SIMULATION-ASSISTED APPROACHES TOWARDS OPTIMIZING EAP APPLICATIONS

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21. April 2015 - Electroactive Polymers: how to link science and industry

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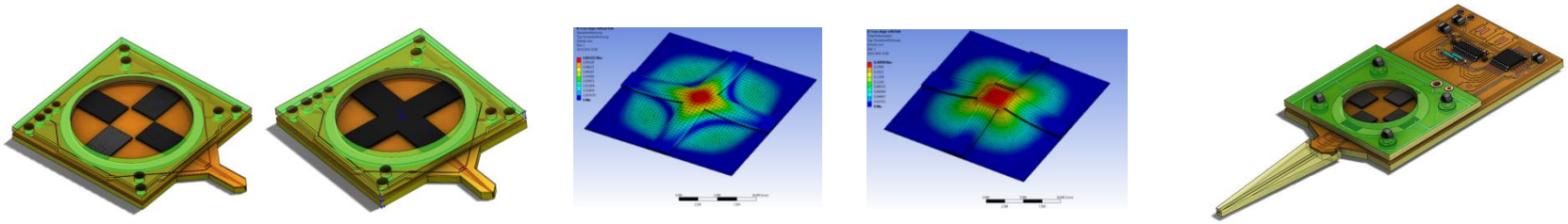


Why use simulation?
4 main reasons for going virtual

- Simple and fast investigation of the influence of different material and design parameters on actuator performance
- No need for manufacturing multiple prototypes
- No need to conduct costly and time-consuming test series
- Easy prediction of actuator system performance

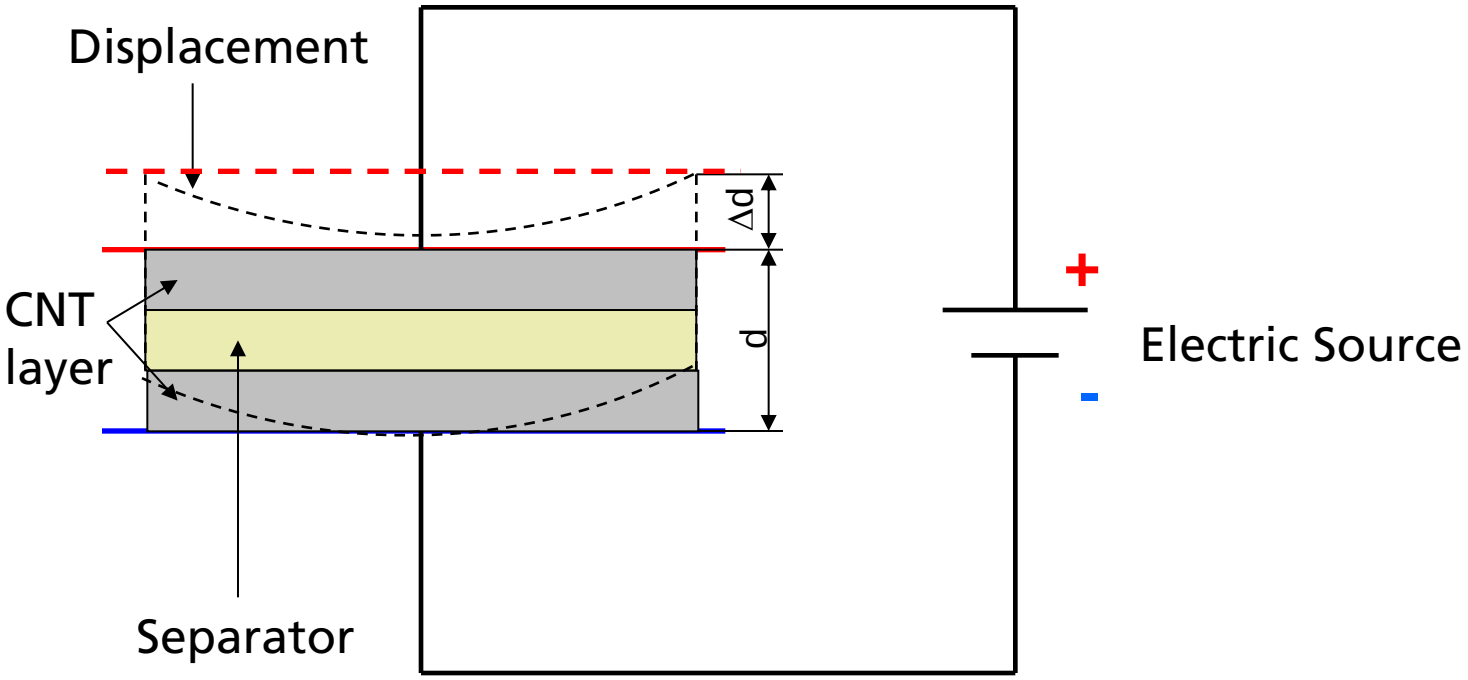
Main goal:
To be able to predict the actuation performance of various [pipette-] geometries in order to optimize shapes for individual applications and enhance the actuation mechanism through mechanical leverage effects.

Part 1

BASICS

Motion principle of EAP-Actuators

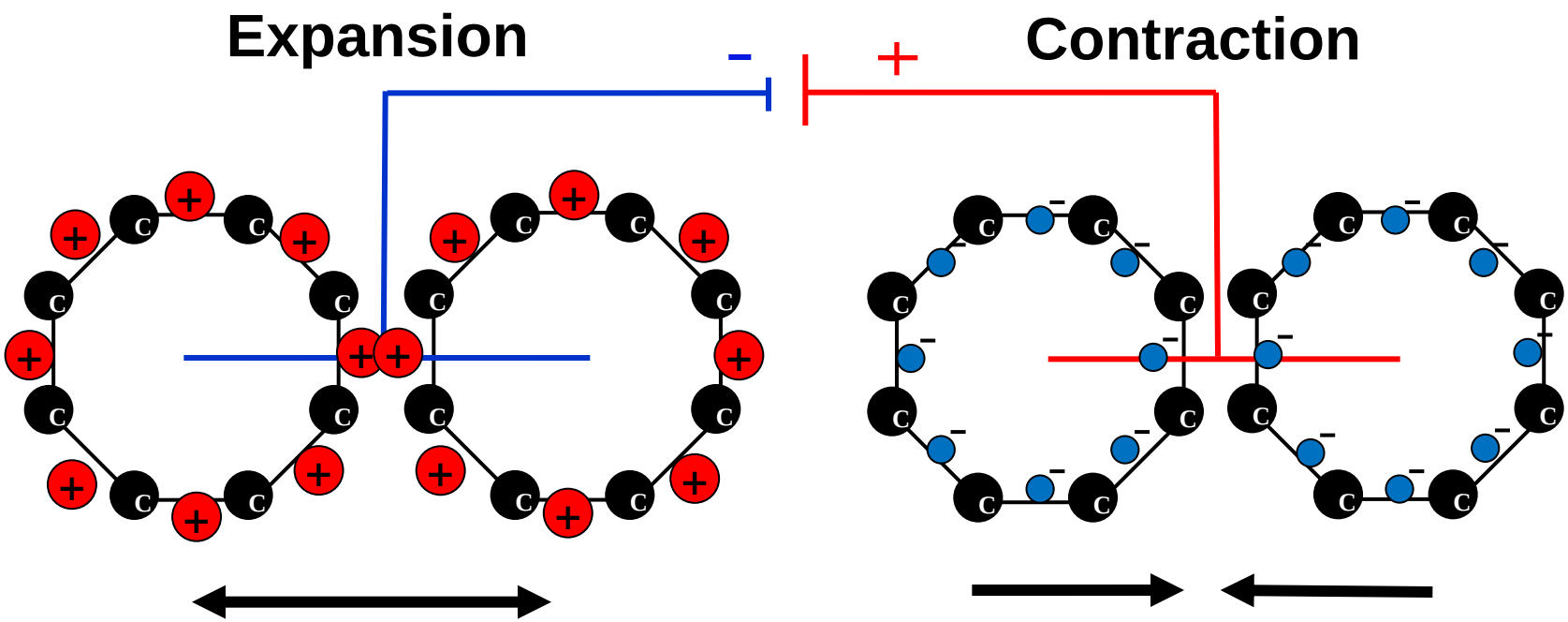
How they work



Actuation principles in CNT-EAPs

Combination of different effects

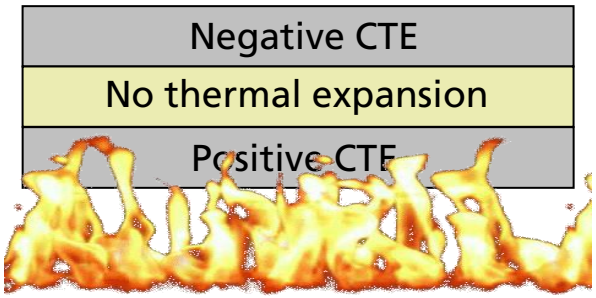
1. Effect: Electrostatic repulsion
2. C-C bond elongation
3. Effect: Ion-Intercalation

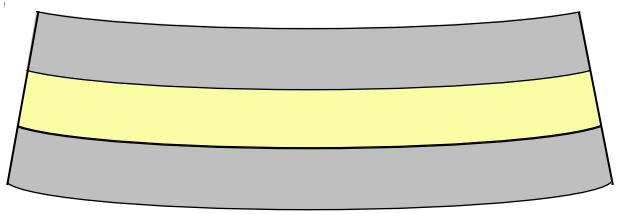


How is simulation for EAPs done at Fraunhofer IPA?
"Parameter matching technique"

Transfer existing measurement data about voltage/displacement and force relationships of CNT actuators into a set of virtual material parameters usable for simulation environments.

- Step1: Get mechanical material parameters from experimental tests
- Step 2: Obtain basic performance characteristics from tests with small actuator samples
- Step 3: Match force-displacement characteristic for different voltages with a virtual thermal load applied to all parts of the simulation assembly.
- Step 4: adjust CTE values for EAP electrodes until the virtual performance matches the experimental tests



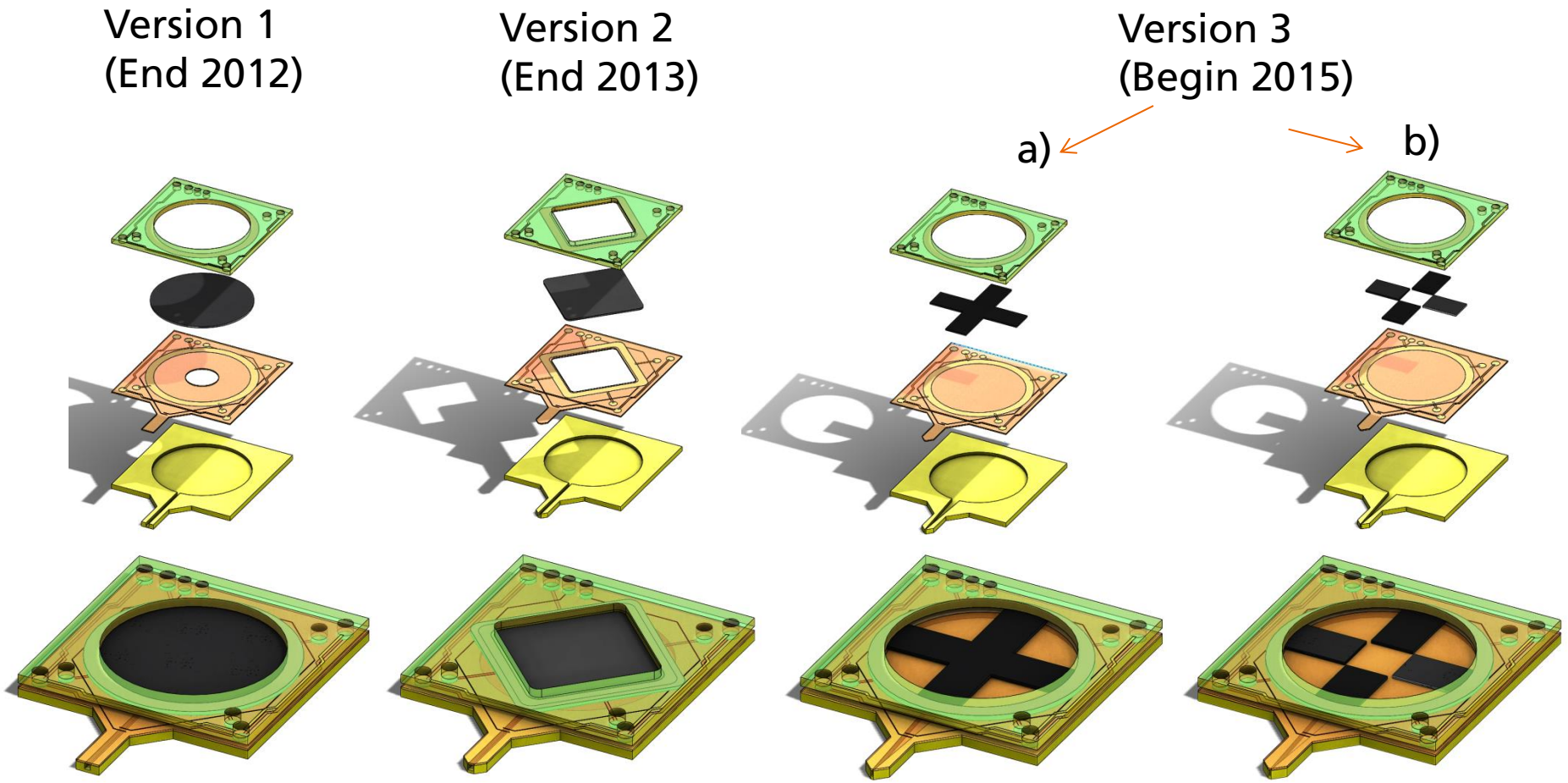


CTE = **C**oefficient of **T**hermal **E**xpansion

Part 2

APPLICATION EXAMPLE

Compilation of past and current prototypes



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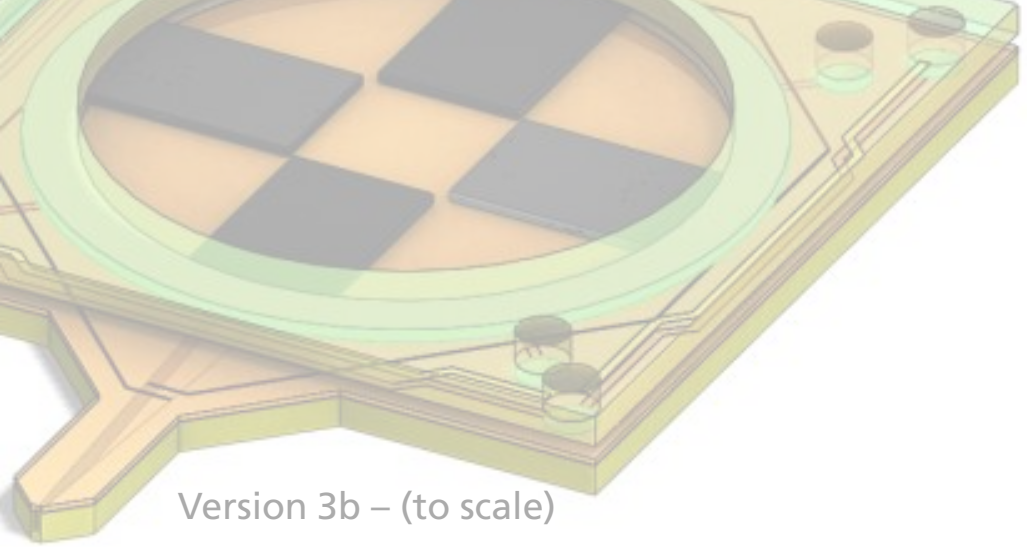
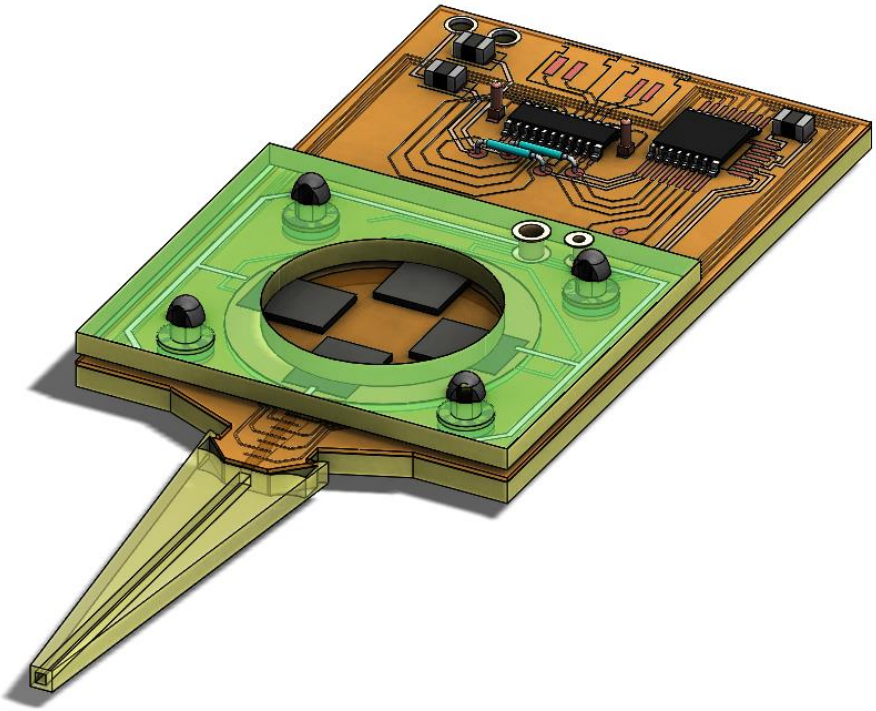


Version 3b – (to scale)

CAD model of VERSION 4

(subject to change)

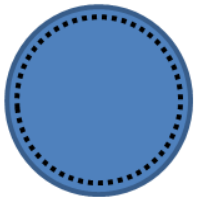
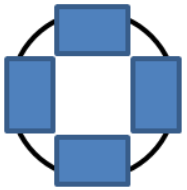
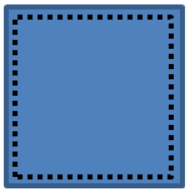
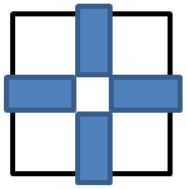
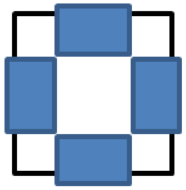


Features:

- Detachable pipette tip
- Integrated electronic control circuit
- Simple & automated manufacturing & assembly of parts
- Simple scalability
- Pure PCB technology with SMDs

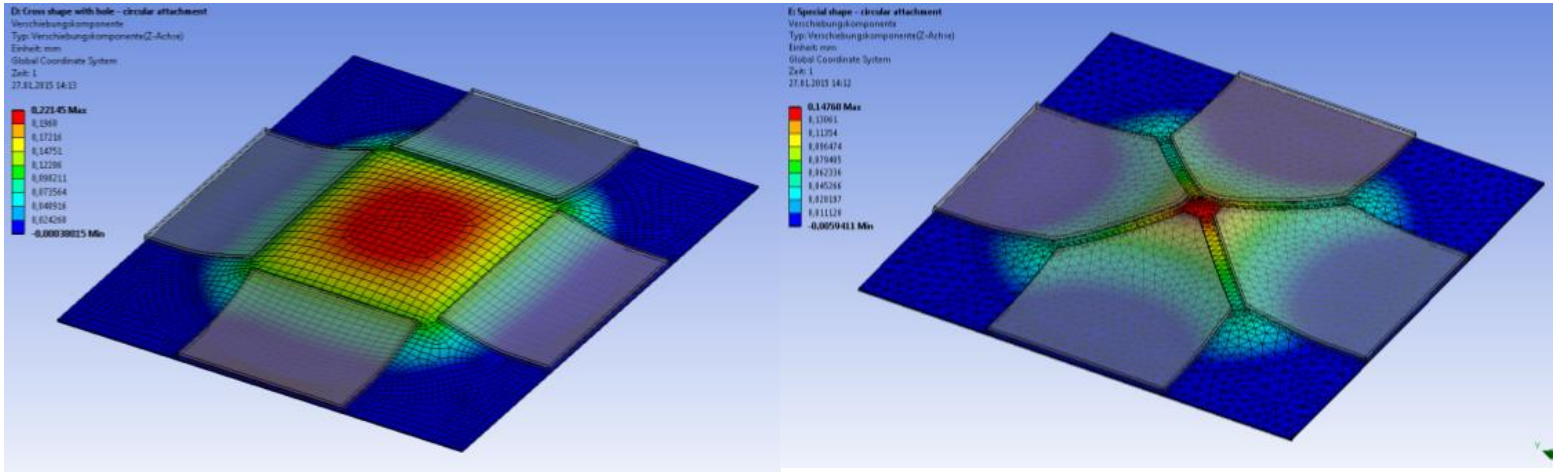
Example for meaningful usage of simulation

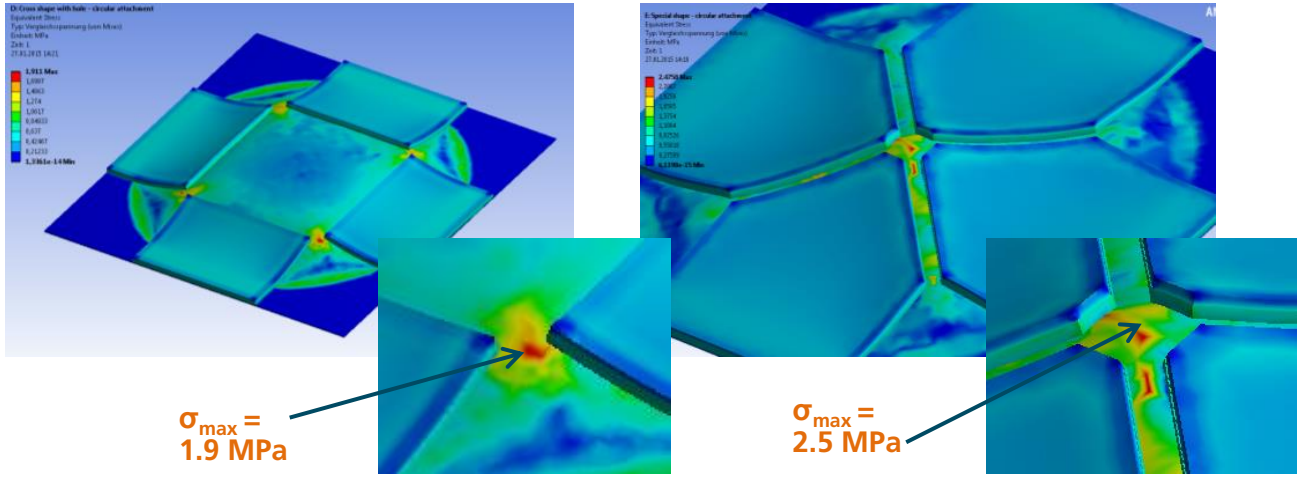
Investigation of actuator shape and configuration design

	„**closed**“ Full cover	„**closed**“ cross-shape narrow beam	„**closed**“ cross-shape wide beam	„**open**“ cross-shape narrow beam	„**open**“ cross-shape wide beam	„**open**“ cross-shape Special cut
Attachment to **circular** contact						
Attachment to **square** contact						

Prediction of membrane displacement

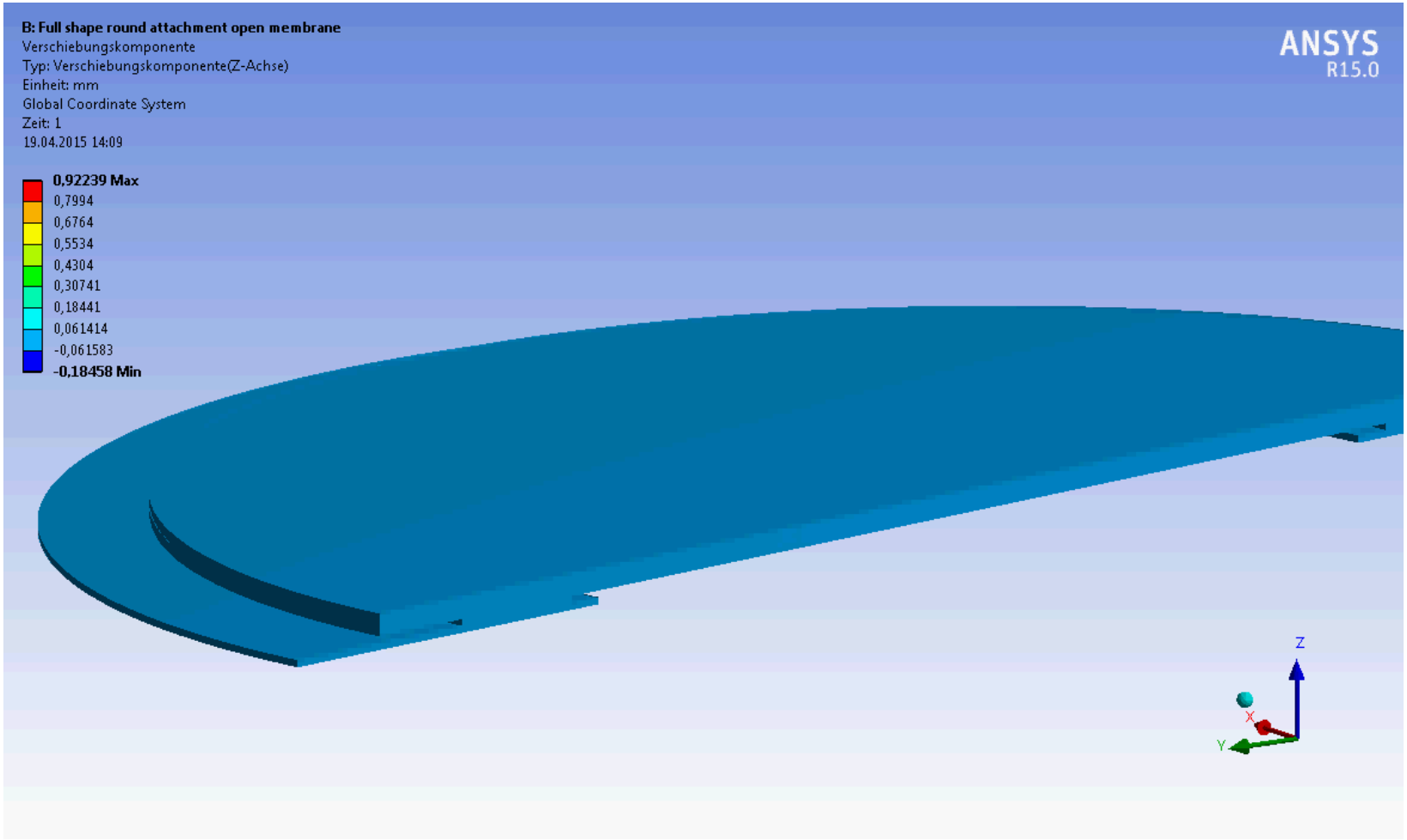
FEM-Simulation of different configurations





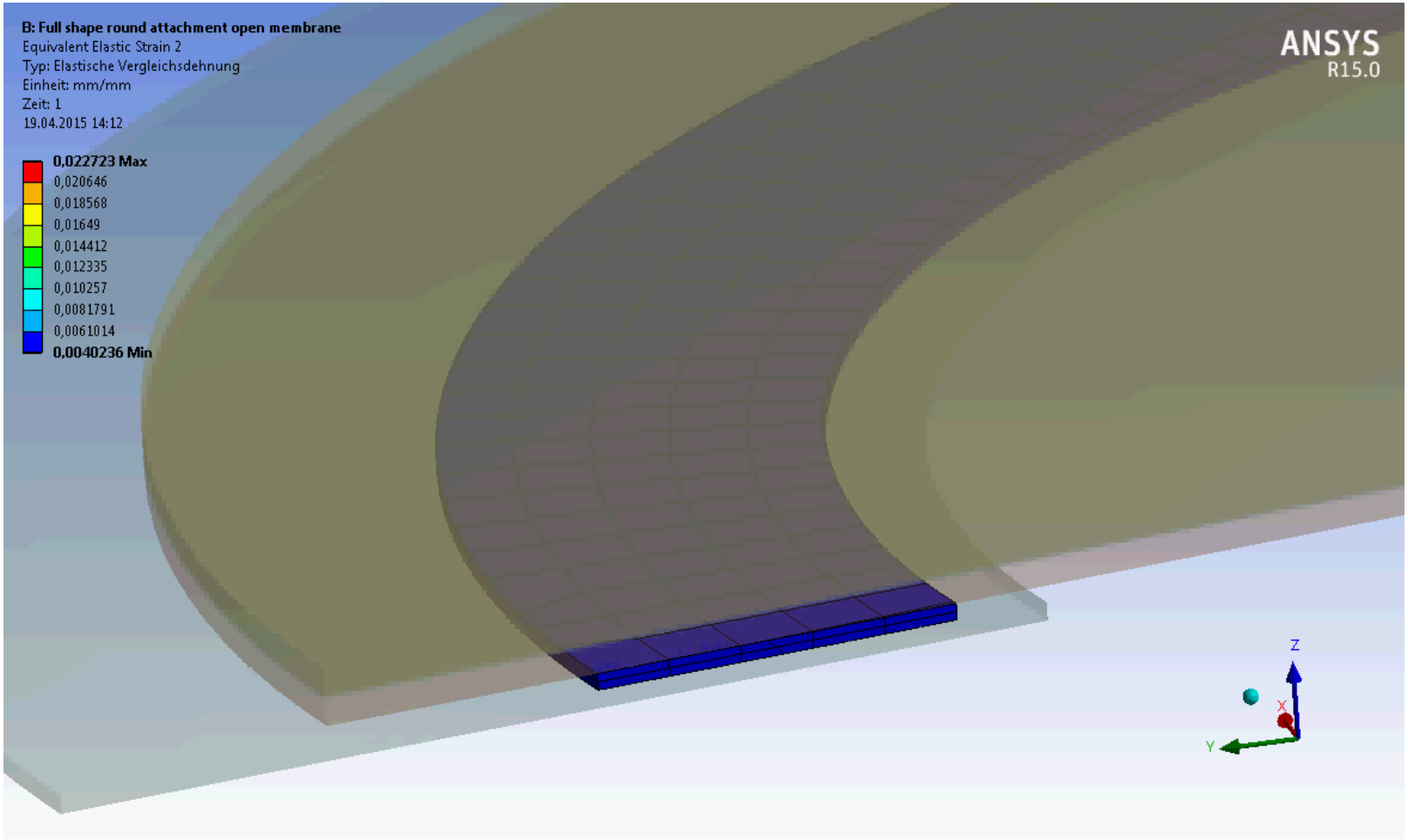
Prediction of membrane displacement

FEM-Simulation of full-shape round actuator



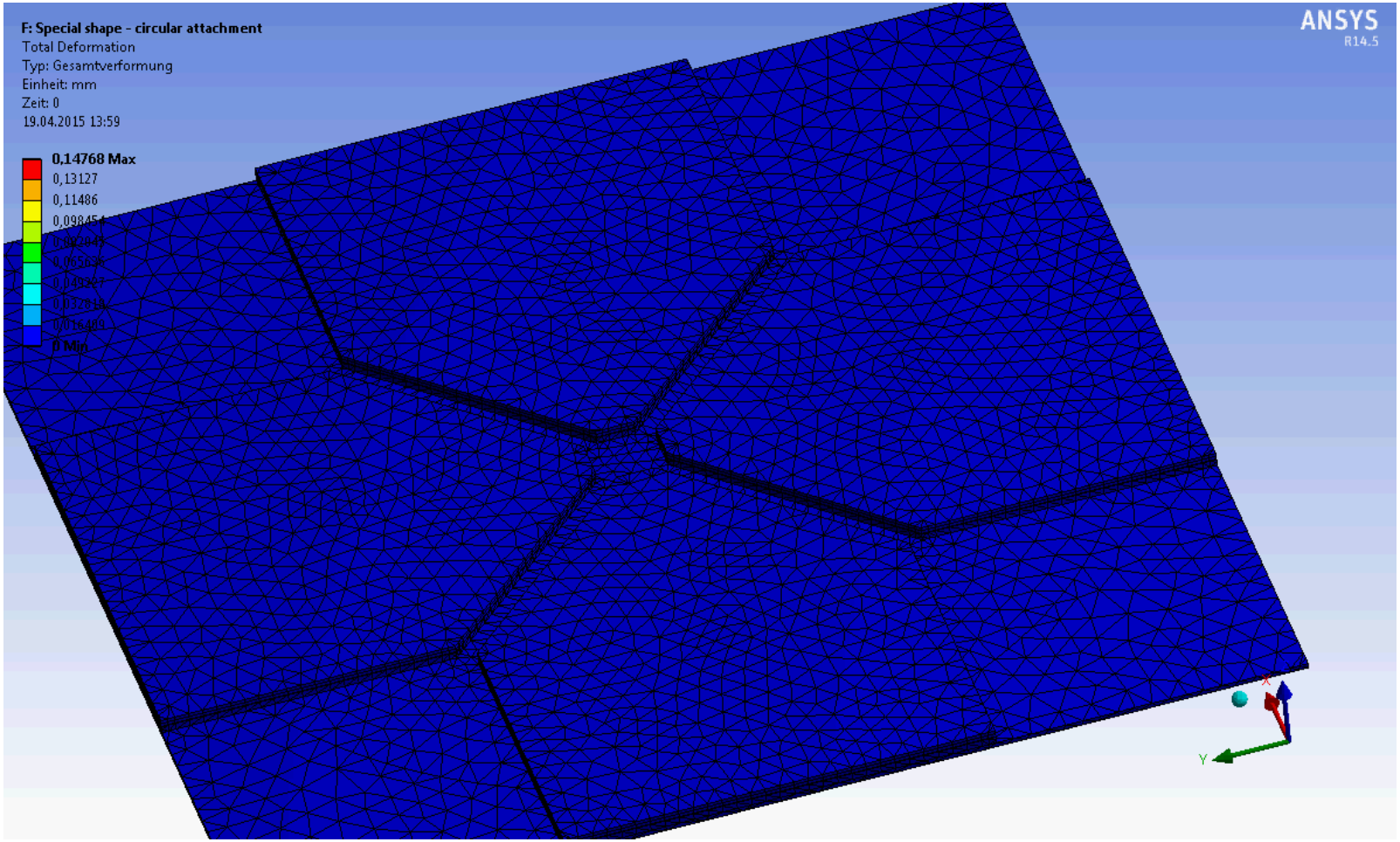
Prediction of membrane displacement

Strain inside the glue tape



Prediction of membrane displacement

displacement of “special shape” actuator configuration



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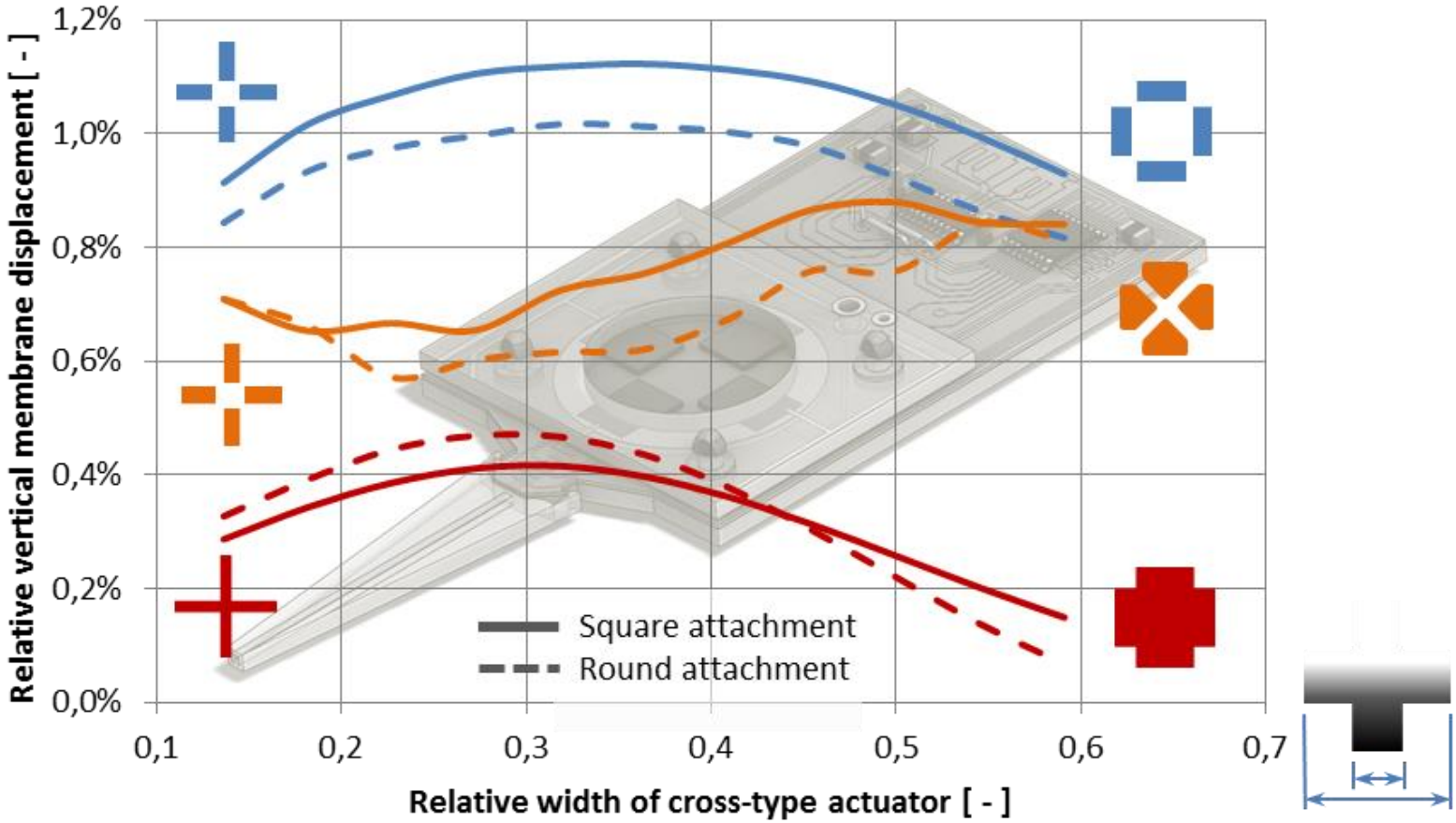
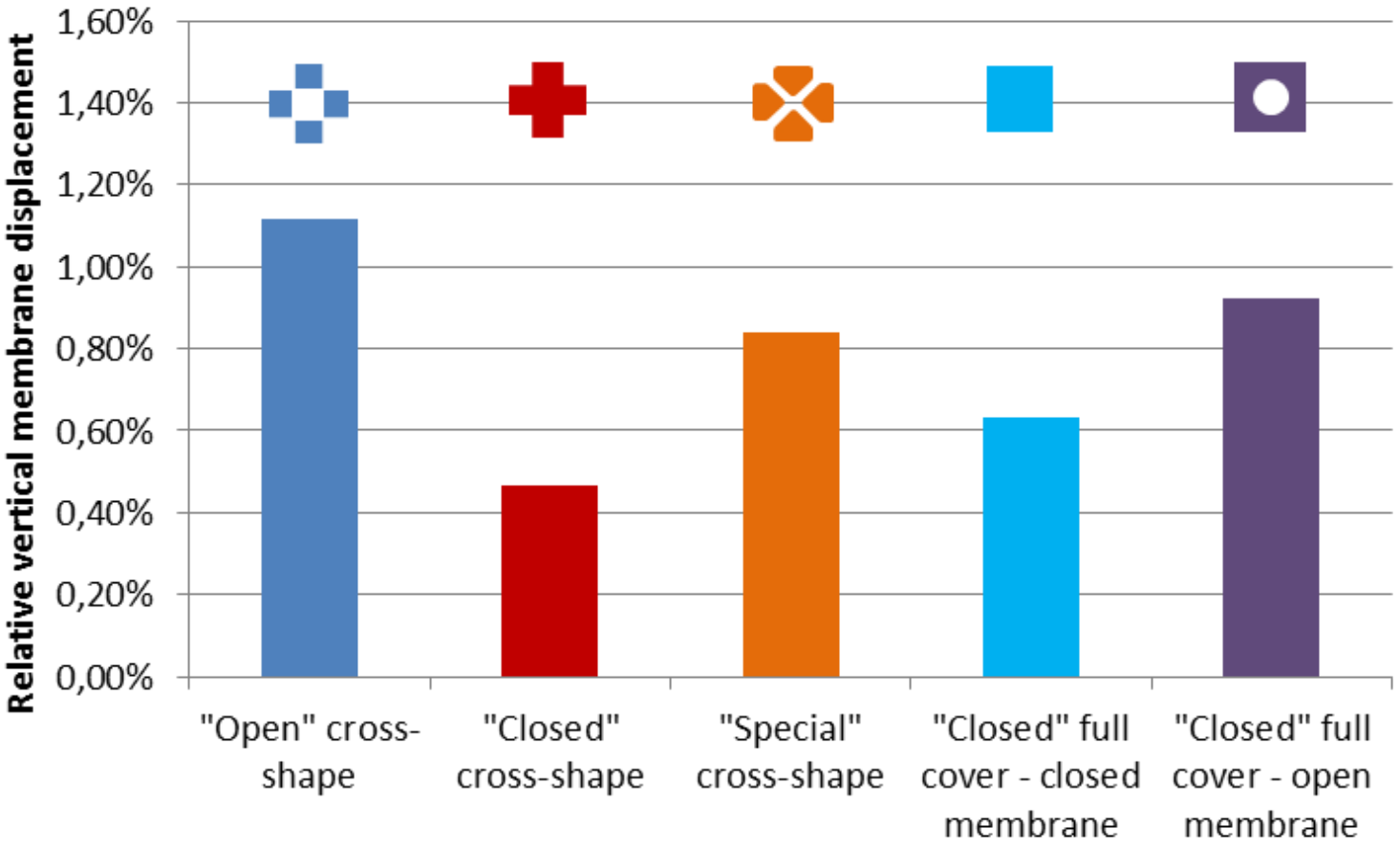
Prediction of membrane displacement

Results for different shapes and configurations

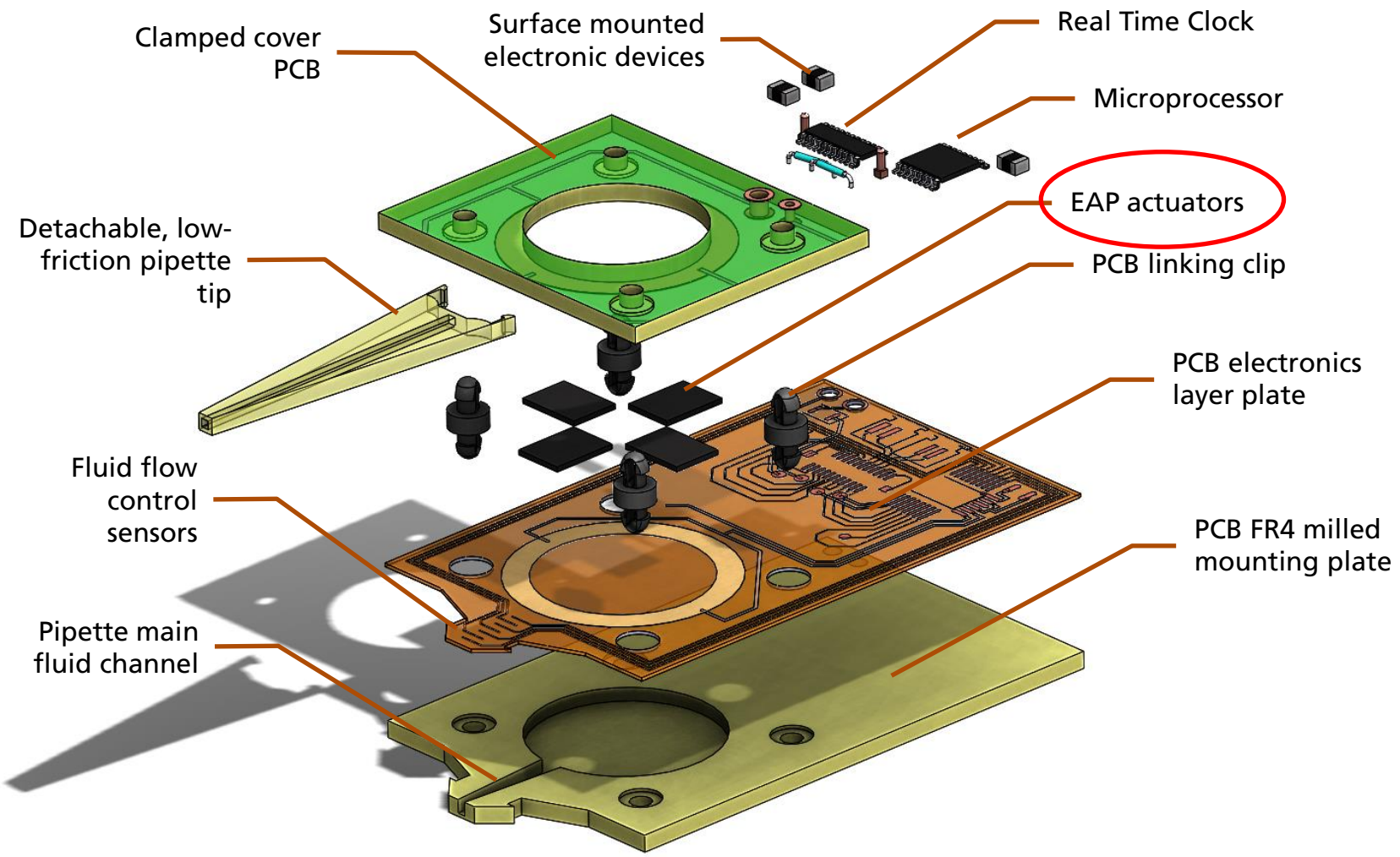


Prediction of membrane displacement

Results for different shapes and configurations



Component view of potential VERSION 4



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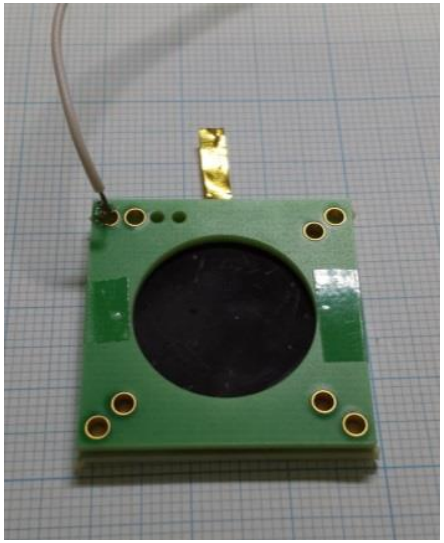
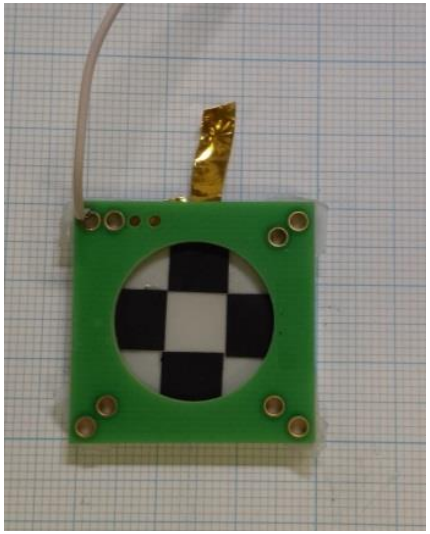
Membrane displacement
Actual measurement results from prototypes

Full cover actuator on rubber membrane
- Max. displacement: **0,25mm** (pp)
- Volume increase: **~43mm³**



~ 2 x better than pipette V1

Cross shape actuator on rubber membrane
- Max. displacement: **0,40mm** (pp)
- Volume increase: **~ 85mm³**



~ 4 x better than pipette V1

Summary
The three main statements

- Simulation of EAP applications saves time and cost (fewer tests, less prototypes)
  -> more than 200 configurations have been simulated -> effective cost savings

- Parameter matching technique works within a broad range of EAP applications
  -> improved models consider ***back-relaxation effects*** and ***transmission line effects***

- Qualitative and (more and more) quantitative predictions of the performance of EAP application can be achieved
  -> build-up of simulation know-how and data