

Collaborative Study on the Impact of Die Attach Adhesives for MEMS Integration

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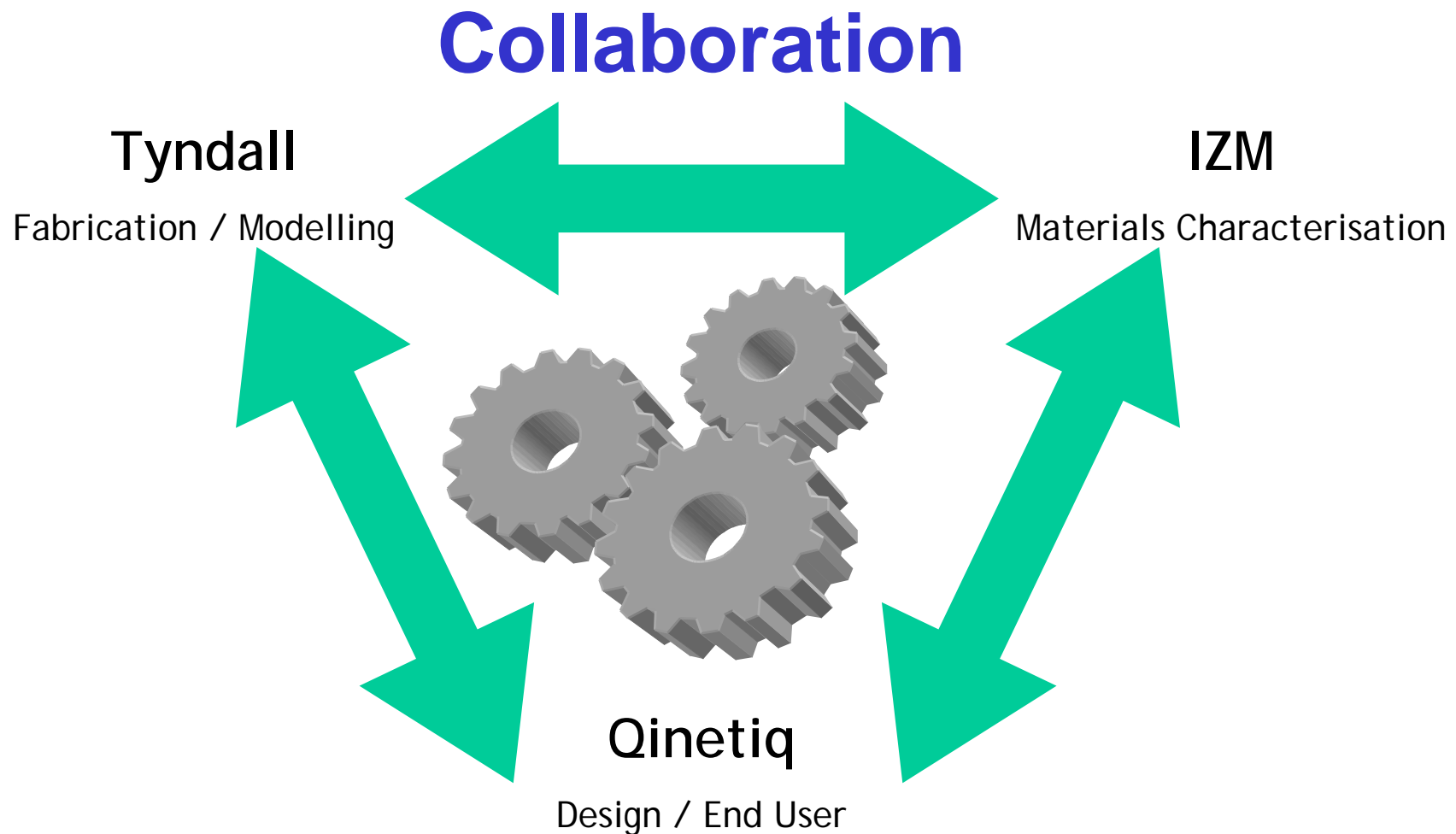
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Outline

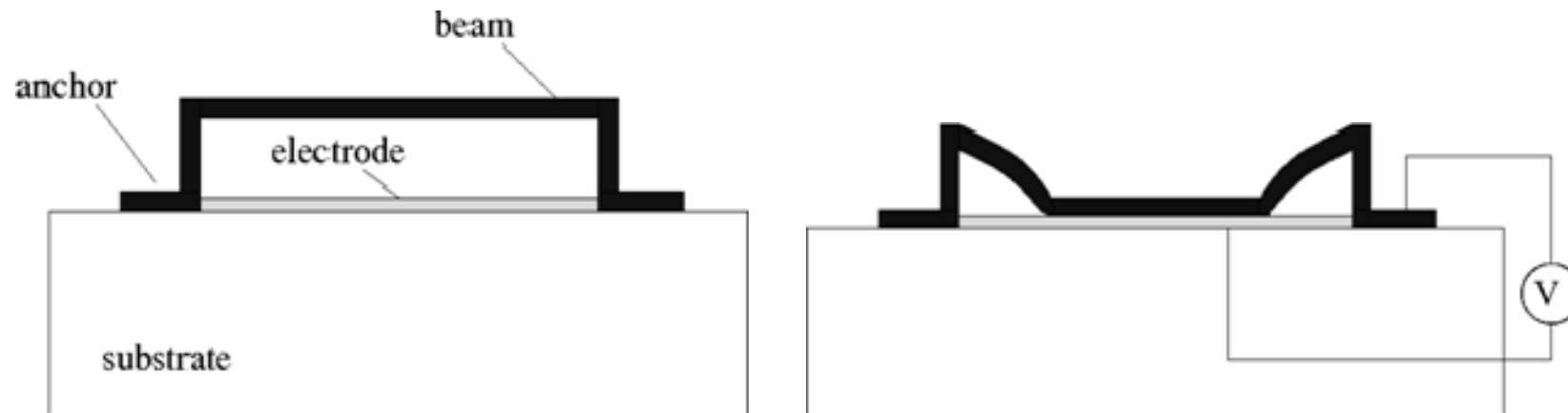
- Collaboration
- Material Characterisation
- Modelling
- Results
- Conclusions



Collaboration of partners with differing and complementary expertise in MEMS Modelling, Fabrication, Test Structures, Reliability and Packaging

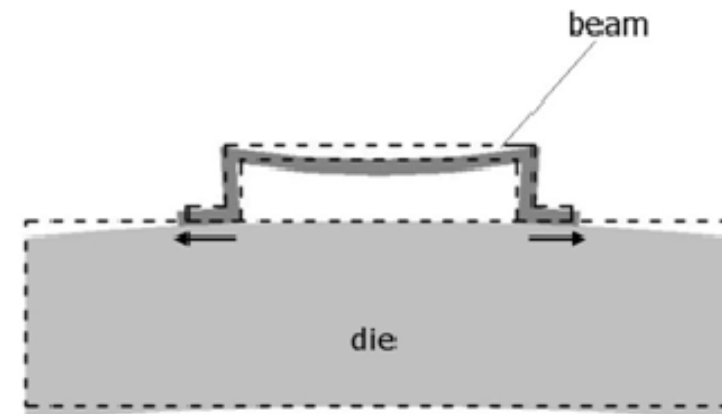
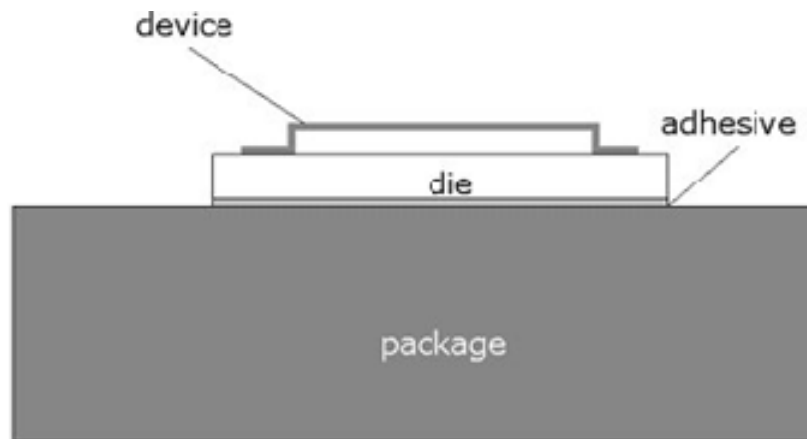
Micromachined Beam

- Elastic stiffness vs. electrostatic force
- “Pull-in” voltage:
 - Structure mechanically unstable
 - Collapses to the ground



Packaged Component

- Die attached to package using adhesive
- Thermal cure of adhesive causes die deformation → Device deformation



Adhesives

Common materials used in electronic packaging

- Heraeus PC3001
- Sylgard 184
- Ablebond 84-1LM1

Step 1: Characterisation of adhesives

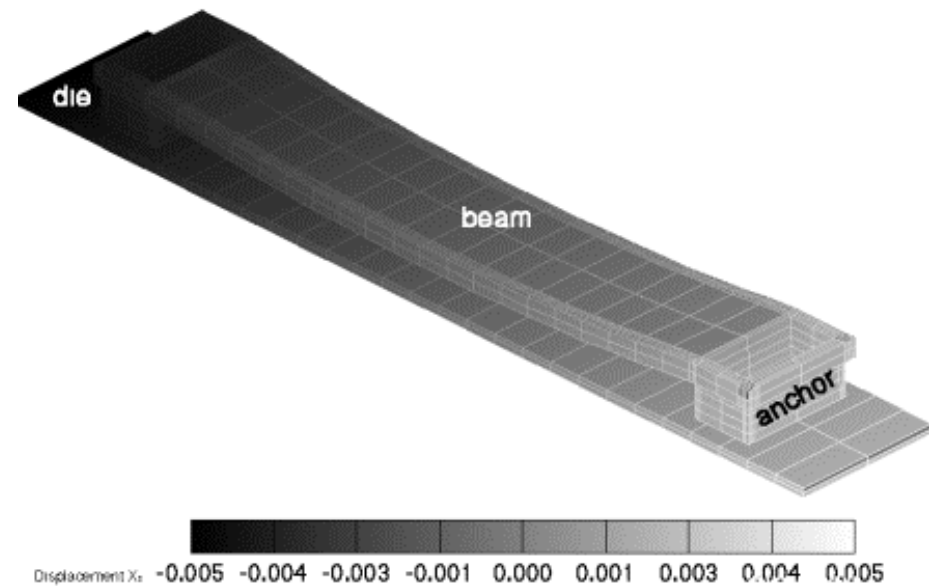
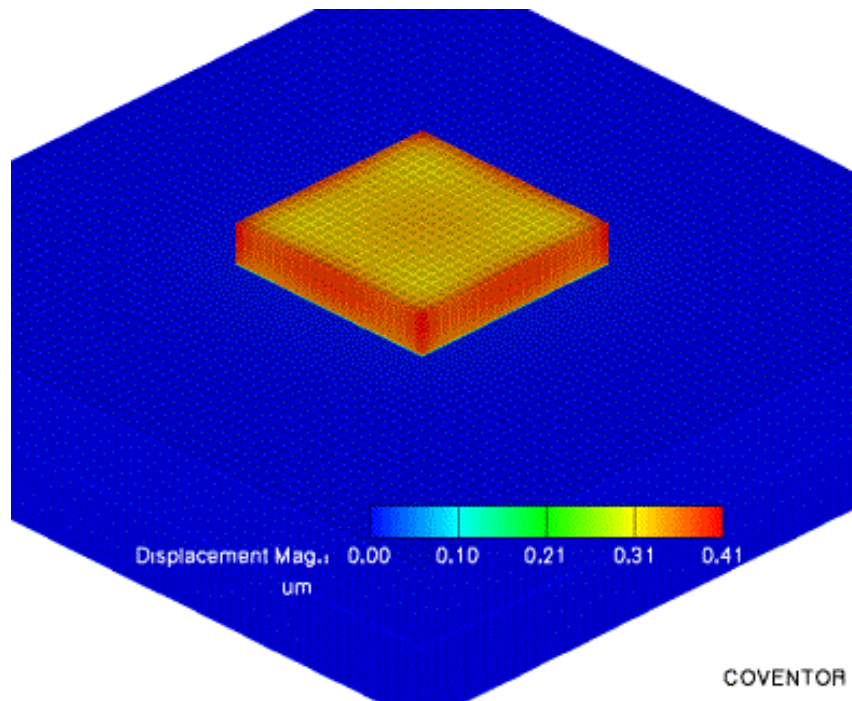
- Linear viscoelastic behaviour
- Using Dynamic Mechanical Analysis

	T _g (°C)	CTE (ppm/K)	Curing T (°C)
Heraeus	81	<100 → 98 >100 → 115	120
Sylgard		310	125
Ablebond	103	<T _g → 55 >T _g → 105	125

Step 2 - Modelling

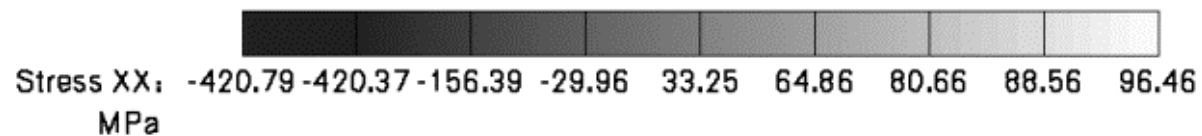
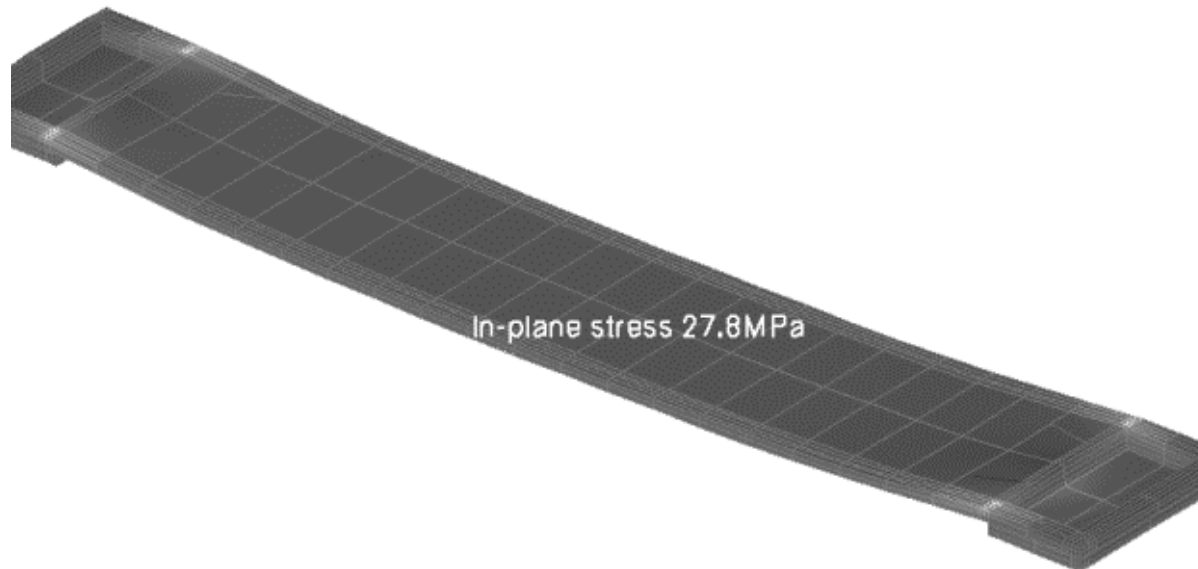
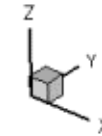
- Thermomechanical modelling of packaging with adhesive curing
- Use this as mechanical boundary conditions for die
- Mechanical constraints on beam supports
- Electromechanical modelling of pull-in voltage
- Temperature-dependent properties

Calculated Displacement



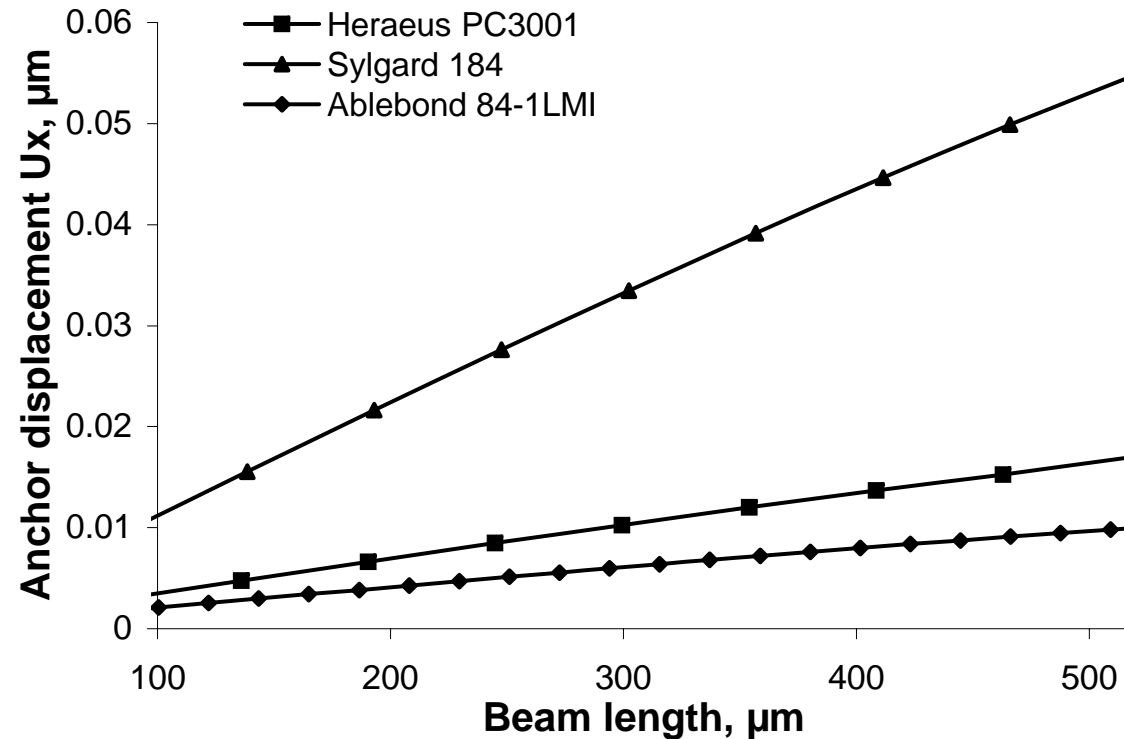
Displacements exaggerated 100 times

Calculated Stress

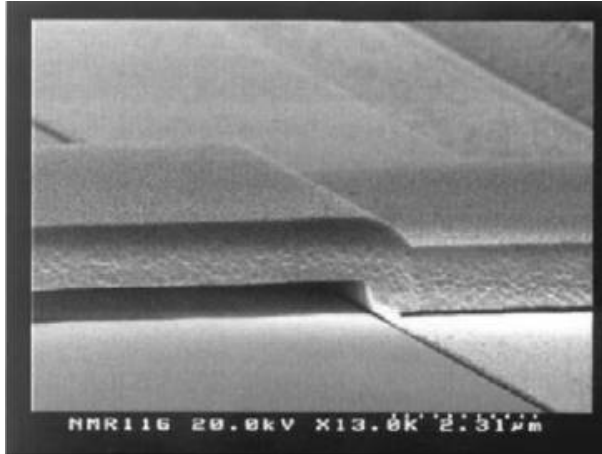


Beam becomes stiffer → Higher pull-in voltage

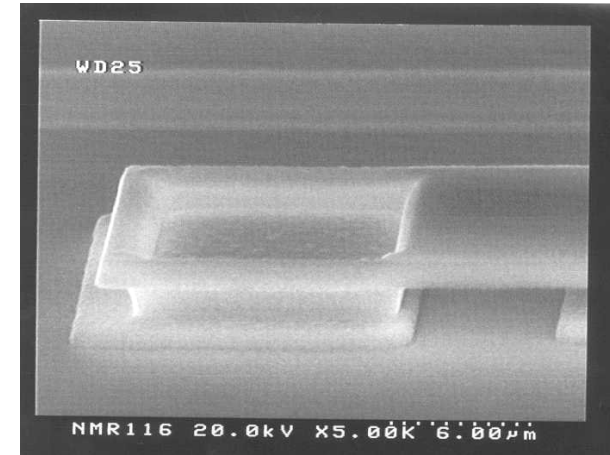
Simulated Displacements



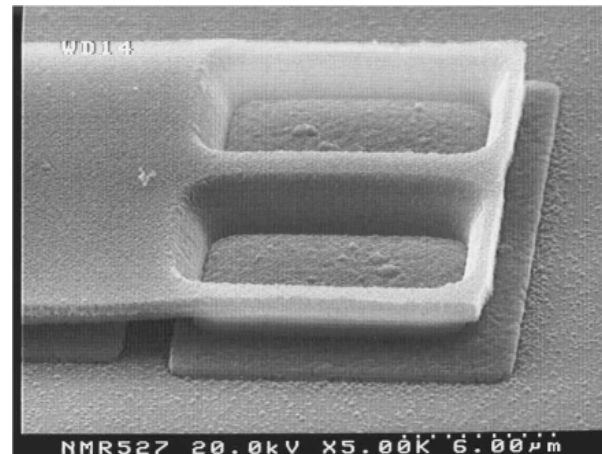
Effect of Anchor Construction



Step-up



Standard

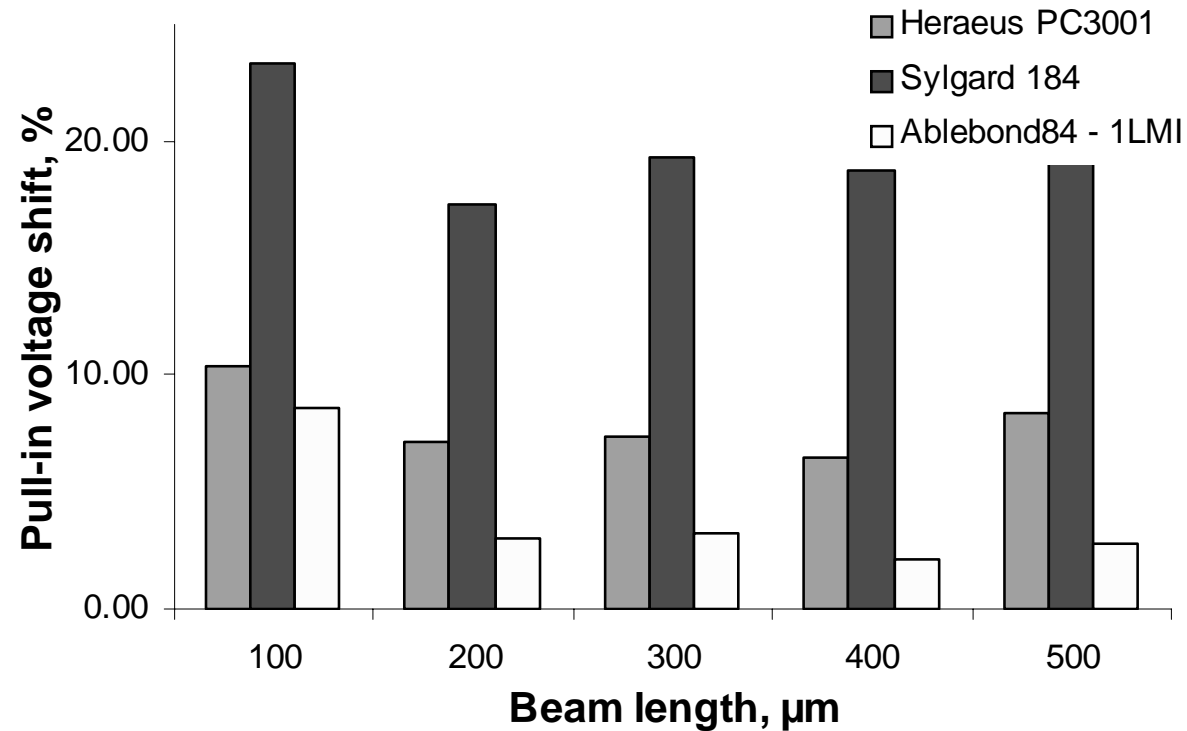


Double Cup

Shift in Pull-In Voltage

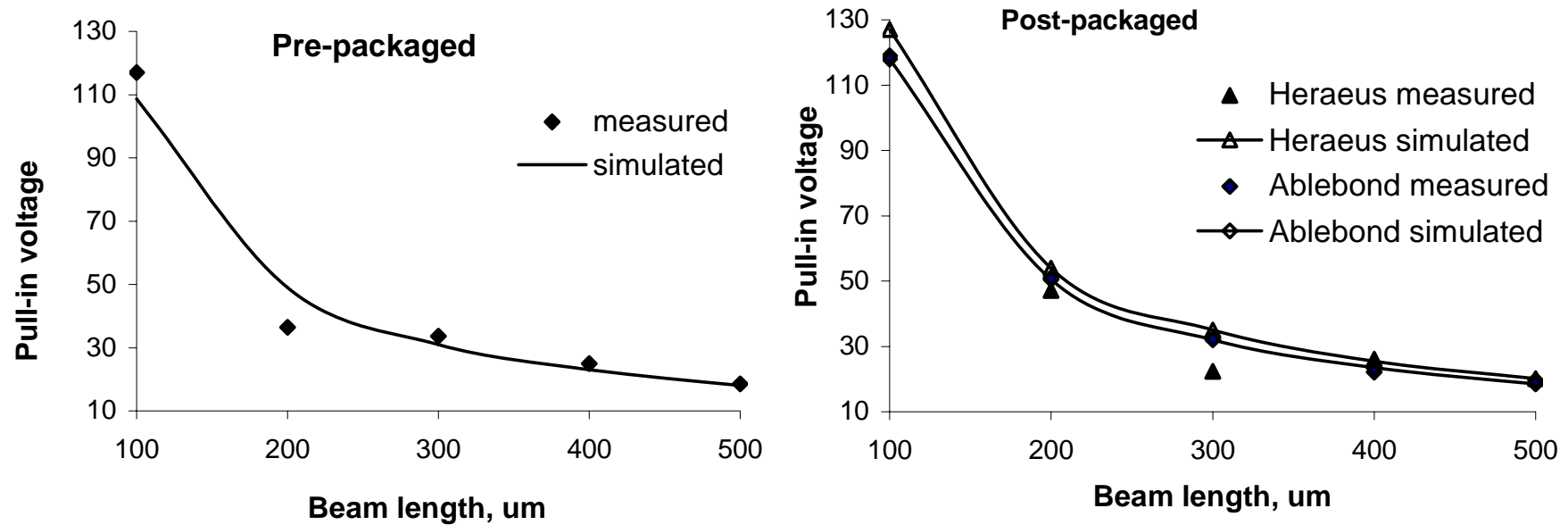
- **Anchor construction**
 - Step-up: 9.8%
 - Standard: 8%
 - Double Cup: 6%
- **Beam Width**
 - 10 μm : 6%
 - 20 μm : 8%
 - 30 μm : 10%

Adhesives



Higher CTE Mismatch or Adhesive Thickness → Pull-in Voltage Shift

Simulation vs. Experiment

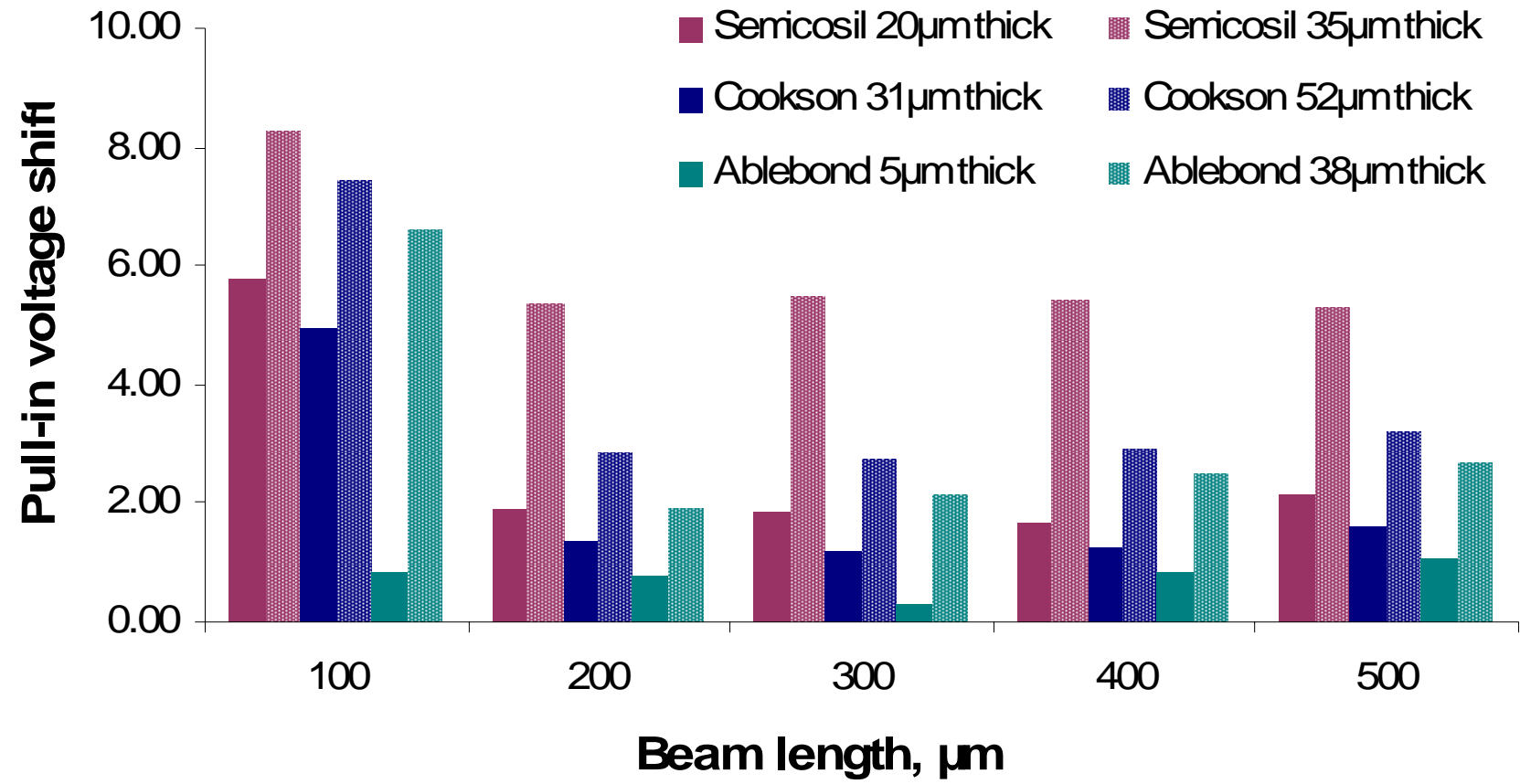


Good correlation between measured and simulated data

More Adhesives

	CTE (ppm/K)	Curing T (°C)
Semicosil 989	<100°C → 275 >100°C → 287	150
Cookson Staystick 371	<25°C → 92 >25°C → 263	200
Ablebond 84-1LMI	<100°C → 77 >100°C → 102	175

More Adhesives



Conclusions

- Significant influence of packaging (die attach) on electromechanical performance
 - Due to CTE mismatch of package components
 - Anchor displacement
 - Mechanical stiffening
- Shift in pull-in voltage
 - Up to 25%
 - Influenced by: adhesive properties, adhesive thickness, beam width and anchor compliance