Nov. 2022

The challenges in testing small and highly integrated devices in a massive parallel test system

Markus Wagner

ISG Manager Engineering

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Overview

- Trends and objectives for high parallel testing
- The challenges of testing IC´s in a massive parallel test system
- Concepts and solution for high parallel test contactor and results
- Thermal aspects
- Conclusion & follow-on work?

Trends and Objective of IC Handling

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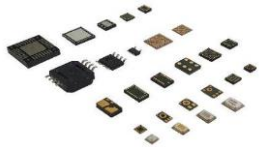
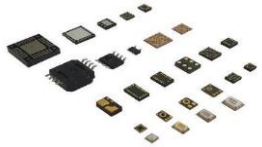
Backend Test Evolution

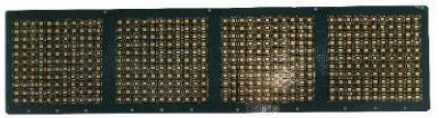
PST (post singulation test)

Strip/Wafer level probing

Gravity (till 2000) → PnP 2000 to 2020 → TIS / Batch 2020 → → Panel Test → 2025







Gravity

Pick and Place

Test in Strip

Sense+

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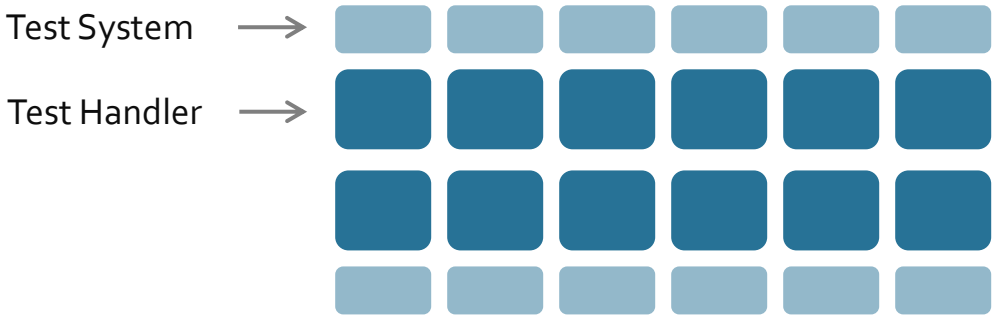
Singulated Handlers vs. Strip-Based Handlers

❑ Conventional Final Test Floor



Objective: 2 Mio. devices / day

Ambient Quad = 7200 IC / h

= 12 handler

= 6000 FT ²

= $9.6M

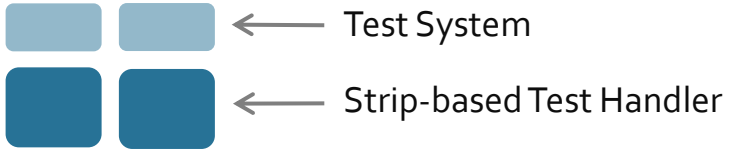
Assumptions: Test Cell $0.8M, 0.75 uptime, index 500 ms TT=1 sec

Replace 12 test cells with 2

Reduce m² x4

Reduce $ x5

❑ Strip-Based Test Floor



Objective: 2 M devices / day

Ambient x32 = 64500 IC / h

= 1.5 handler

= 1500 FT ²

= $1.65M

Assumptions: Test Cell $1.1M, 0.9 uptime, index 180 ms / strip index 2 sec TT=1 sec

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The challenges of testing IC´s in a massive parallel test system

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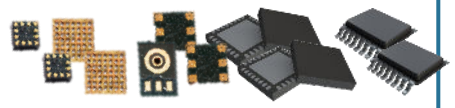
Requirement and Challenges

"Contactor / and Probe card architecture should evolve to simplify the interface, however just the opposite is happening — more complexity is built into the contactor and probe card interfaces"

- **Miniaturization**
  - Very precise contacting technology in X, Y and Z
  - Pad and bumps may get damaged during the contacting process
  - Very thin and fragile package require accurate pick and place as well as force-controlled contacting
- **Diversification in Geometry of Device and Pads**
  - Standardization is difficult
  - Technical clarification becomes challenging
- **Reducing cost is a constant goal**
  - Reliability
  - Throughput – Tester capability, Handler thruput & Parallelism need to get balanced
- **Time to market**
  - Shorter life cycle

Packages

Type: 

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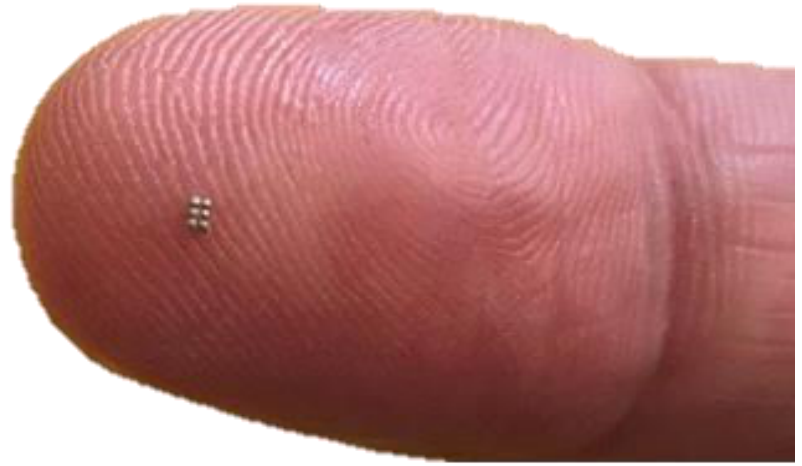

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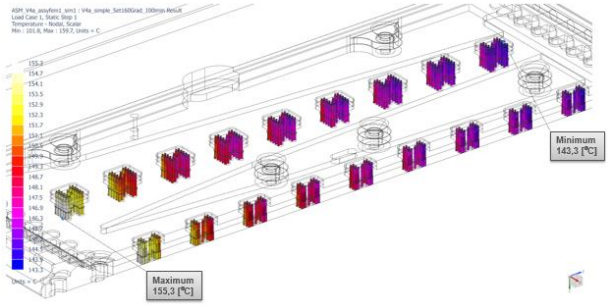
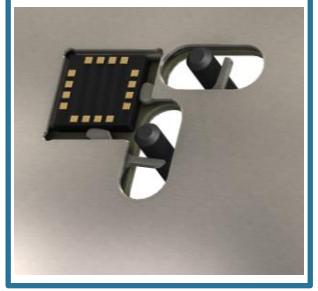
Requirement and Challenges

- **Temperature management**
  - Homogeneous temperature over the entire contactor array
  - Power applications need to dissipate Temperature to sustain the set-temperature
  - Temperature ranges are expanding – Automotive, military, Aerospace…
  - Immediate heat control
- **Sensor & Stimuli**
  - MEMS application require a variety of testing environments such as pressure, magnetic, acceleration….
- **Reliability Electrically and mechanically**
  - Manufacturing capabilities progressed which is raising the electrical and mechanical requirements of a test socket
  - High power / voltage /current tighter pitch smaller formfactors (multi physics problems)
- **Track and trace functionality**
  - Collecting data´s
  - Data analytics
  - Maintenance

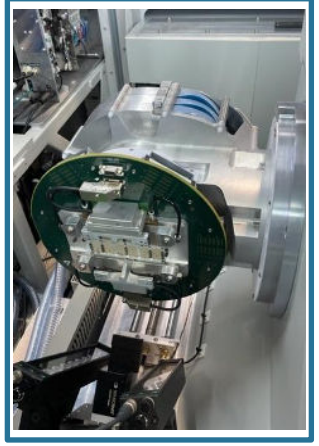
Thermal simulation



LGA 2 x 2
at InCarrier



Gyro sensor test



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Concept / Solution for high parallel test contactor

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Integration on an Example of a MEMS Test

- **Example describes a project:**
  - Implementation of generic methods and technology
  - Applicable for further multi site testing projects

Batch Carrier Vacuum

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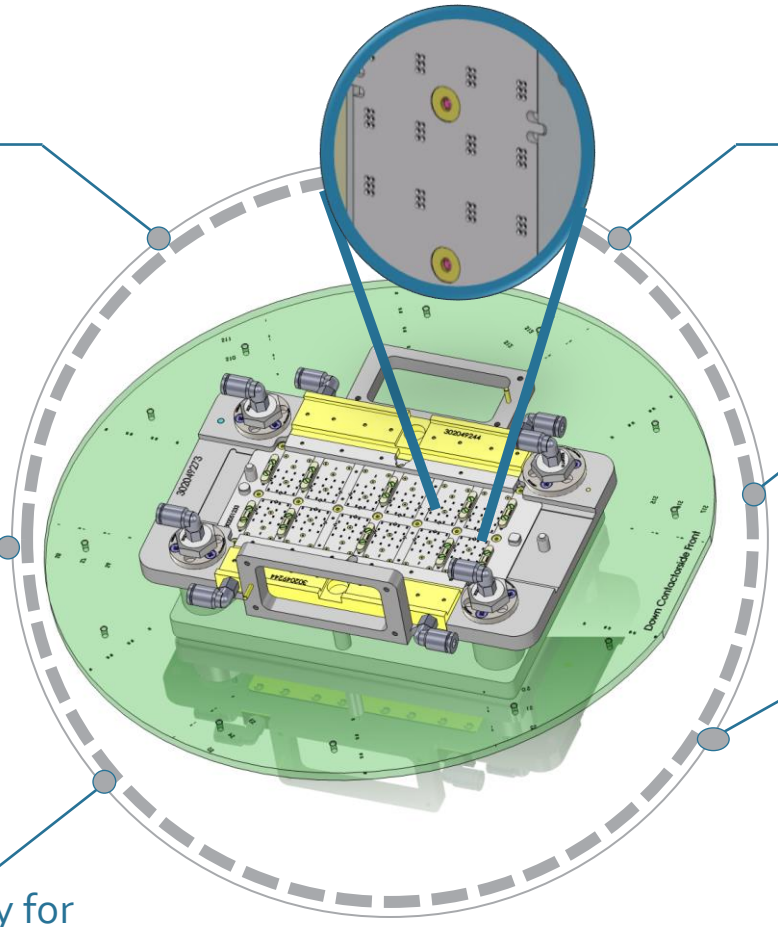
Concept for a high parallelism contactor - Facts

Highest parallelism with 196 Devices testing in one shot > 3000 signal lines (shielded)

Active contacting

Highest positioning accuracy for small devices (1.2 mm x 0.8 mm) 6 electrical connections 0.4 mm pitch stable cRes

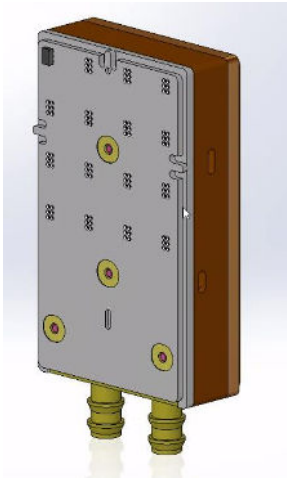


Each 16-site Contactor Module includes PROTRACE and temperature sensor

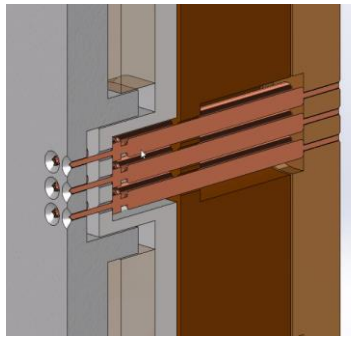
Optimized and integration into the Sense+ Environment

Force controlled Contacting Tight tolerances No Bending and bowing during operation

Single module



Active retracting



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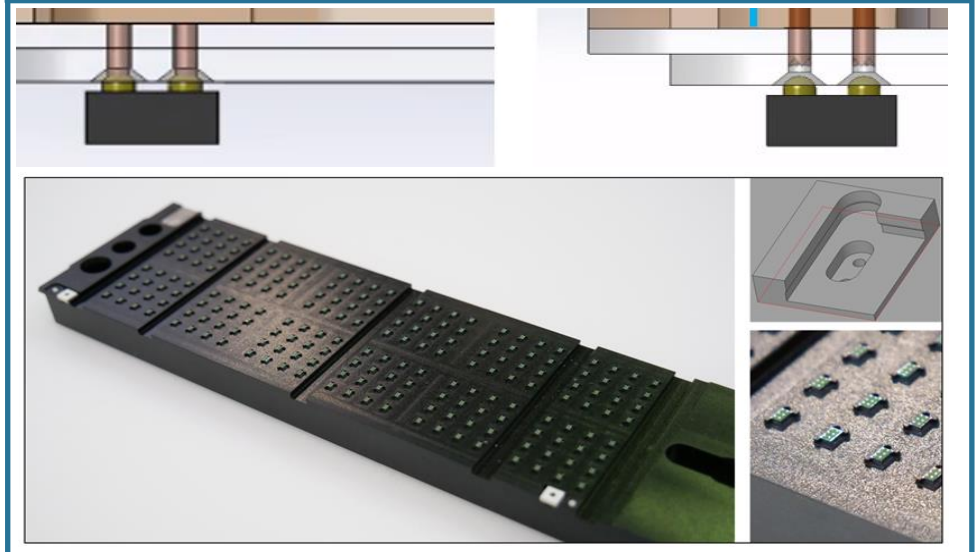
Miniaturization - Reliability

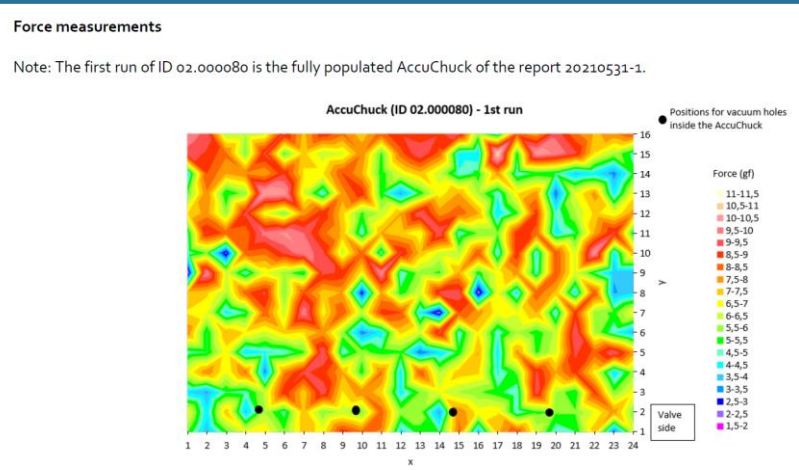
❑ Simulation and Test

- Simulation of holding force on the "Accuchuck" - Batchcarrier
- Measurement of holding force
- Development of an „Active Retracting" concept - **Patented**
- Close corporation with all involved stake holders
  - ➢ Best solution /optimized solution

Accu chuck – contactor



Force measurement plot



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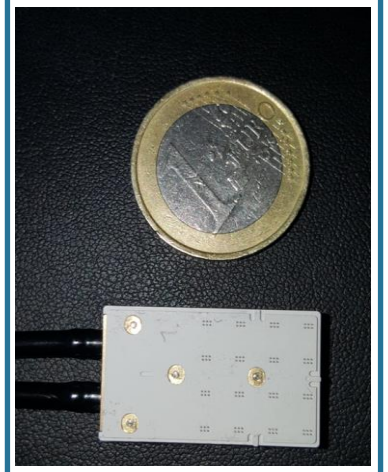
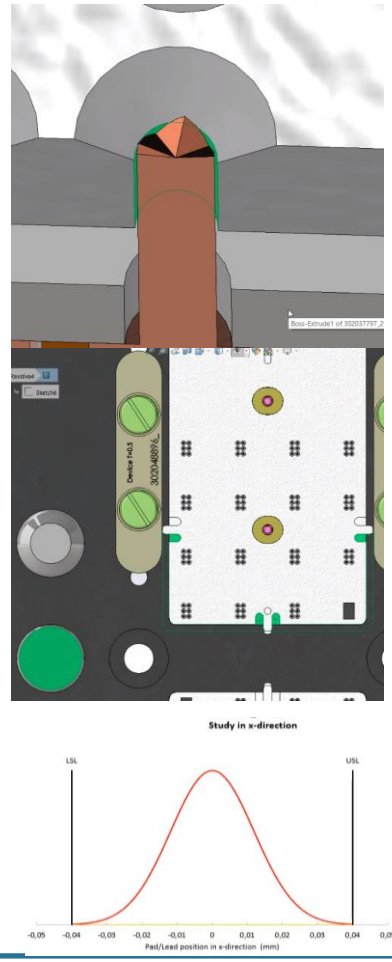
Tolerance analysis and optimization

- **Target : +/-40 µm positioning accuracy over all 1176 I/O´s)**
  - Reduced tolerance chain→ only 4 dimensions from the contact tip to the positioning feature from the contactor
  - Appropriate material selection (Manufacturability/ Thermal expansion/ cost…)
  - Spring pin selection with an optimized tolerance of +/-0,0035mm in diameter (Kita Cohu Pin)
  - Hand in hand collaboration between handler team and Contactor team
  - Closed Loop tolerance analysis und mechanical simulation → 99.925% within +/-40 µm cpk 1.12 (3.3Sigma)

Miniaturization



Tolerance chain



Component	Distribution function	Tolerance type	Description	Material of this component	Algebraic sign	Nominal dimension (mm)	±Tolerance	Angle dependence	Linear expansion coefficient (1/°C)	Statistical σ_i (mm)	Contribution to deviation of M_0
M1	Parabolic							yes	0	0,003812671	10,314%
	Trapezoidal (1/2:1)	Female	Pogo bohrloch		+	0,14	0,007		0	0,003195048	
	Normal	Male	Pogo Diameter		-	0,1265	0,0035		0	0,001166667	
M2	Trapezoidal (1/2:1)		Distance Pogohole to Base B X		+	6,2	0,01	no	0	0,004564355	14,781%
		not relevant							0		
		not relevant							0		
M3	Trapezoidal (1/2:1)		Distance Base B (x) to Nose		+	0	0,01	no	0	0,004564355	14,781%
		not relevant							0		
		not relevant							0		
M4	Parabolic							no	0	0,007994138	45,342%
	Trapezoidal (1/2:1)	Female	Nose Longhole		+	0,61	0,005		0	0,002282177	
	Trapezoidal (1/2:1)	Male	Nose with		-	0,59	0,01		0	0,004564355	
M5	Trapezoidal (1/2:1)		Distance Precision Bolt to Nose Longhole			16	0,01	no	0	0,004564355	14,781%
		not relevant							0		
		not relevant							0		
M6	Normal				+	9,8	0	no	0	0	0,000%
		not relevant							0		
		not relevant							0		

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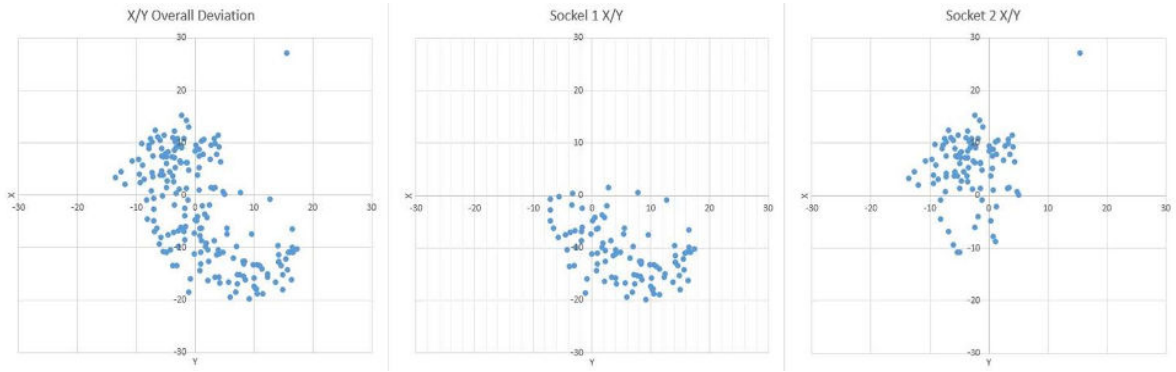
Results - Measurement

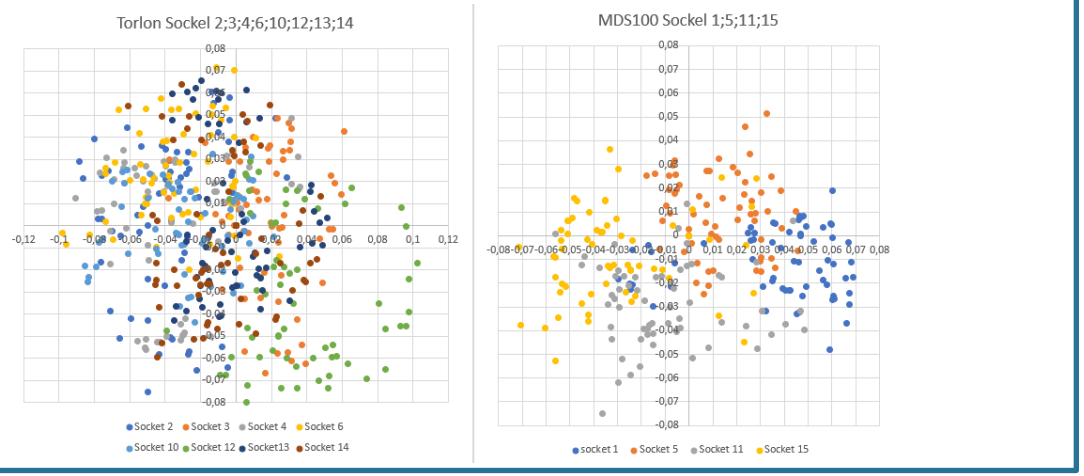
What was achieved?

- Positioning accuracy: +/-20 µm
- active contacting – contacting feature
  - Force controlled contacting
  - Active release of device from contact element
- Lifetime test >> 1.5M of active retracting feature

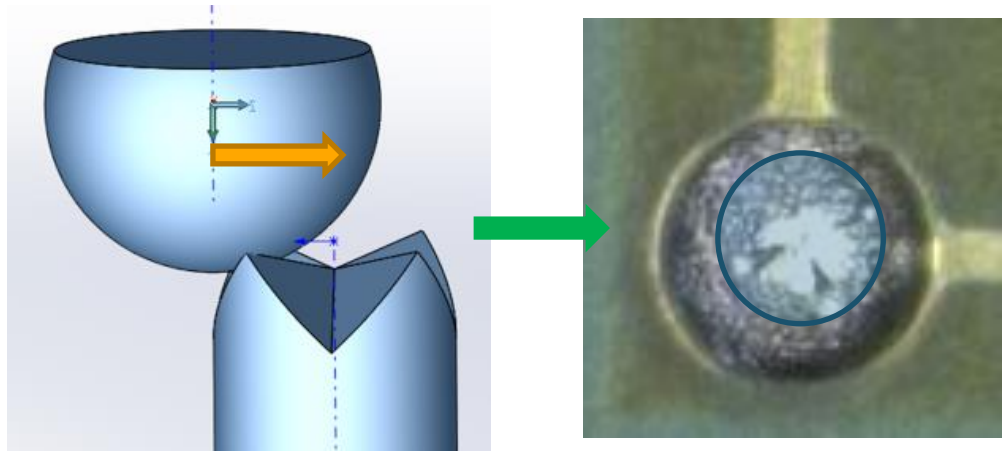
Imprint measurement



Imprint measurement



Imprint check



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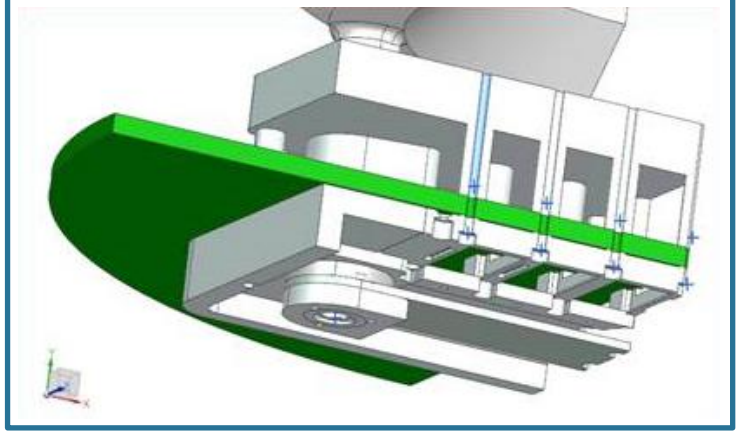
Mechanical Integration – Simulation

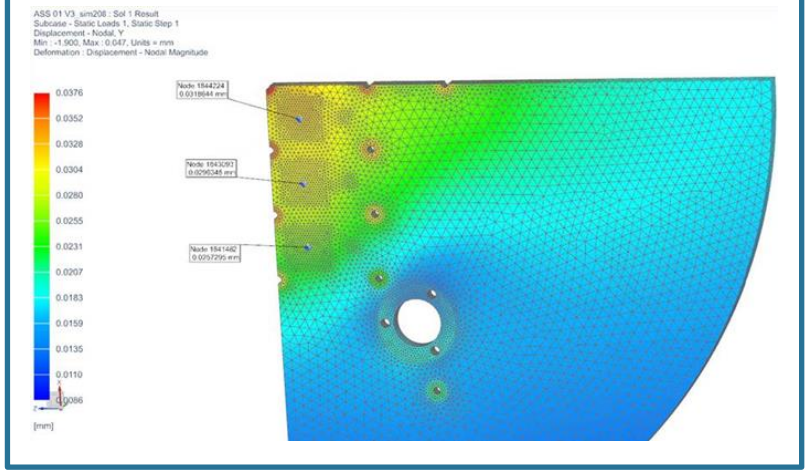
❑ Highly integrated

- One stop shop
  - ➢ Board, stiffener, contactor, reference sensors "Track & Trace" functionality and alignment concept with "AccuChuck"
  - ➢ Simulation (mechanical, tolerances, temperature)
  - ➢ Overall positioning accuracy over the entire contactor +/-60 µm (including "AccuChuck")
  - ➢ Maximum z-deflection on board <40 µm over the entire test array

Mechanical robustness



Mech. Stress on board



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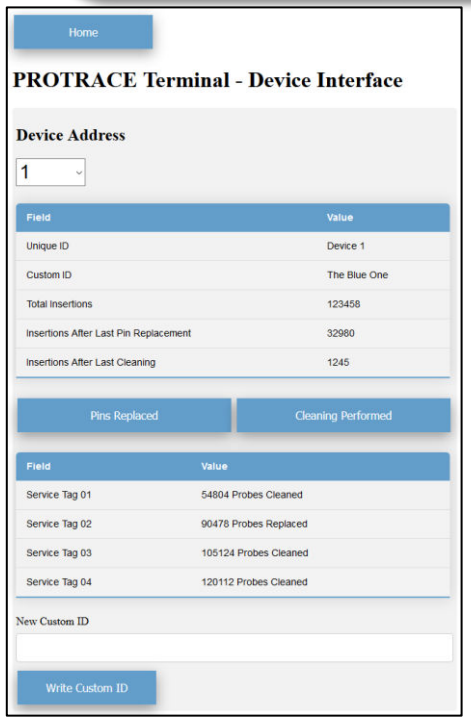
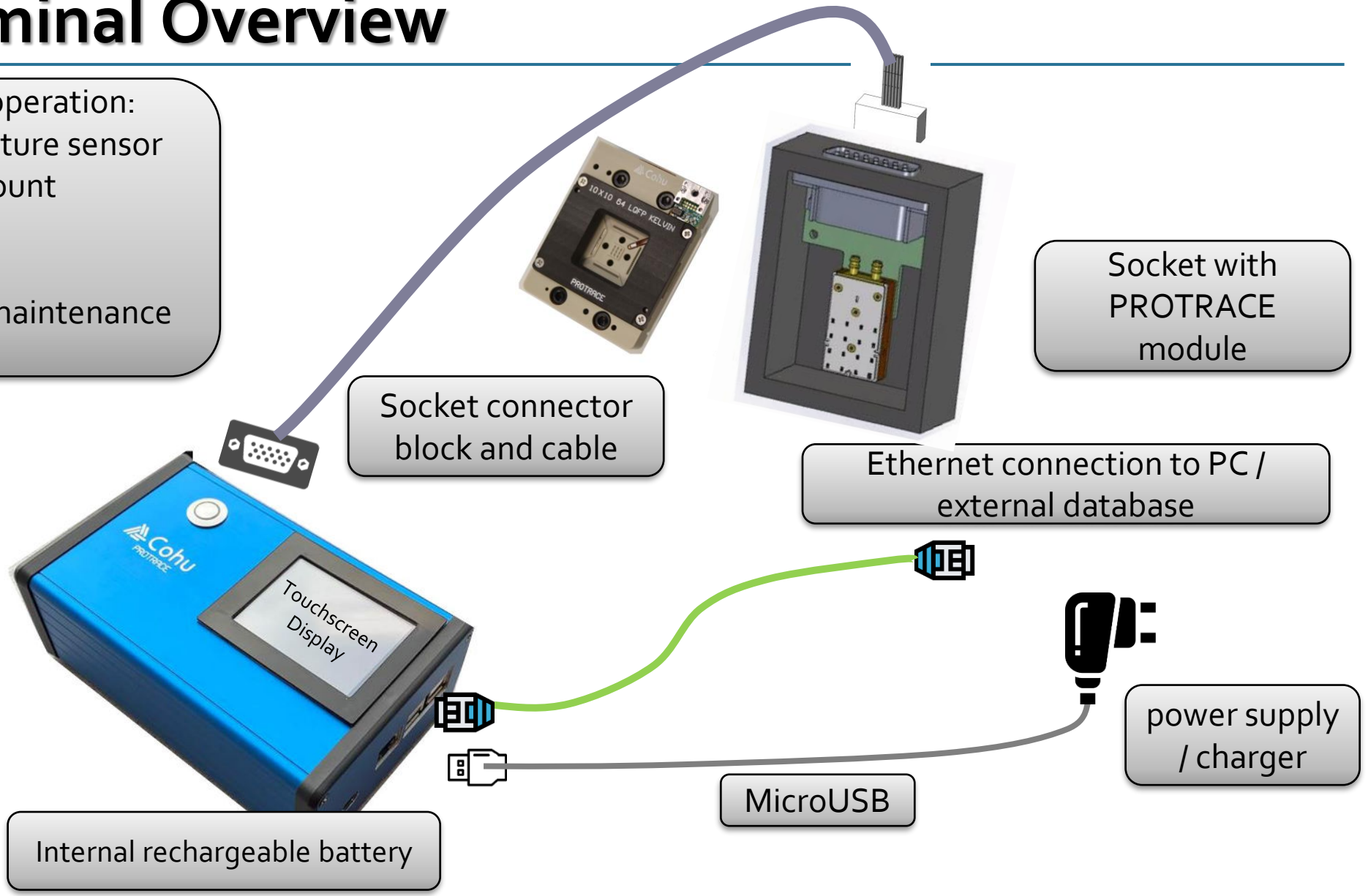
Service Terminal Overview

Supports stand-alone operation:
- Embedded temperature sensor
- Retrieve insertion count
- Retrieve socket ID
- Program user data
- Enables predictive maintenance
- Service terminal for





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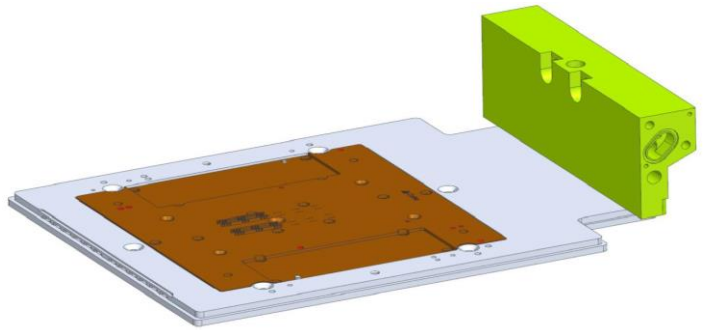
Thermal aspects

Thermal aspects at high parallelism

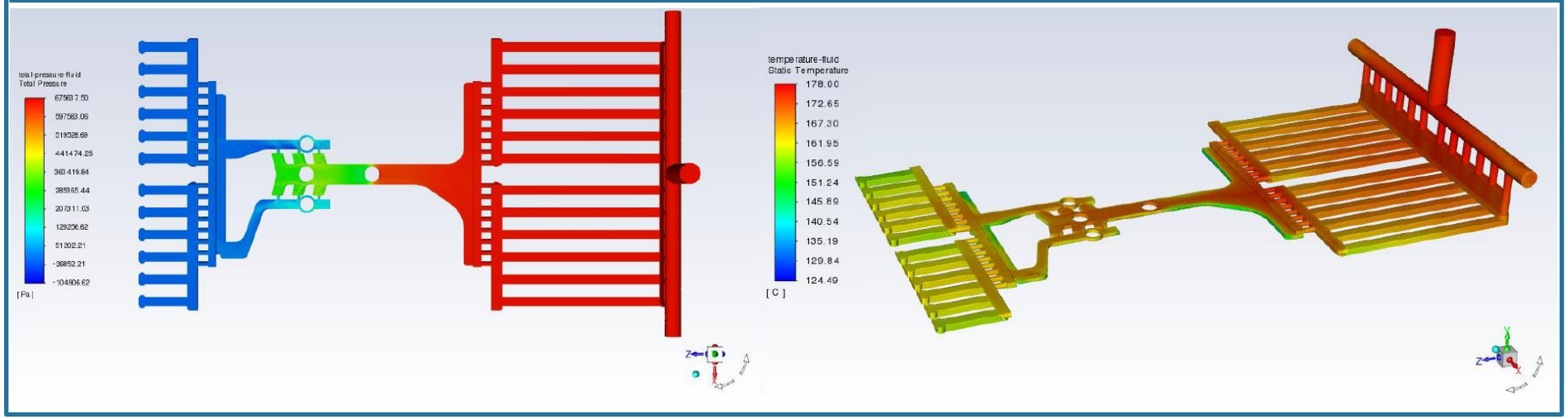
Temperature management

- Homogeneous temperature over the entire contactor array
- Temperature ranges are expanding – Automotive, military, Aerospace… -60°C – 175°C
- Power applications need to dissipate Temperature to sustain the set-temperature
- Immediate heat control

Thermal model



Flow Simulation



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Conclusion and follow-on work

Conclusion

- Miniaturization, cost reduction, time to market, reliability, MEMS integration were successfully addressed by this project:
  - Higher Test Yield by tuned plunger and contactor **System** FEM Simulation assure mechanical robustness by appropriate material selection
  - Best handler touchdown efficiency by matched contact site parallelism
  - Cohu project management of all key deliverables
  - Coordination of activities with key supplier which simplifies customer experience and reduces risk
- Follow-on work - Can the effort be justified by only one application?
  - Recipe creation and active thermal control – Thermal aspects
  - Faster technical clarification by using standardized mechanical /electrical interfaces


Grazzi
OBRIGADO
KIITOS
SALAMAT
PALDIES
SPASIBO
XIE XIE
SHUKRAN
ASANTE
TODA
DEKUJI
EFHARISTO
SHUKRIYA
Go raibh maith agaibh
DANKE
Cảm ơn
Hsieh hsieh
NA GODE
DO JEH
GRATIAS TIBI
THANK YOU
Blagodarya
DANKE JE
Gamsahabnida
Dhanyavaad
Khob-kun
NGIYABONGA
MERCI
GRACIAS
Tusen takk
Köszönöm
DANK U
FALEMINDERIT
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