULTIPHYSICS

Demcon multiphysics

Applying fundamental physical insight to generate innovative engineering solutions.

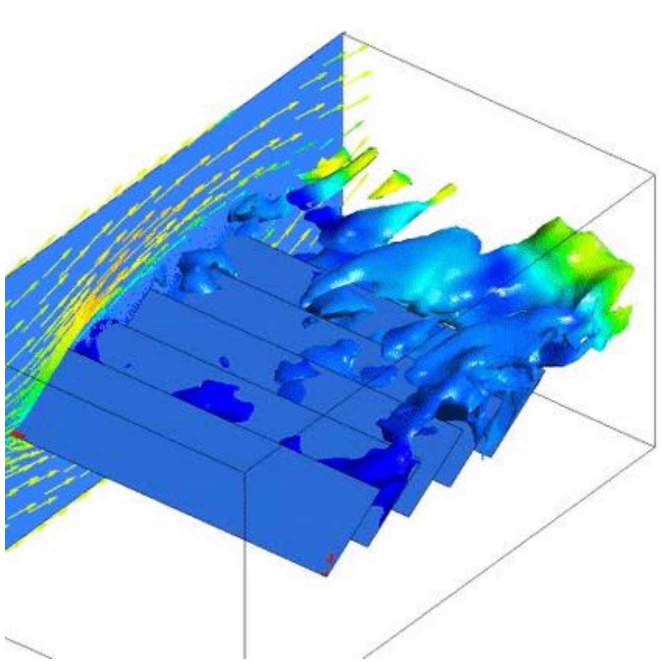
- Analytics
- Back-of-the-envelope calculations
- Simulations
- Experiments

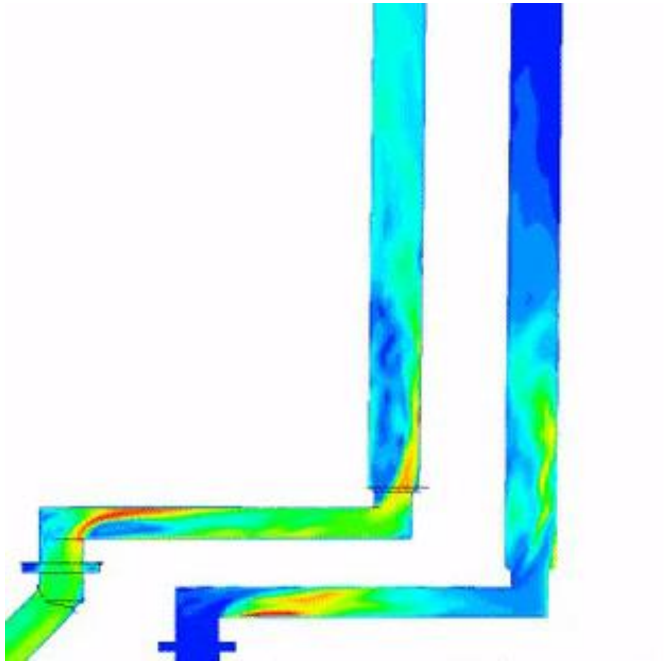


High-end engineering services in the field of multiphysics

High-end engineering services in the field of multiphysics

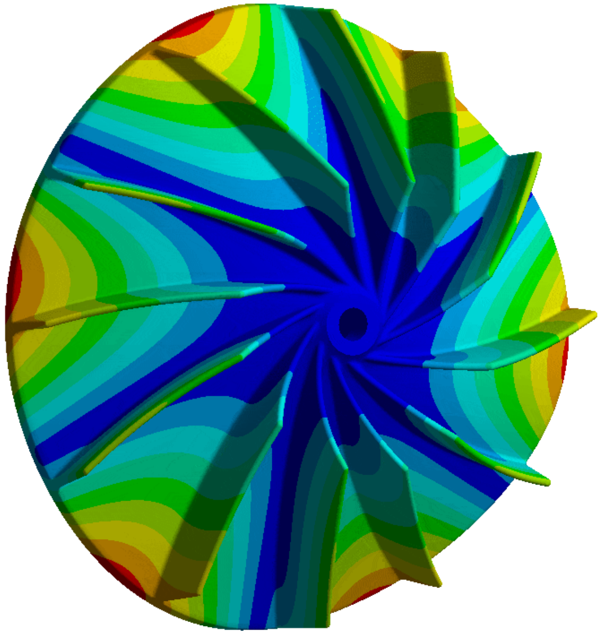
Fluid flows





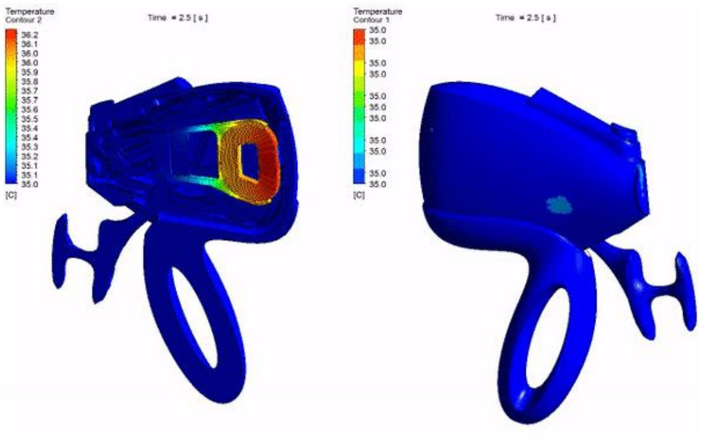
High-end engineering services in the field of multiphysics

Structural mechanics



High-end engineering services in the field of multiphysics

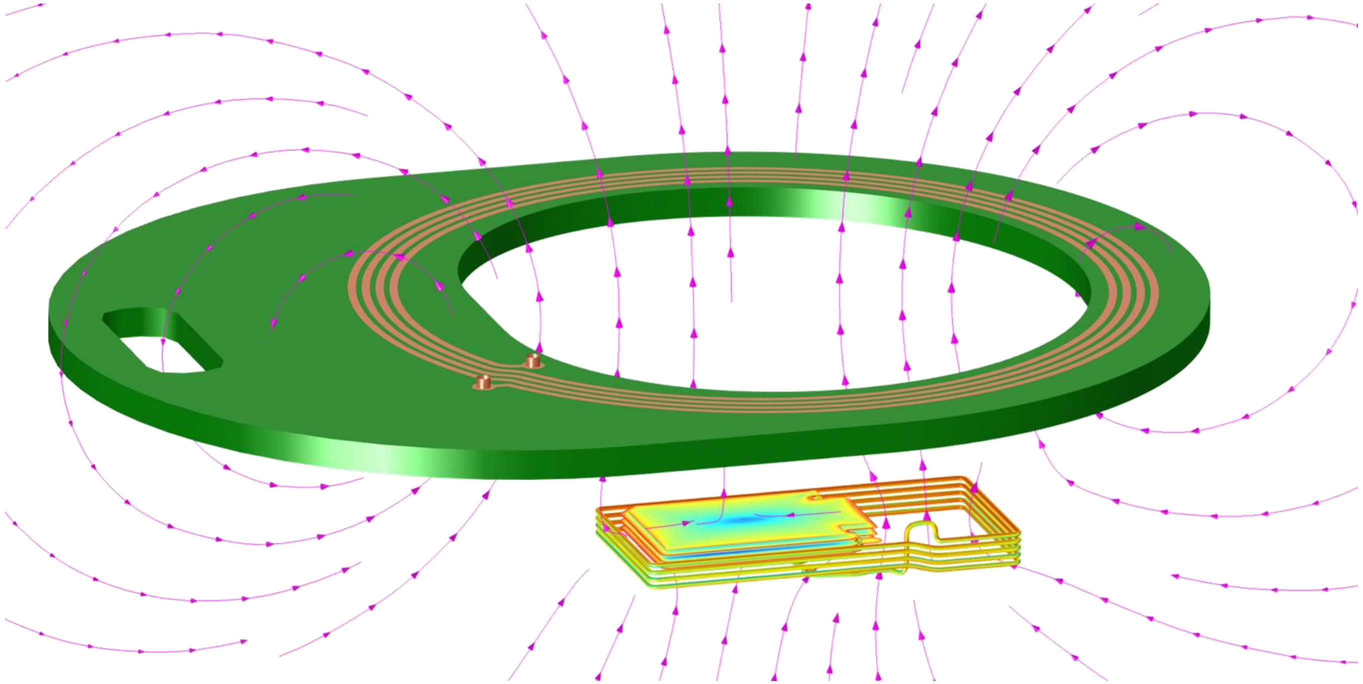
Thermal engineering



DEMCON | MULTIPHYSICS

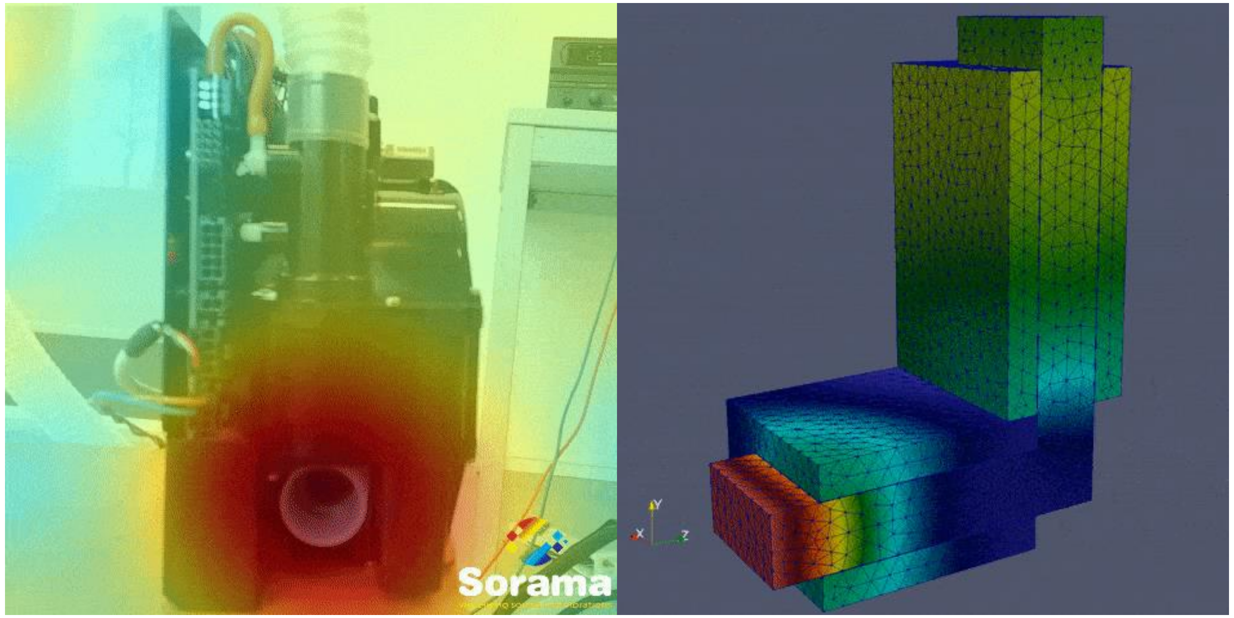
High-end engineering services in the field of multiphysics

Electromagnetics



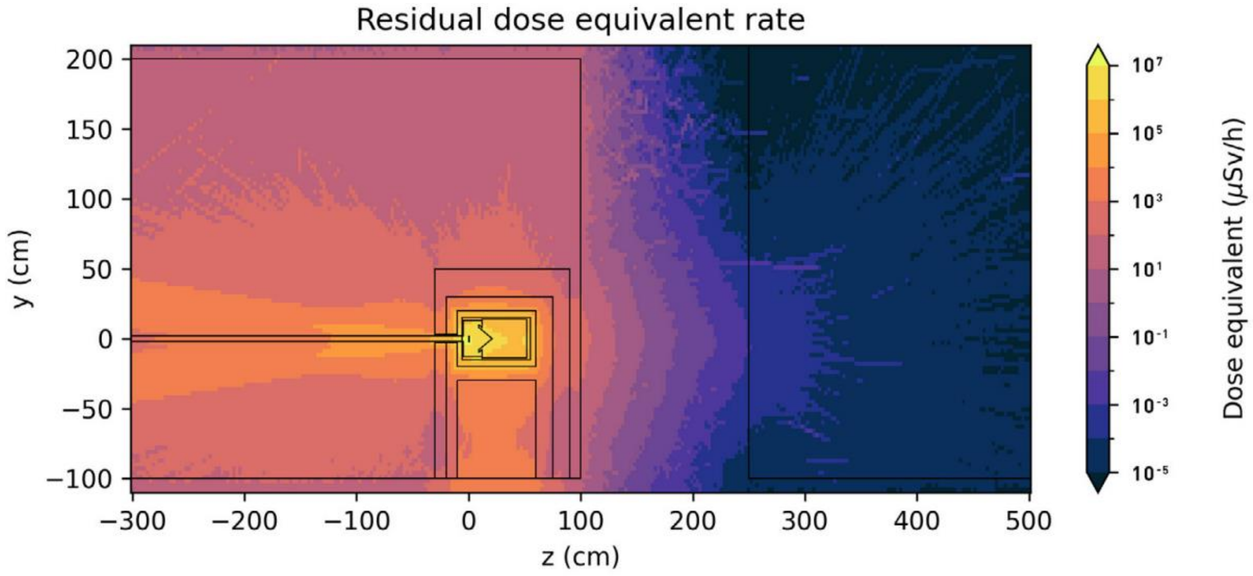
High-end engineering services in the field of multiphysics

Acoustics & vibrations



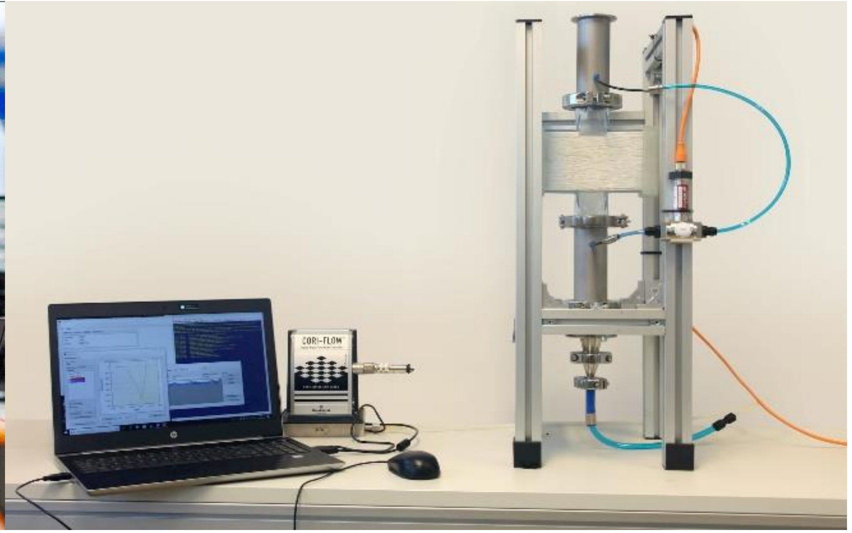
High-end engineering services in the field of multiphysics

Nuclear physics



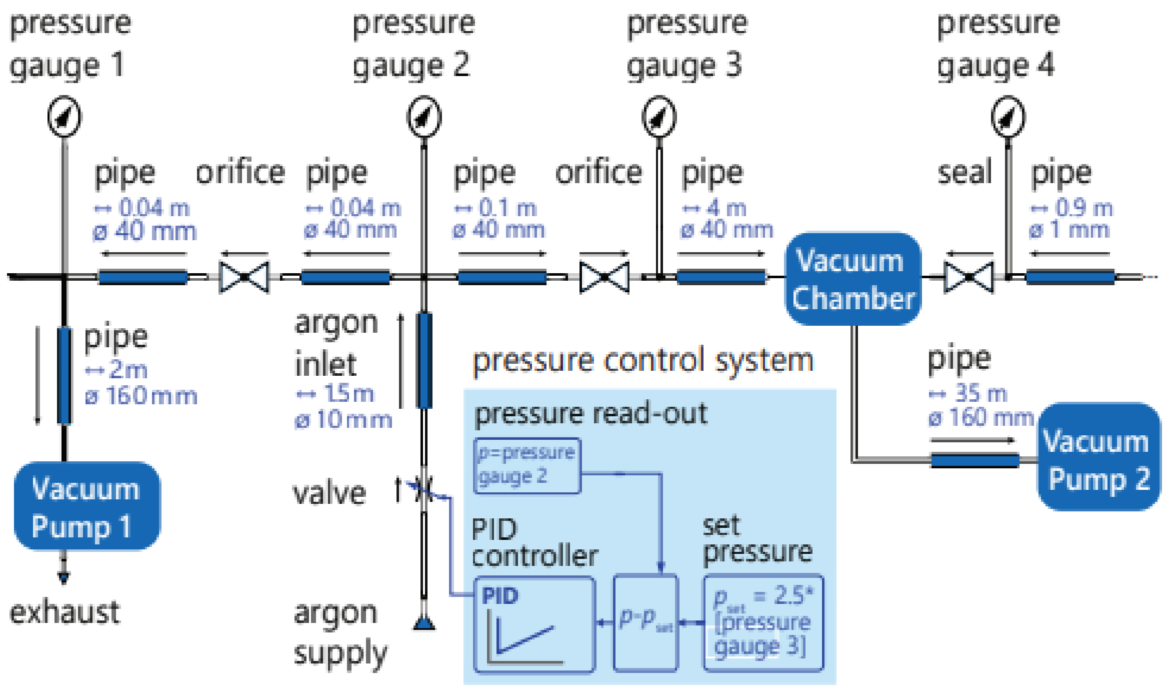
High-end engineering services in the field of multiphysics

Experiments



High-end engineering services in the field of multiphysics

Product development



Active in many different markets

HIGH-TECH SYSTEMS & MATERIALS

LIFE SCIENCES & HEALTH

ENERGY

SMART INDUSTRY

WATER & MARITIME

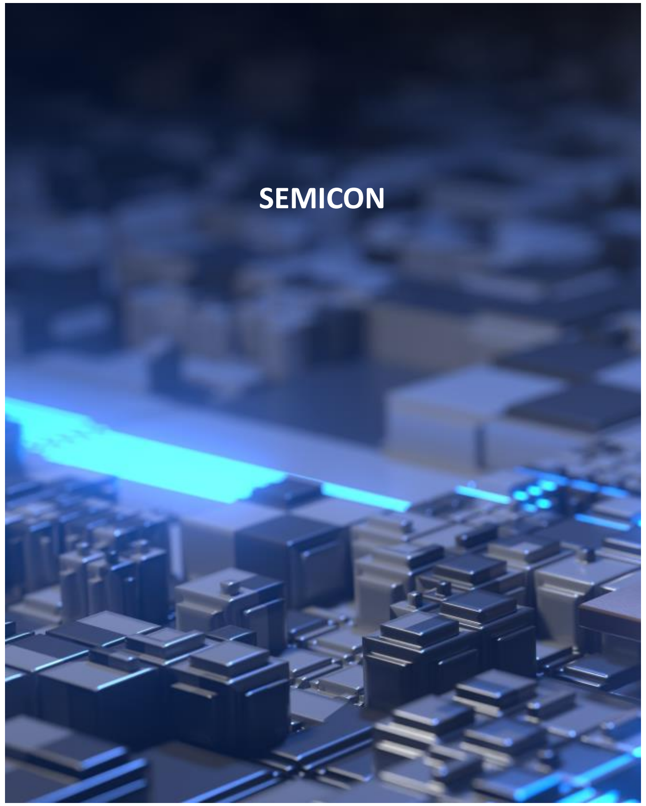
AGRI & FOOD

AEROSPACE

DEFENSE & SECURITY

Active in many different markets

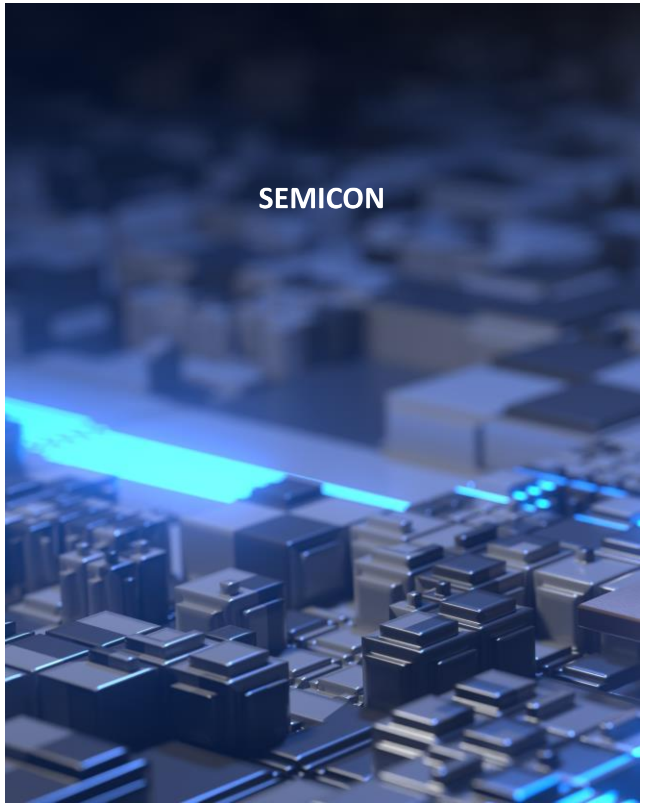
HIGH-TECH
SYSTEMS
& MATERIALS



Typical challenges & simulations

- Operating in **vacuum** at **high temperatures** with **high precision.**
  - Thermomechanical effects
  - Sensor placement
  - Control and dynamics
  - Material handling

- Advantage of simulations
  - Prevent costly and complex experiments
  - Fast and aimed iterations in design phase
  - Understand separate and combined physics



Practical examples from the chip industry

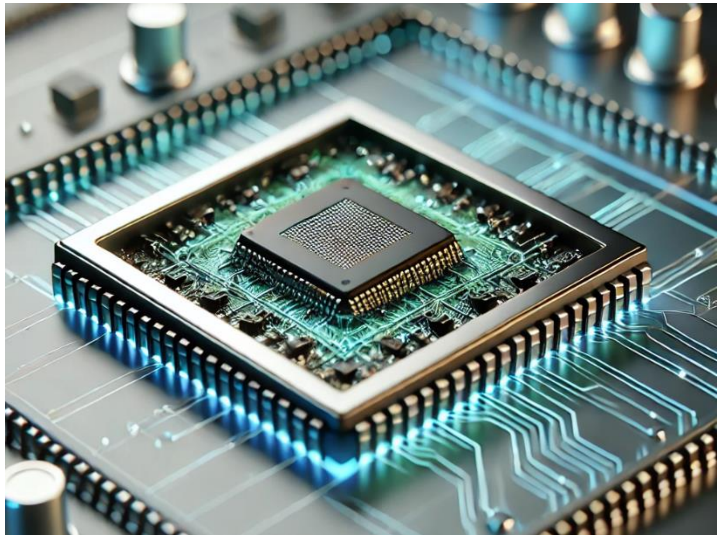
Three examples from our experiences:

1. Cu-Cu bonding – Machine conditioning
2. Panel level packaging – warpage prediction
3. High precision systems – Thermal drift

Cu-Cu bonding – Machine conditioning

1. Copper-to-copper bonding

- Copper for 3D-stacking
- Favorable material properties
- Elevated temperature for bonding
- *New challenges!*

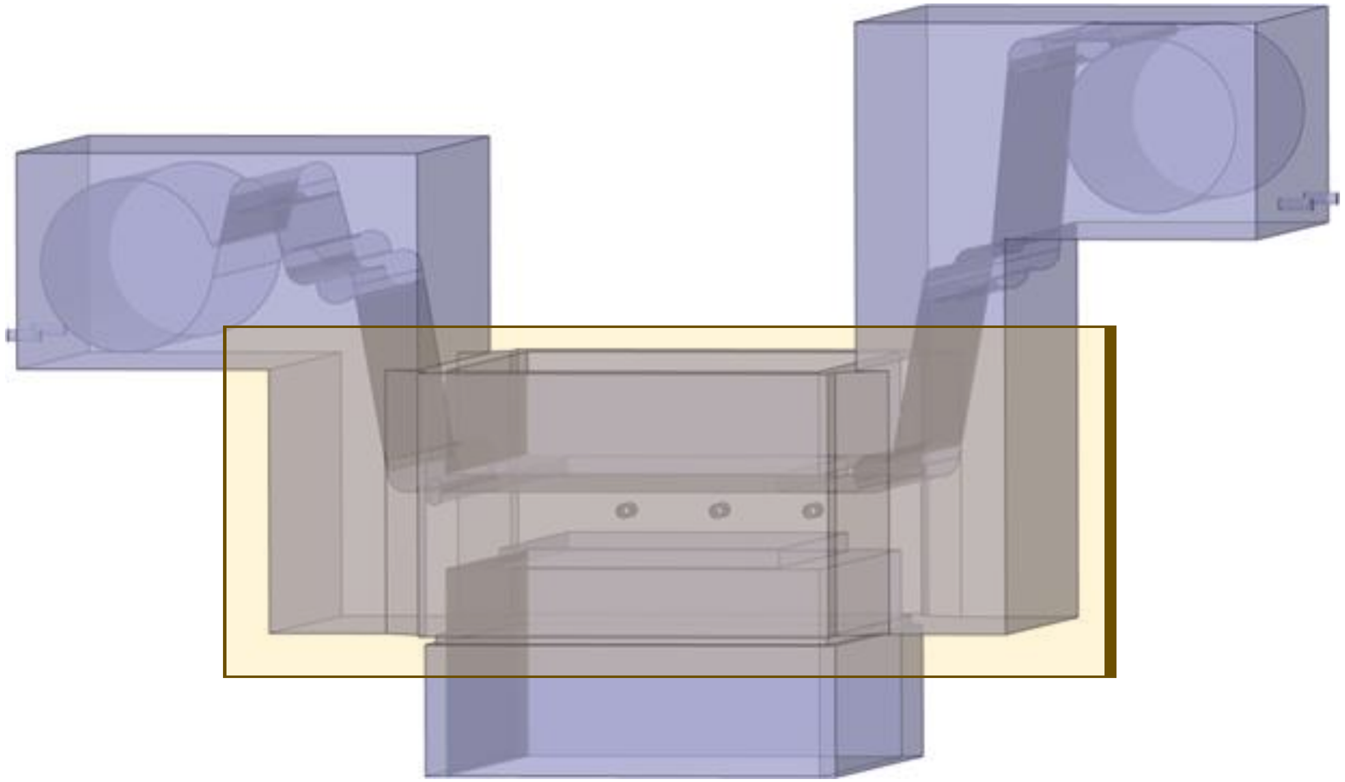


1. Copper-to-copper bonding

- Problem: Copper at elevated temperatures → Corrosion…
- Approach: Concept feasibility study for machine conditioning!
- Questions: Best or worst-case scenarios? Bottlenecks?

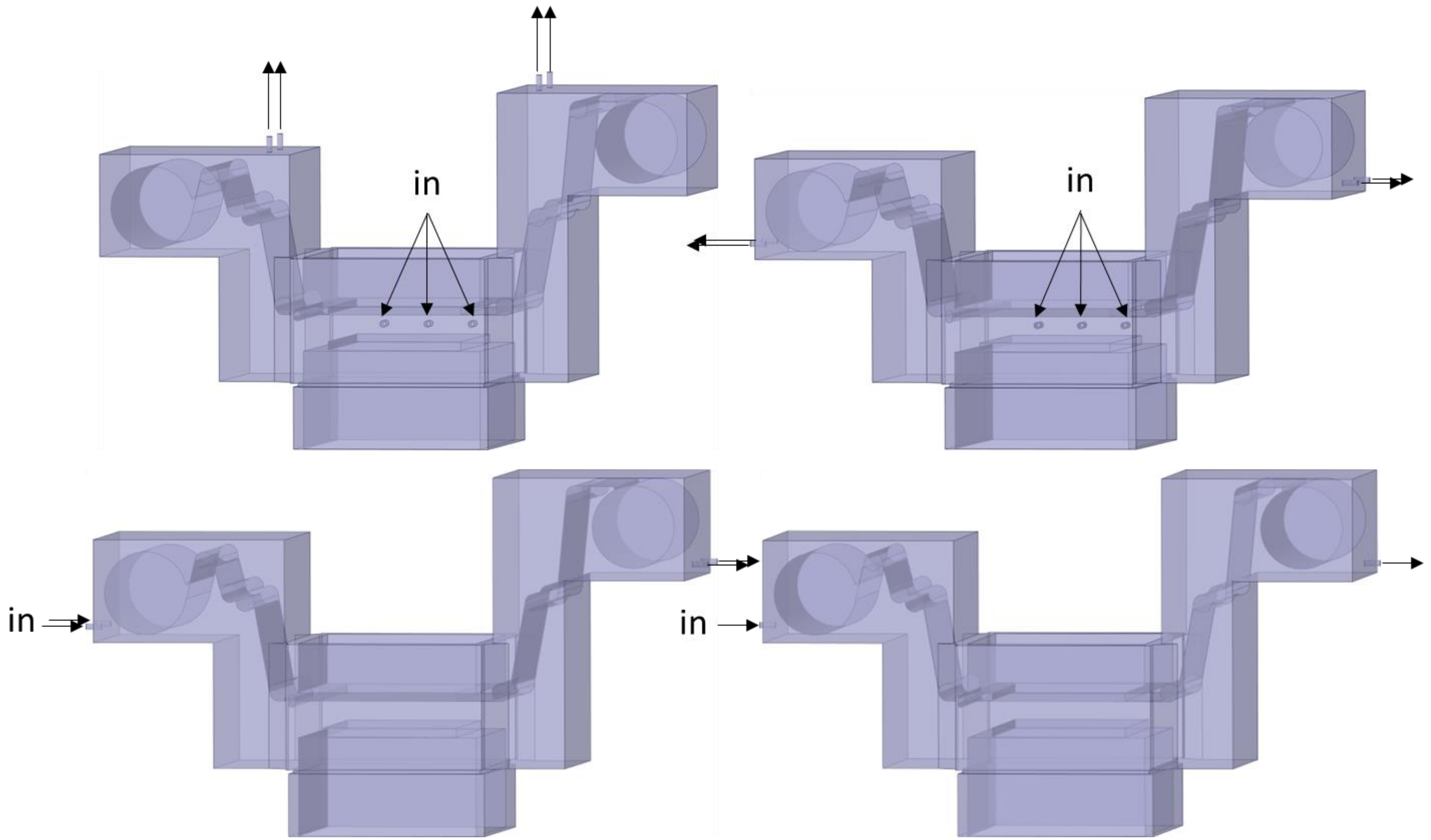
1. Copper-to-copper bonding – machine conditioning

- Machine with copper components in yellow domain.
- Multi-component simulation
  - Initially everything air
  - N_2 injection at chosen points
  - Tracking of concentration O_2
- Target is 300 ppm O_2 in 500 s.



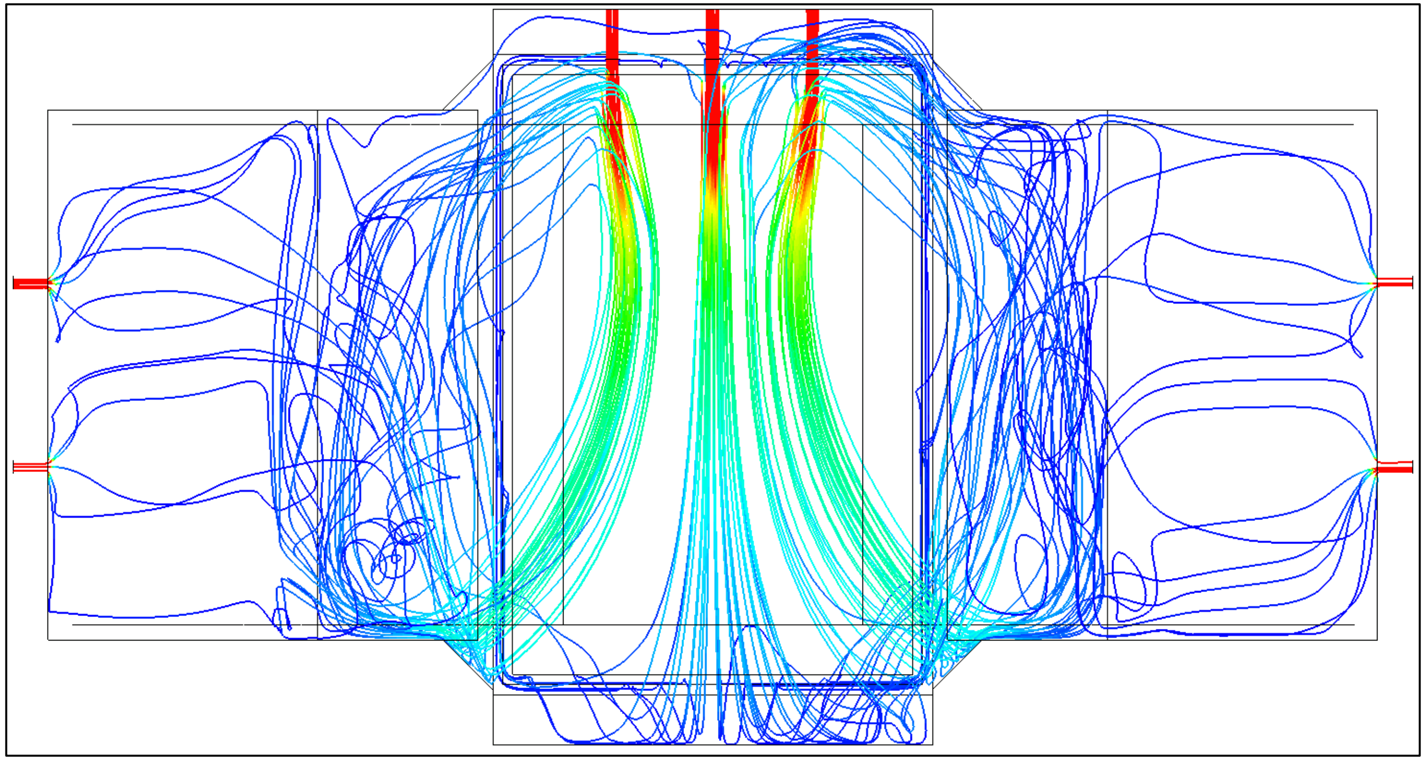
1. Copper-to-copper bonding – machine conditioning

- Strategic injection points analysis



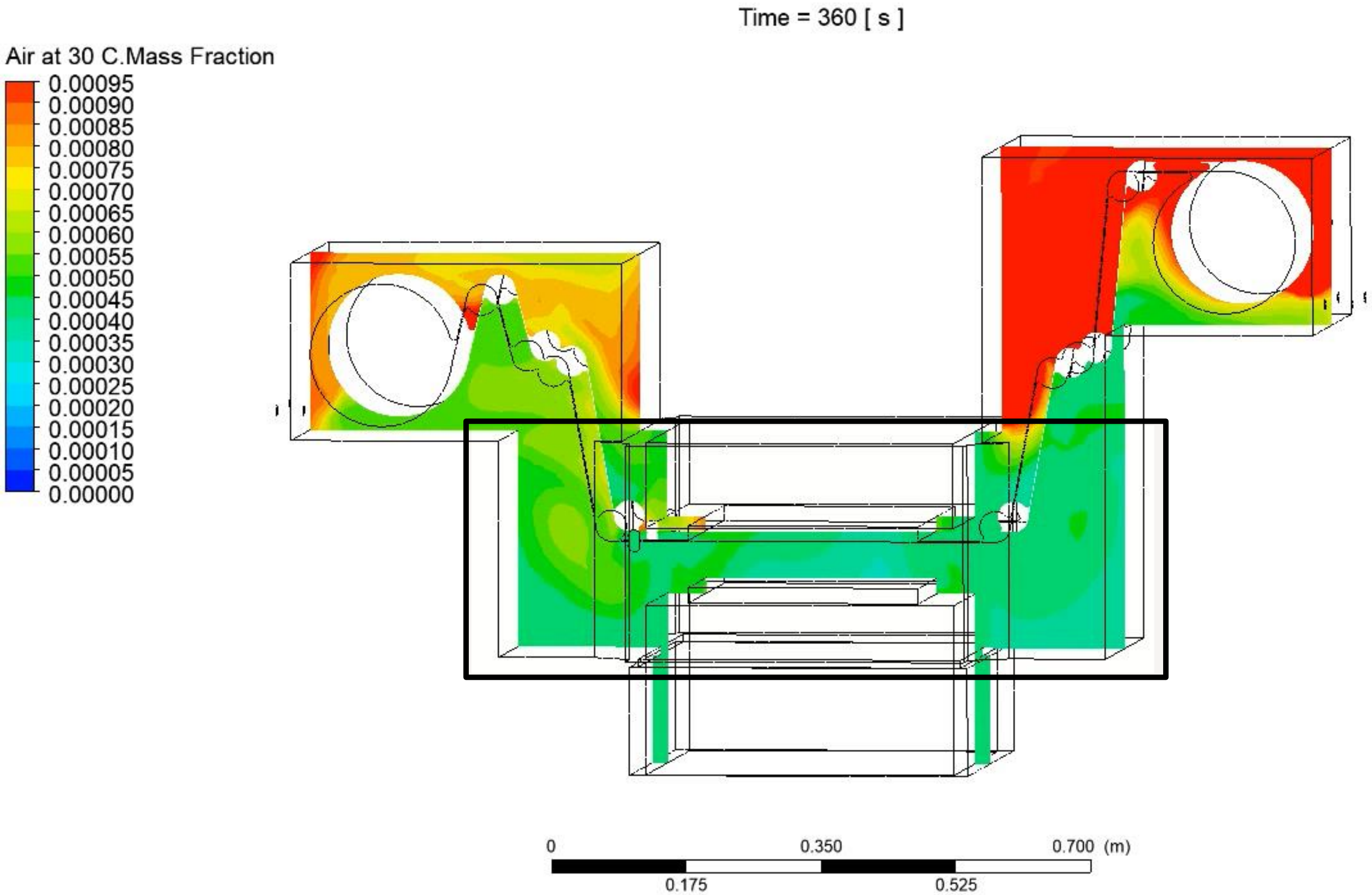
1. Copper-to-copper bonding – machine conditioning

- Analyze flow fields of concepts
- Make sure;
  - No stagnant volumes
  - N2 flushes all critical areas



1. Copper-to-copper bonding – machine conditioning

- Target achieved after 358 seconds!



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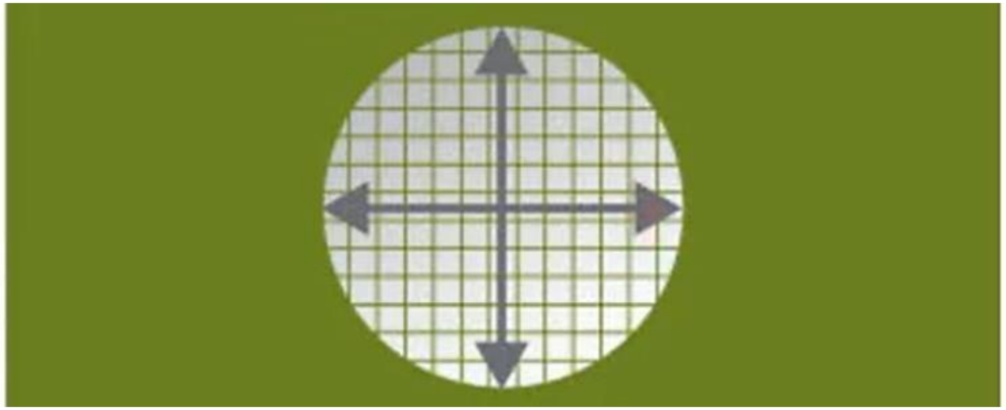
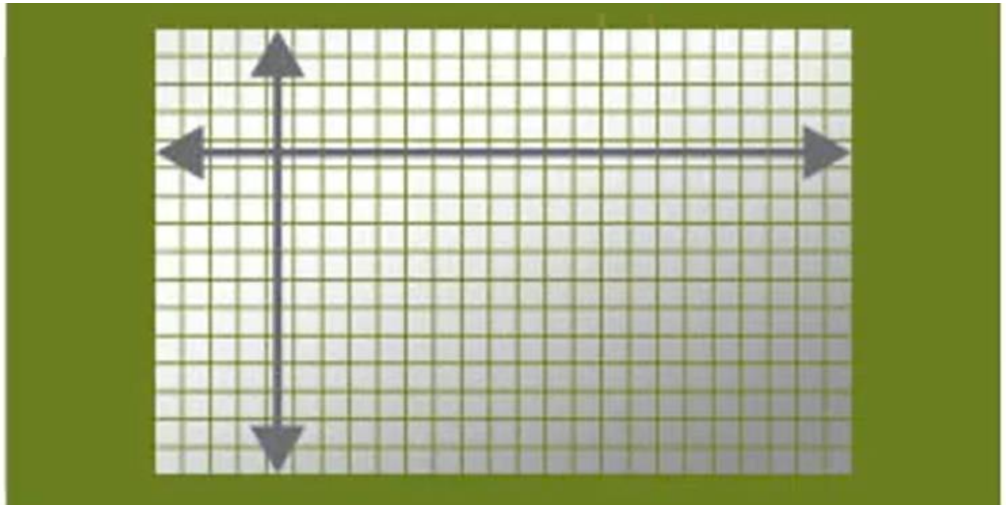
Panel level packaging – warpage prediction

2. Panel-level packaging

- Wafer-level packaging
  - Fully developed
  - High yield, low costs
  - Controlled production issues



- Panel-level packaging
  - In development
  - Higher yield, lower costs
  - *Production issues more complex*



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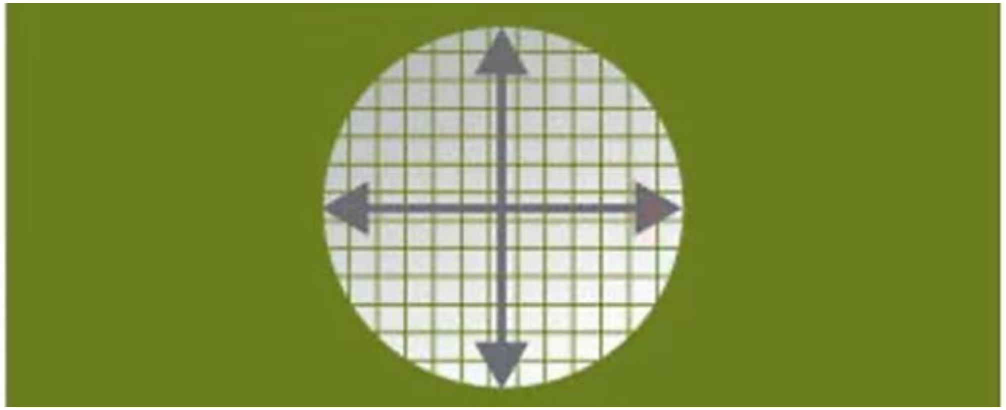

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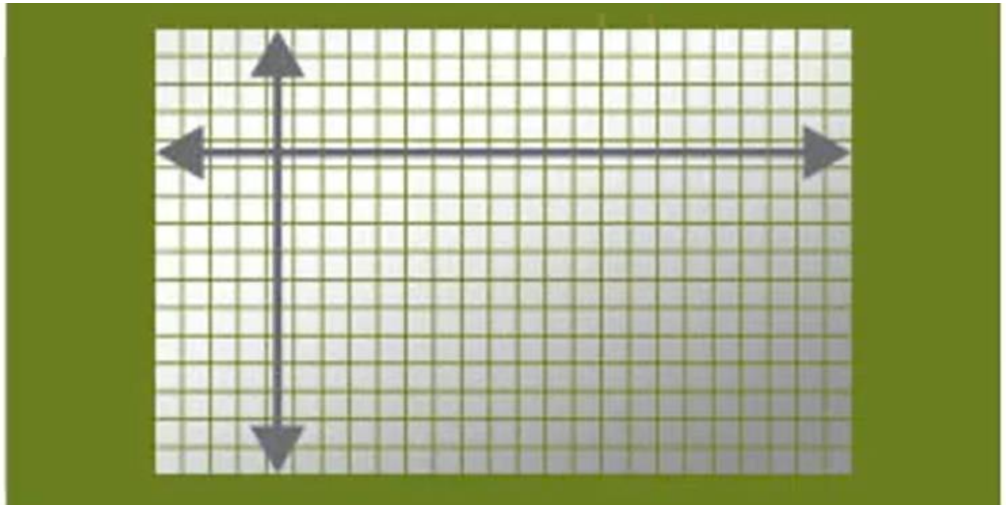
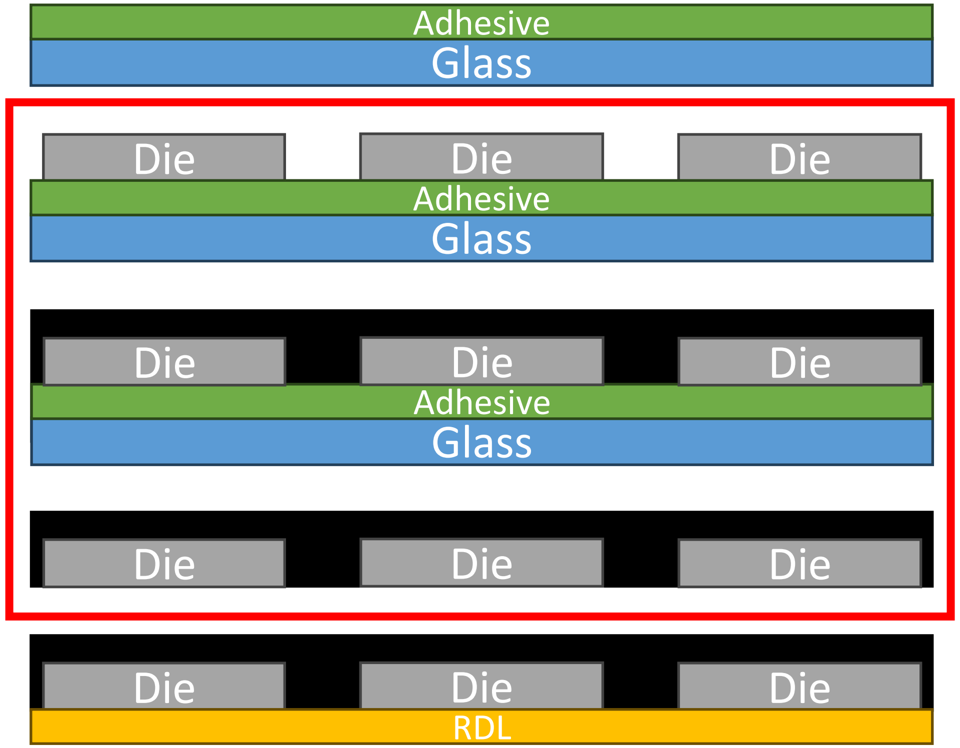


2. Panel-level packaging

- Problem: Panel-level packaging → Excessive warpage…
- Approach: Stress and deformation analysis with simulations!
- Questions: Suitable material? Cooling rate? Final deformations?

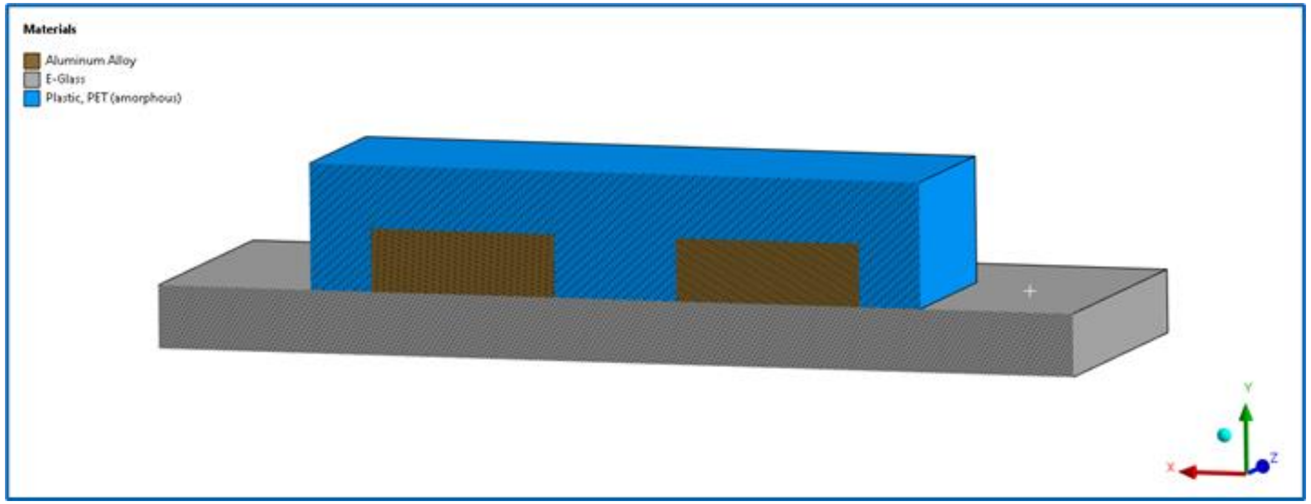
2. Panel-level packaging – warpage prediction

- Packaging method
  1. Temporary adhesive layer.
  2. Deposition of dies
  3. Addition of compound
  4. Removal of adhesive and glass
  5. Addition of RDL components



2. Panel-level packaging – warpage prediction

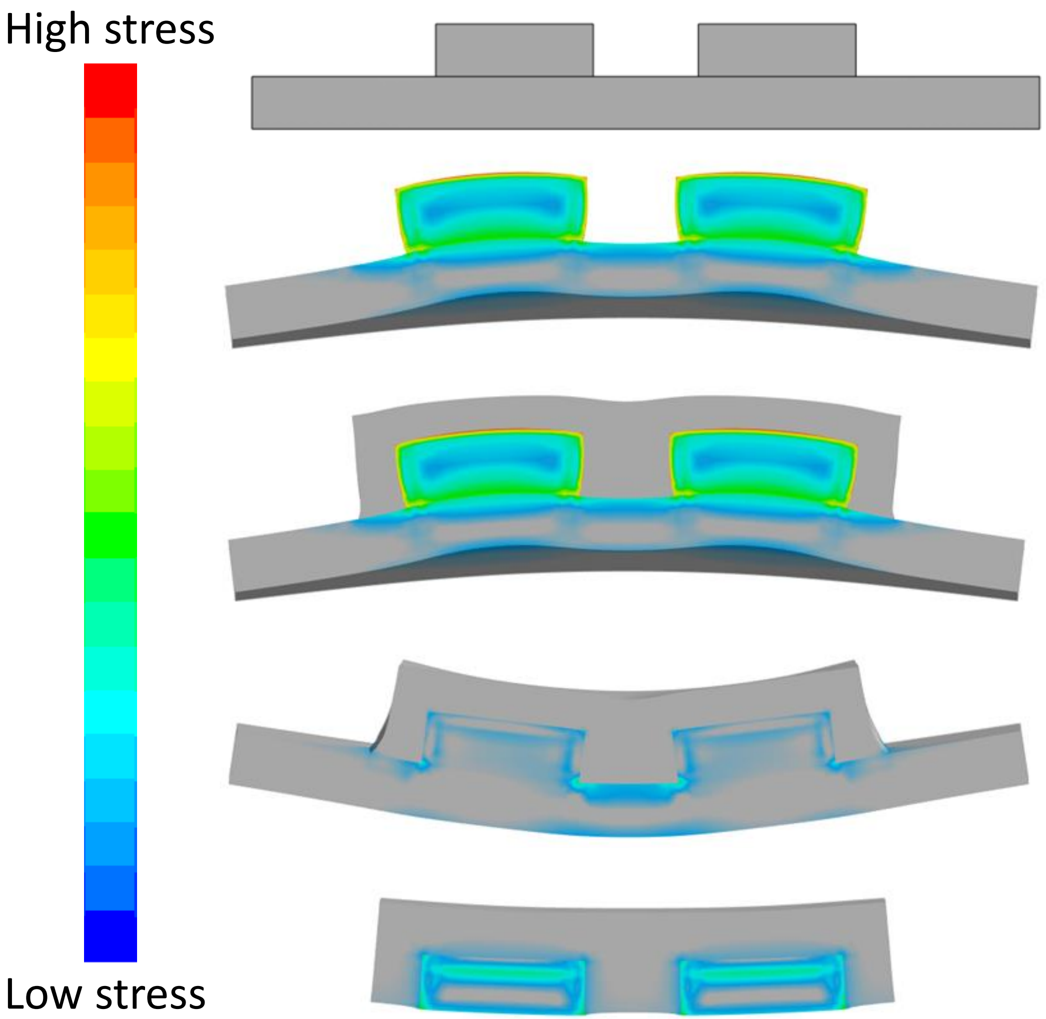
- Physical steps:
  - Initial state at 20 °C
  - Heating up die and glass to 100 °C
  - Adding compound
  - Cooldown to 20 °C
  - Removing glass



2. Panel-level packaging – warpage prediction

- Physical steps:
  - Initial state at 20 °C
  - Heating up die and glass to 100 °C
  - Adding compound
  - Cooldown to 20 °C
  - Removing glass

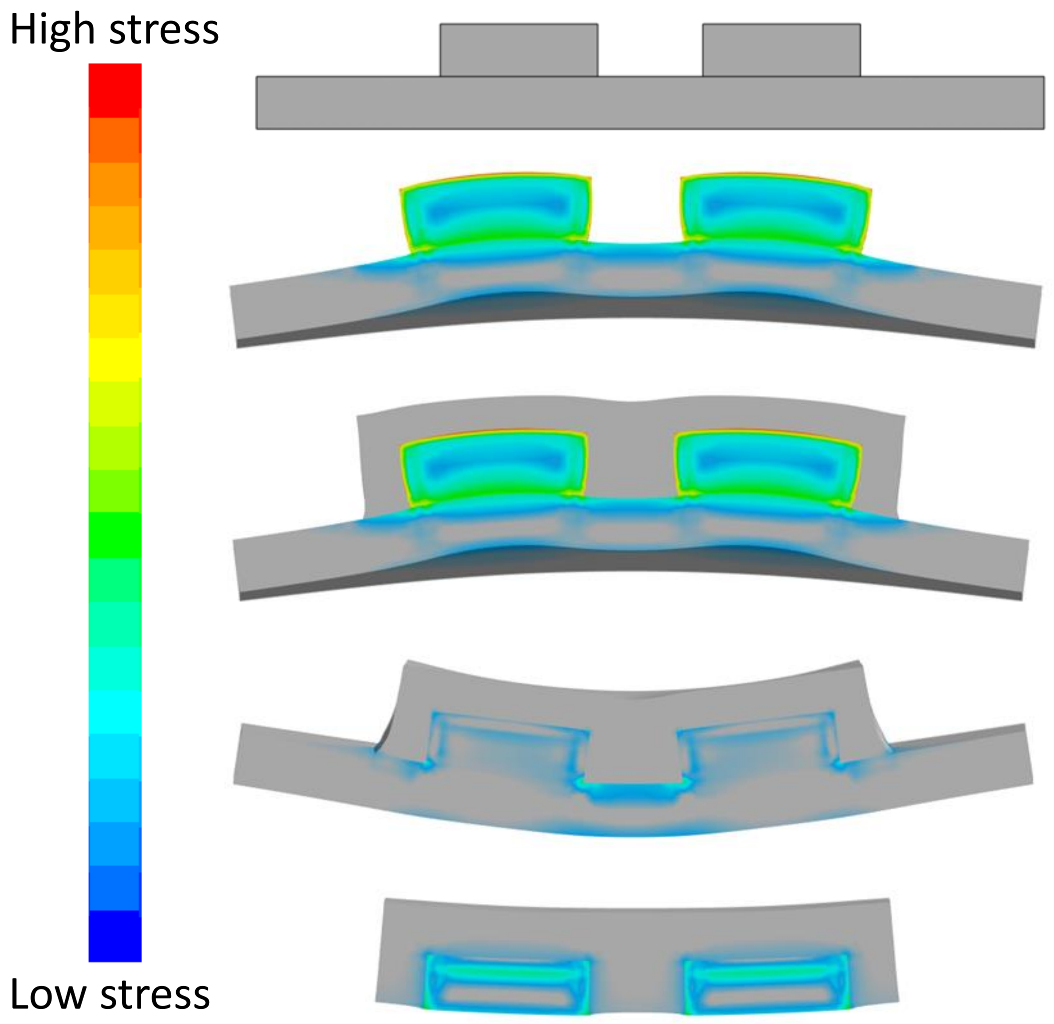
CTE:
glass < die < compound



2. Panel-level packaging – warpage prediction

- Resulting stresses
- Final warpage
- RDL on curved surface

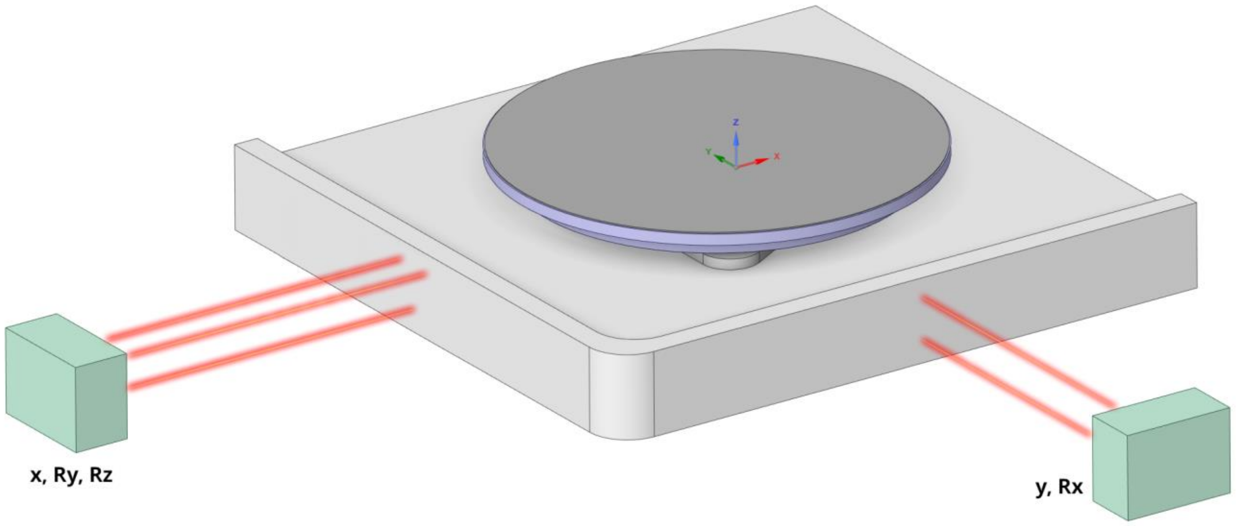
- Improvement options:
  - Materials
  - Production conditions
  - Design



High precision systems – Thermal drift

3. High precision systems

- Wafer placement and control
- Elevated temperatures
- Upscaling & sophistication
- *Control of system behavior*

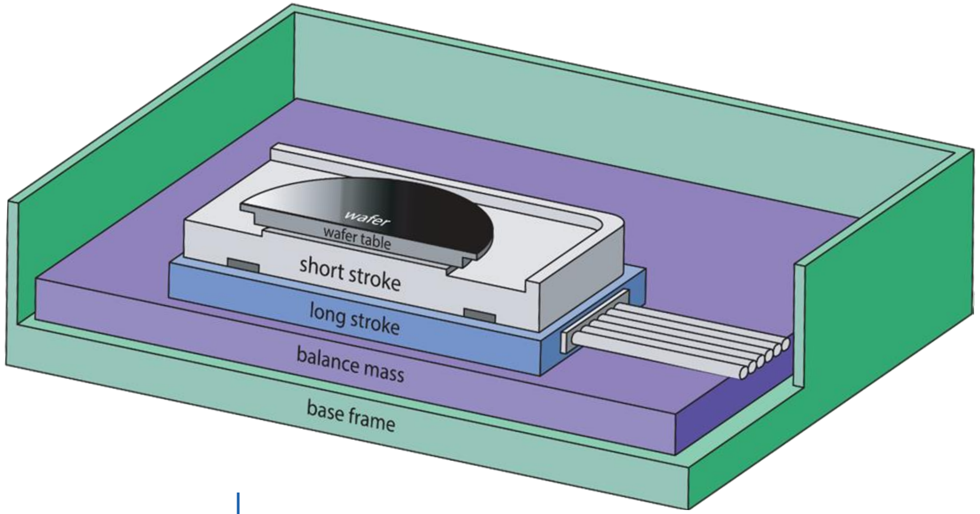


3. High precision systems

- Problem: Thermal drift hinders accurate placement…
- Approach: Transient simulation of thermal behavior!
- Questions: Deformation rate? Thermal center?

3. High precision systems – thermal drift

- Positioning wafer
  - Long stroke
  - Short stroke
- Positioning control
  - Lasers & sensors
  - Mirror planes



3. High precision systems – thermal drift

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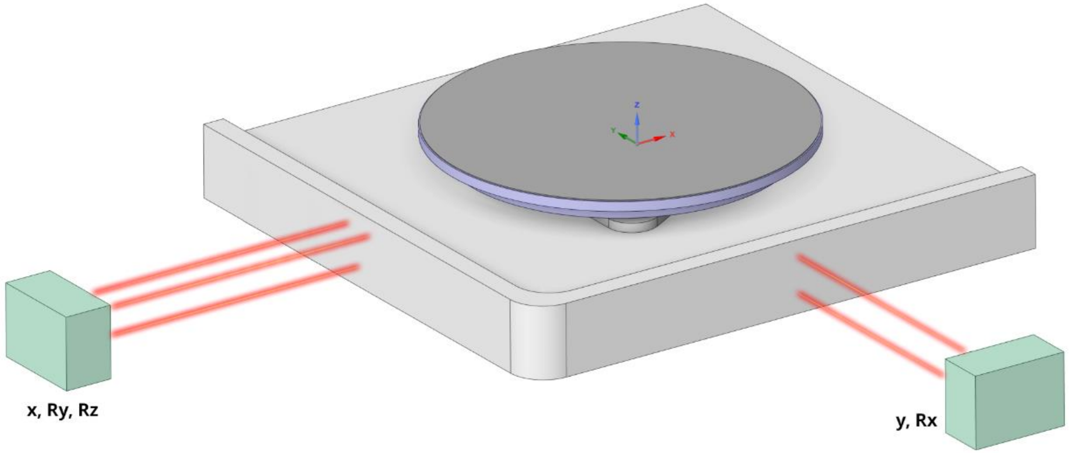
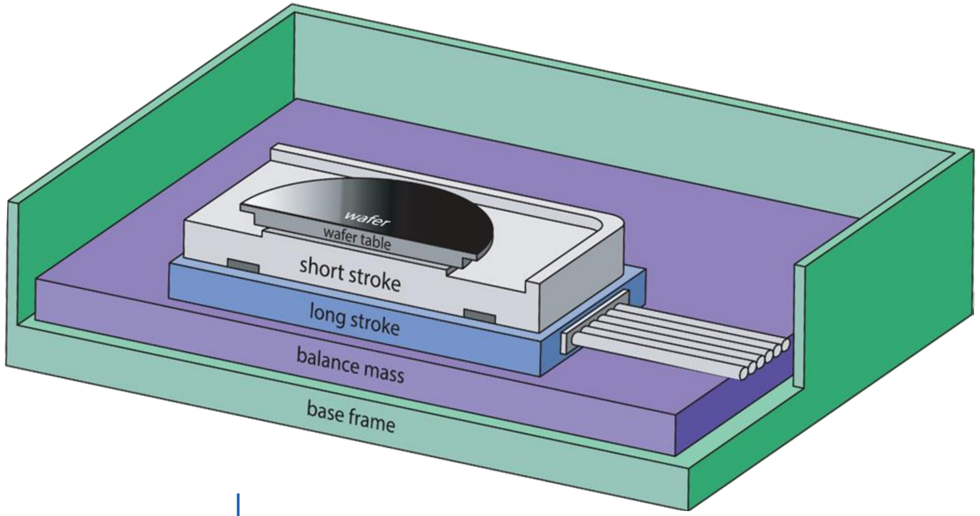
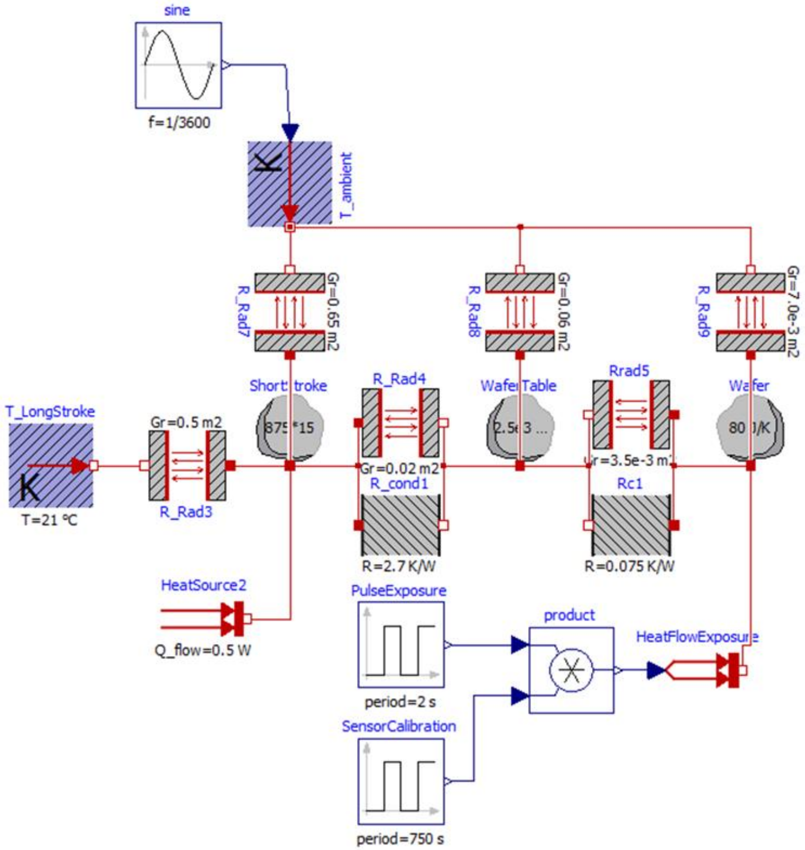


3. High precision systems – thermal drift

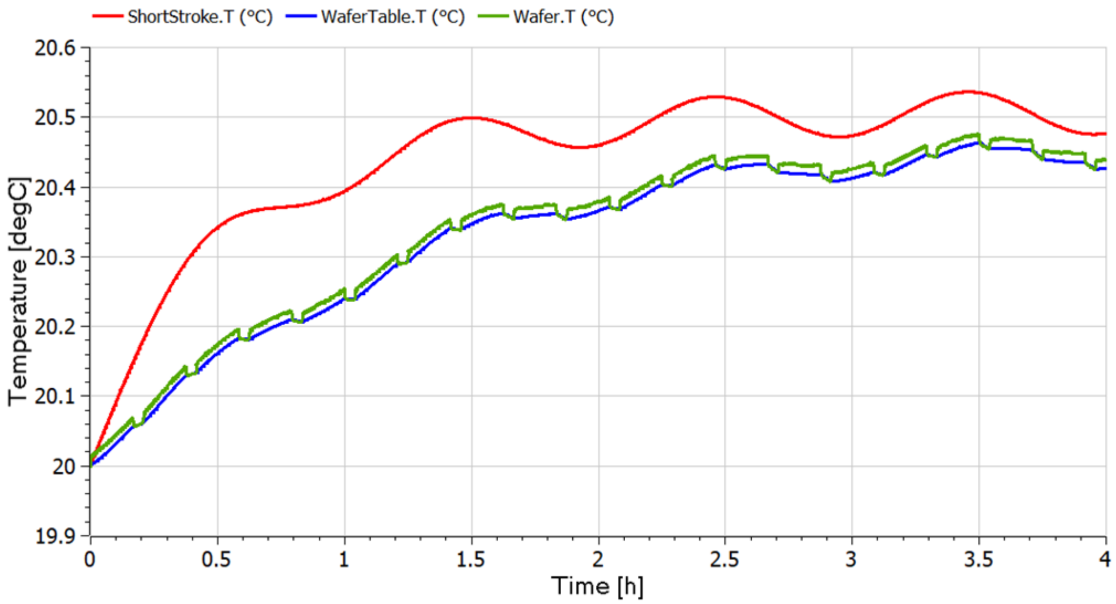
- Lumped Element Modelling
- Components: heat capacities
- Short stroke + photo-lithography: heat sources





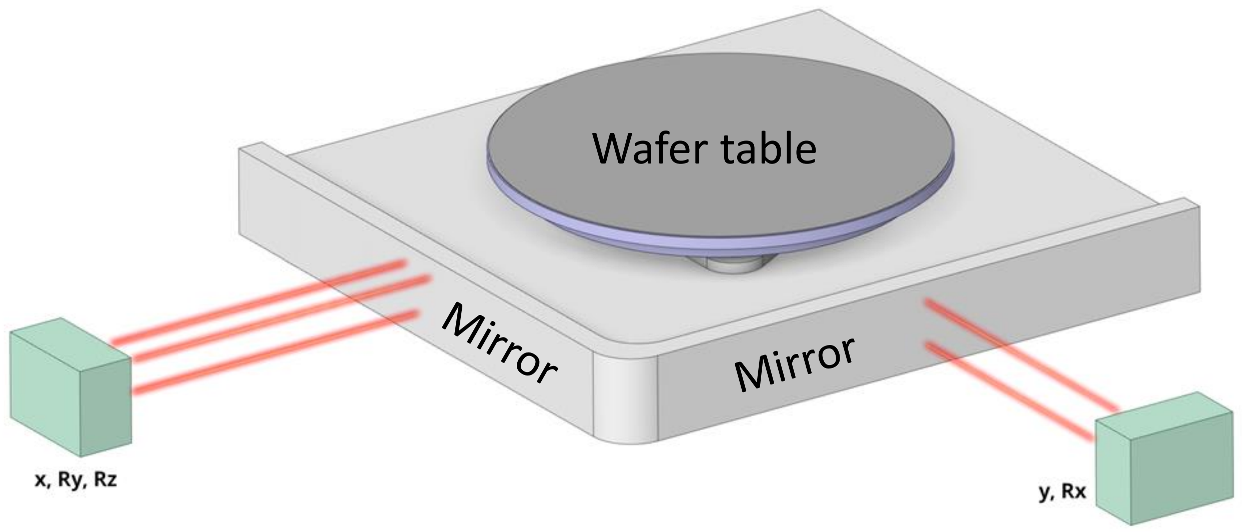
3. High precision systems – thermal drift

- Tactical recalibration moments
- Expected ΔT → Prediction of thermal expansions!



3. High precision systems – thermal drift

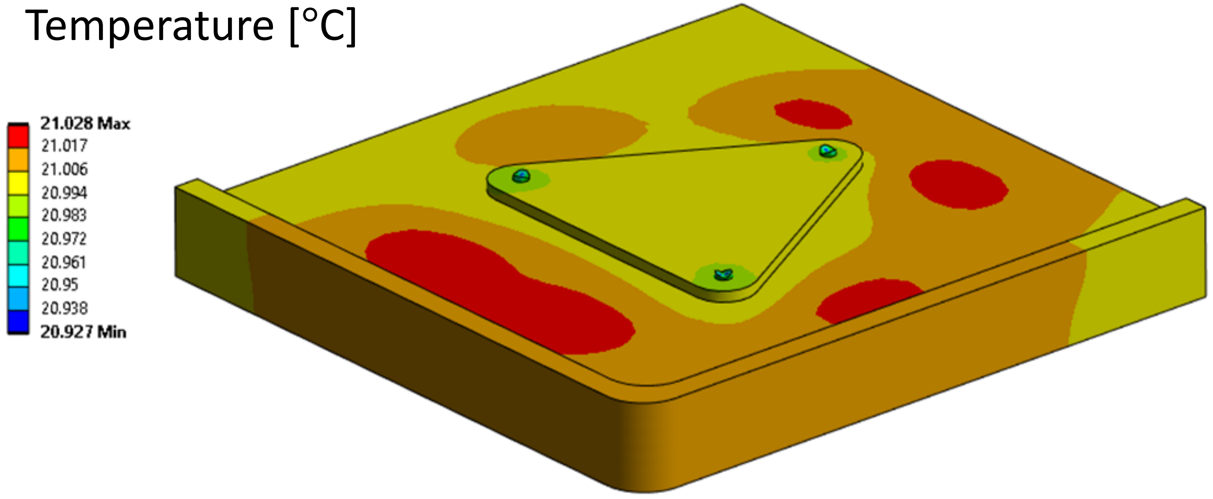
- Finite Element Modelling
- Identical loads as previous
- Detailed thermal-mechanical effects
- Flatness of mirror planes?



3. High precision systems – thermal drift

- Hot spots from radiation & magnetic eddy currents
- Non-uniform temperature on mirror planes
- ΔT = 0.021 °C this is small!

Temperature [°C]



- Still; Large deformation effects!

Out-of-plane deformation [m]

Simulations in semicon

- Fast and detailed insight in complex physics
- Iterative design preventing costly experiments
- Prove feasibility of new concepts

Thank you for attending

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