Solderless assembly of high pin count packages on PCB

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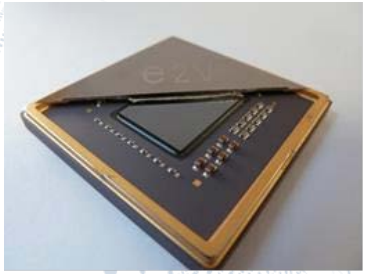
Introduction



- **Context :**
  - Semiconductors used on the new generation of digital equipment present fine device features (e.g. 65 nm), high I/O count (Up to 2000's I/O) and fast clock rates (3-10GHz). For today's solutions, the packages are based on ceramic package with column attach (CCGA).
  - Solderless approach using interposer for assembly LGA on PCB could be an alternative, easy to mount and dismount as well as repairing

- **Objective : Developed solderless assembly using interposer for mounting LGA 1752 (42.5X42.5 mm^2) on PCB for high speed application**
  - Define the requirements for the solderless solution and Trade-off
  - Design the interposer system
  - Manufacture and mount the system
  - Demonstrate the performance and the reliability of the system

- **Project : ESA – ARTES 5 (supported by CNES)**
- **Prime : Thales Alenia Space**
- **Partner : Smiths Interconnect**
- **Duration : 18 month**

Solderless assembly requirements

Electrical requirements :

Designation	Criteria
Data rate	6.25 Gbps
Noise Budget	Differential Return loss : S11 < -25 dB + freq [GHz] from 1 MHz to 12 GHz Differential insertion loss : S21 < -0.5 dB @ F= 5GHz Crosstalk: S31&S41 < -30 dB from 1 MHz to 12 GHz

Technological requirements

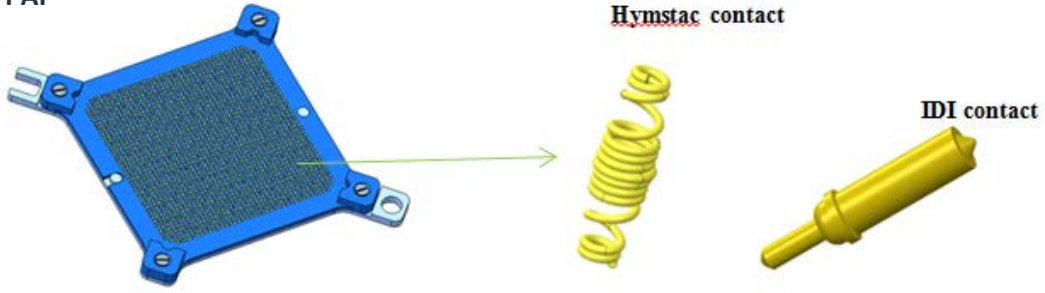
Designation	Criteria
Minimum number of LGA pads	800
Number of package I/Os for die	1000
Pitch	1 mm
Housing Material	Space qualified material (outgassing = as RML <1% and CVCM < 0,1%)
Contact Interfaces	Gold
PCB compatibility	High frequency material
Mass	<CCGA mass
	<20 gr for the electrical interposer
Reliability	Vibration + 1500 thermal -55/ 100°C
Country	Develop and manufacture in a Country without any exportation license

Solution developed and manufactured by Smiths Interconnect

- **A trade-off for the interposer solution was based on criteria :**
  - Country,
  - High Speed LGA capability ,
  - Thickness,
  - Pitch (1 mm),
  - Reliability and maturity,
  - Electrical and mechanical properties,
  - Outgassing properties.

⇒ **Selected technology : Smiths Interconnect interposer enclosing 1752 contacts with a pitch of 1 mm**

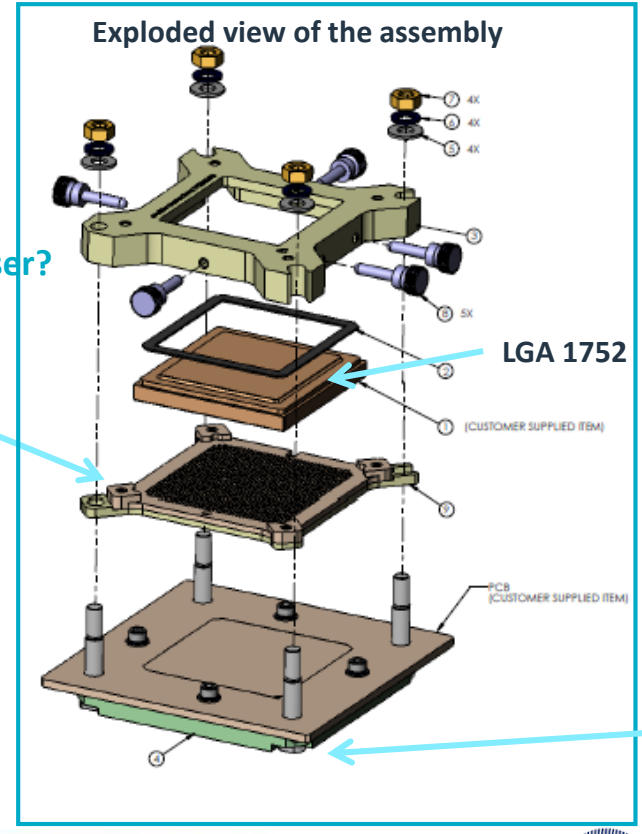
- 2 types of contacts both with gold finish and based on spring technology : Hymstac contact and IDI contact
- 2 types of Housing materials for interposer : PEEK or PAI



LGA assembly using interposer solution

- Type of contact ?
- Type of insulating resin for interposer?
- Design of holding system ?

Exploded view of the assembly

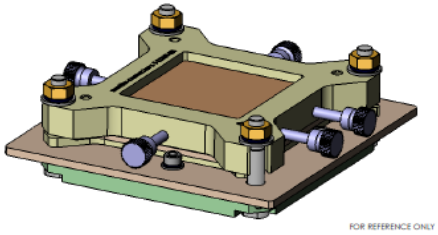


LGA 1752

Interposer

Stiffener

Frame with LGA



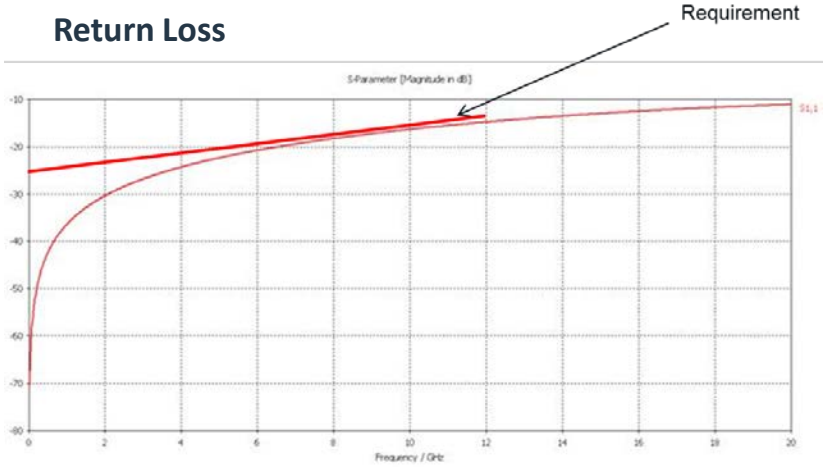
Solution developed and manufactured by Smiths Interconnect

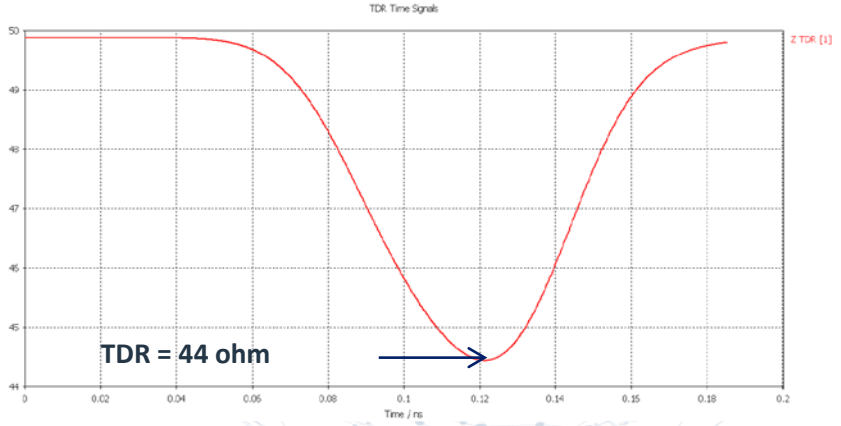
Electrical simulation

- High frequency simulation (Return Loss, TDR) were done with the two types of contacts and two insulating materials for interposer : PEEK and PAI

- PEEK and IDI contact give the best results.

Return Loss





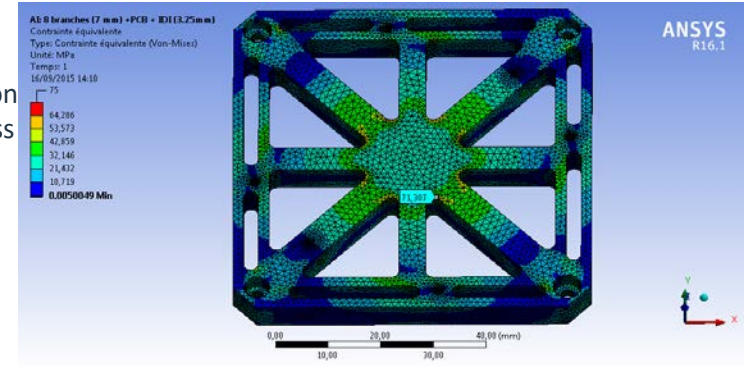
- Return loss and TDR are within the specification

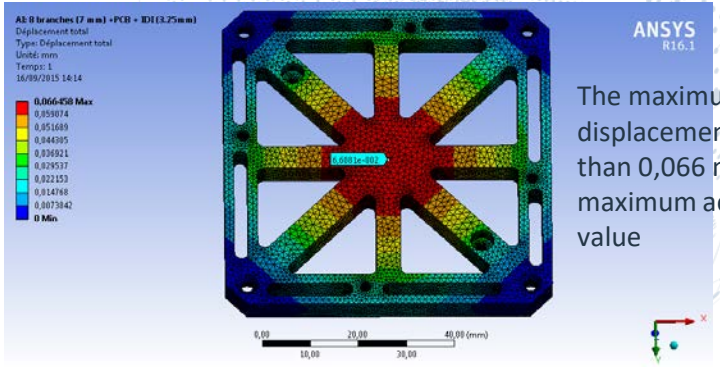
Solution developed and manufactured by Smiths Interconnect

Mechanical simulation

- The mechanical behavior of the system and parts were independently modeled. The displacement and the stress implied by the compression of the 1752 contacts inside the interposer was evaluated. The Von Mises stress and the deformation of the frame and stiffener were evaluated with the ANSYS tool and with the two types of contacts and with different shapes of frame and stiffener.

The maximum Von Mises stress is less than 75 MPa << maximum elastic resistance (260 MPa).



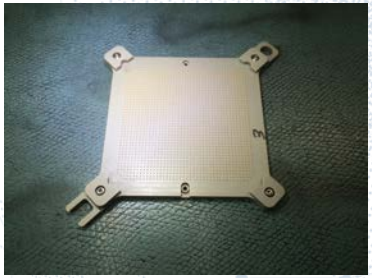


The maximum displacement is less than 0,066 mm = maximum acceptable value

- **IDI contact and star shape frame offer the best solution. However, this assembly is 25% heavier than the target.**

Solution developed and manufactured by Smith Interconnects

- From electrical and mechanical simulation : The Smiths Interconnect interposer with 1752 IDI contacts and star shape stiffener has been selected
  - Housing material : PEEK insulating resin
  - Mass : 17g for interposer
  - Mass of assembly :117g > CCGA mass

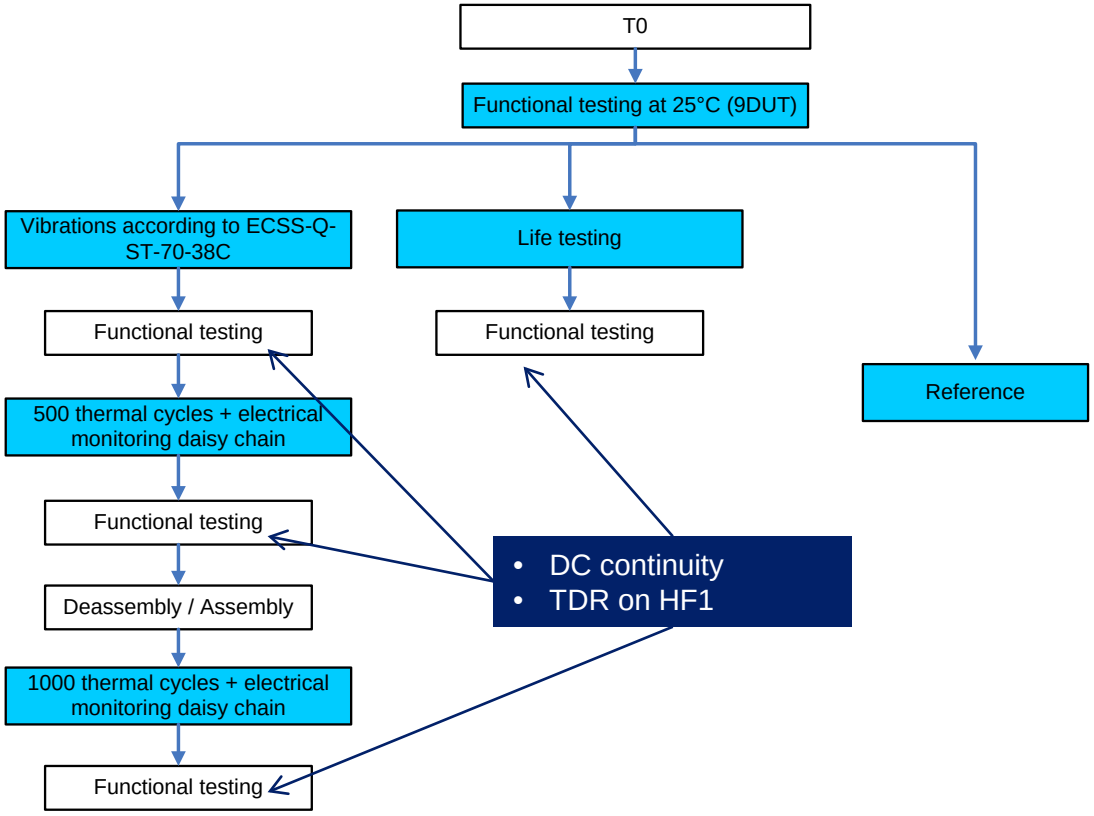


- 9 DUTs were mounted on PCB for testing

- Easy & fast to mount
- Easy to dismount & Repair

Test Campaign

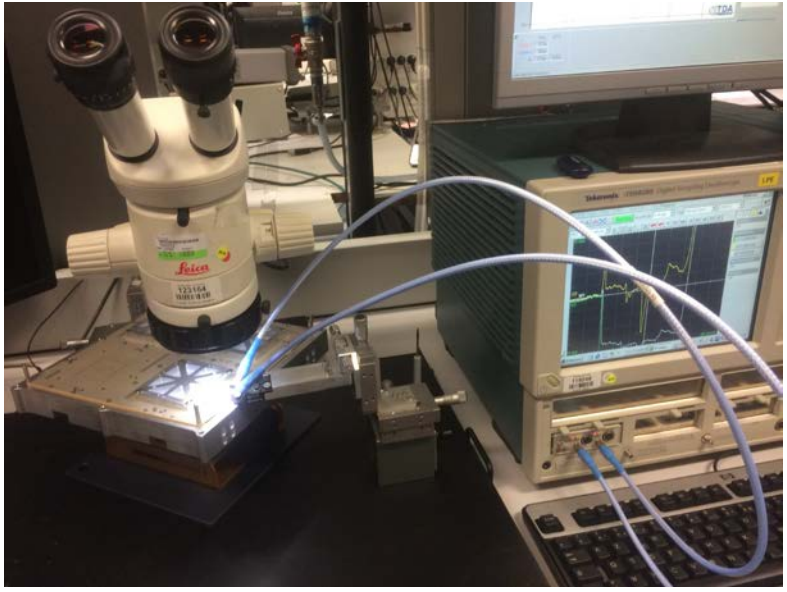
PCB number	Devices number	Test
PCB N°1	DUT 2	Reference
PCB N° 2	DUT 1- DUT 3 - DUT 4 - DUT 9	Vibration + Thermal-cycling
PCB N°4	DUT 6 - DUT 7 - DUT 8	Life Test

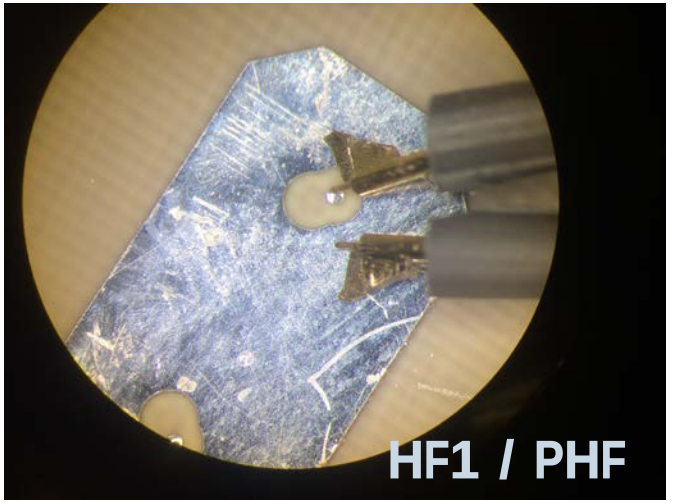


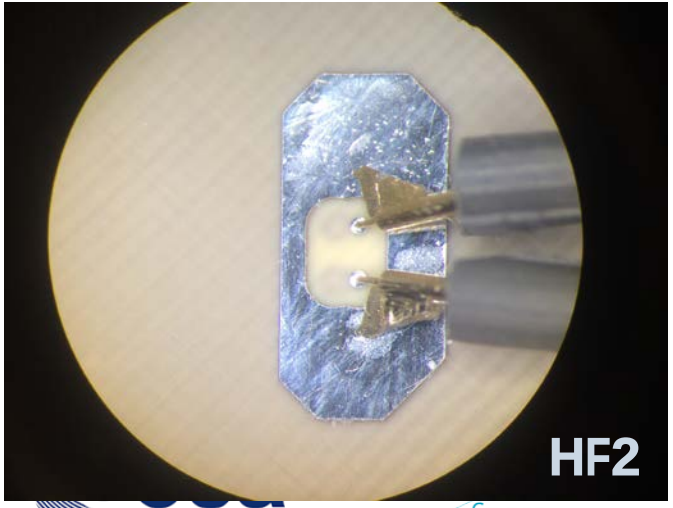
Test Results

- Functional Test @T0
- Thermal-mechanical test results
- Life test results

TDR on HF1 / HF2 / PHF

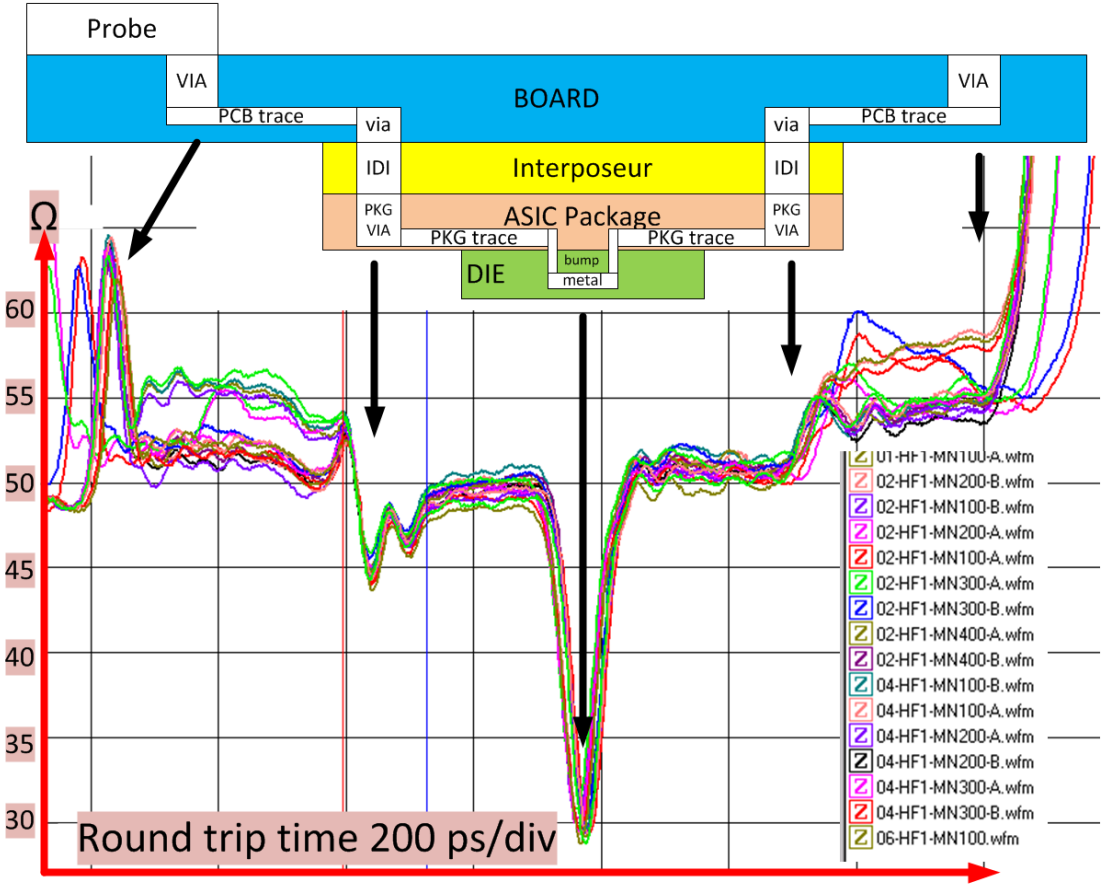






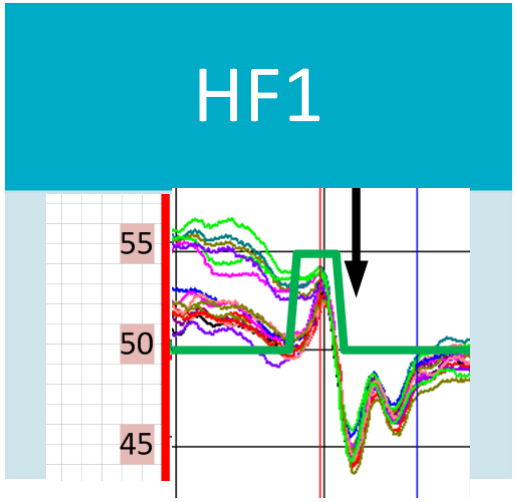
HF1 : 50 Ω impedance lines including die
HF2 : 100 Ω impedance differential pair lines including die
PHF : 50 Ω impedance line across the package

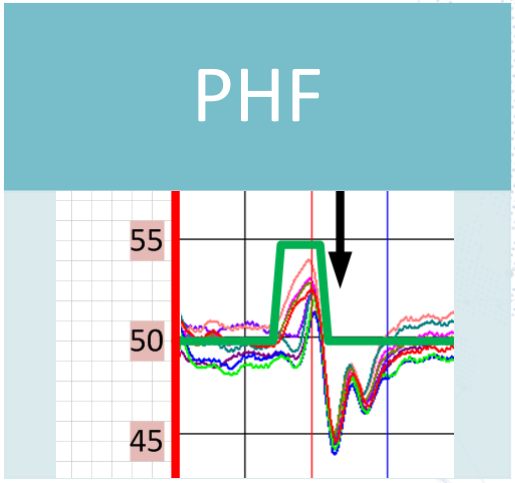
TDR on HF1 @T0

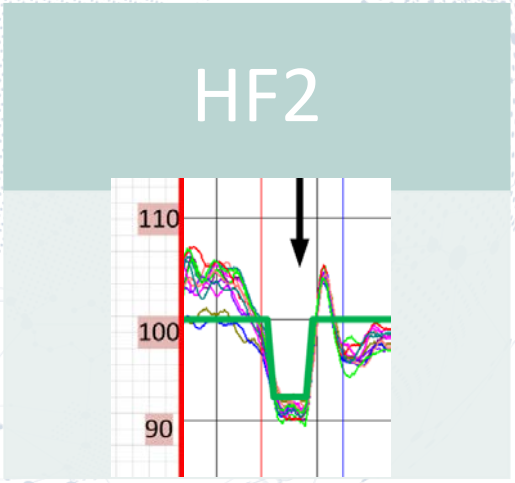


TDR Zoom on Interposer

- Measurements were compared to electrical model provided by Smiths Interconnect



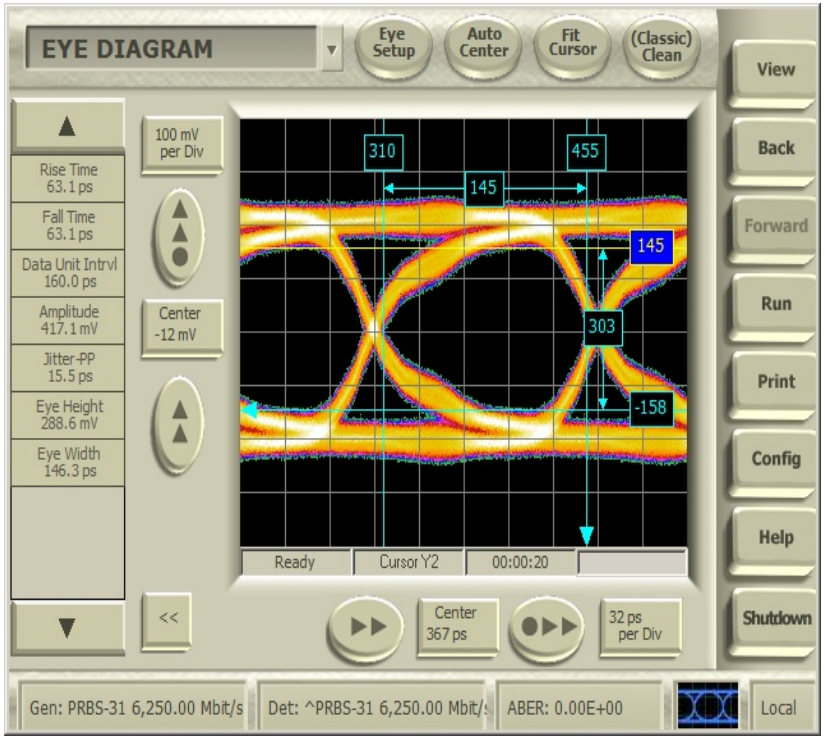


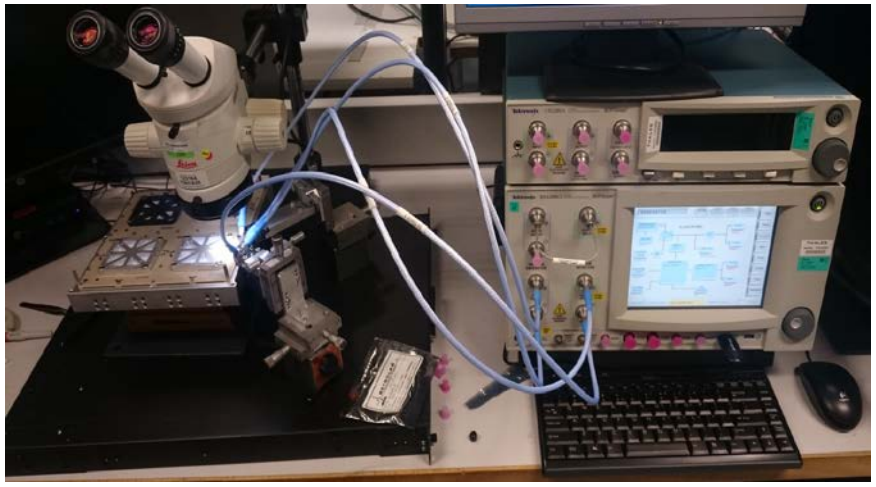


- Good correlation performance

EYE DIAGRAM on HF2

6.25Gbps:





EYE DIAGRAM on HF2

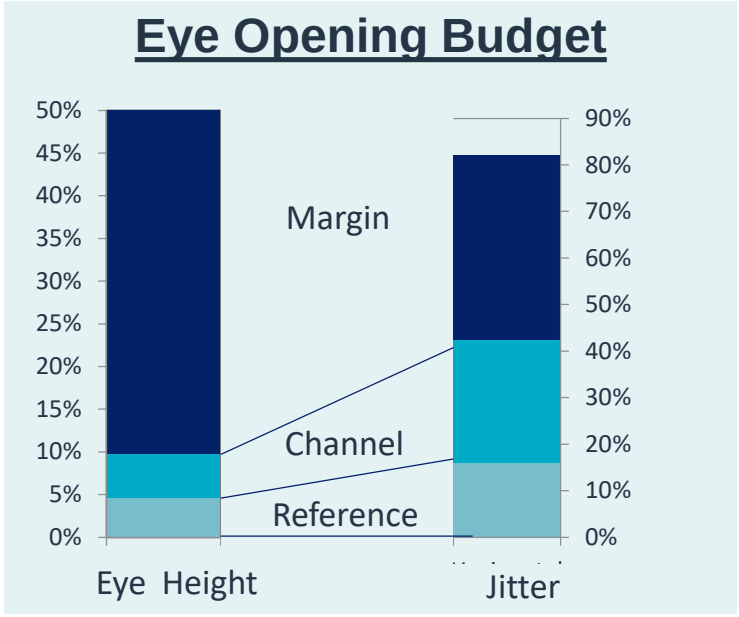
	Jitter (TIE)	Eye Height
Reference	7,3 ps	420 mV
Channel	15,5 ps	288 mV
Acceptable limit	80 ps	125 mV

6,25 Gbit/s

PRBS pattern

Tektronix BERT BSA286CL

- Reference : BERtester looped with coaxial cable
- Test channel: PCB, interposer, ASIC and test probes
- Acceptable limit : real flight model application
- The results indicate good performance of the system with Jitter and Eye Height far from acceptable limit and a contribution of the reference as significant as the channel
- Eye opening budget shows that the test channel is a small contributor and margins are good

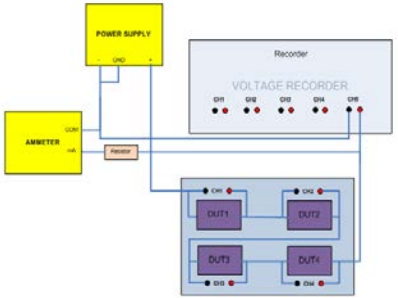


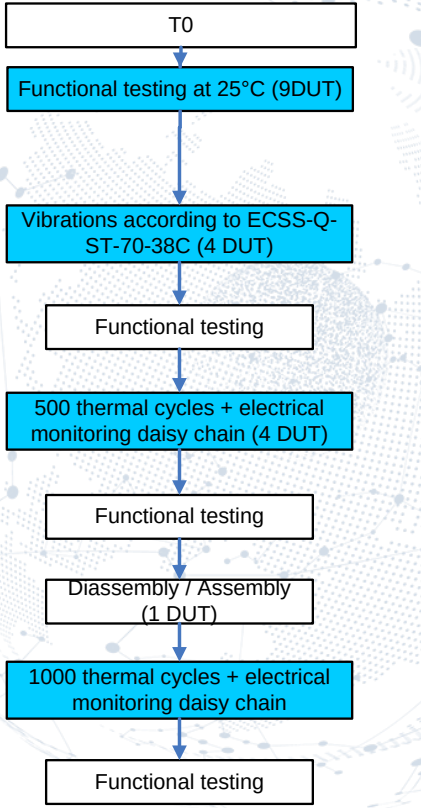
- Good performance for the channel
- Interposer have a very low impact on Eye opening budget.

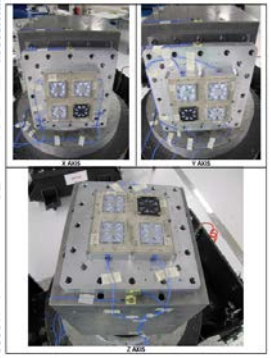
TEST RESULTS

- Functional Test @T0
- Thermal-mechanical test results
- Life test results

Thermal-cycling under continuous electrical monitoring : 500 /1500 thermal-cycles from -55° C to 100 °C with a ramp of 10°C and step of 15 min







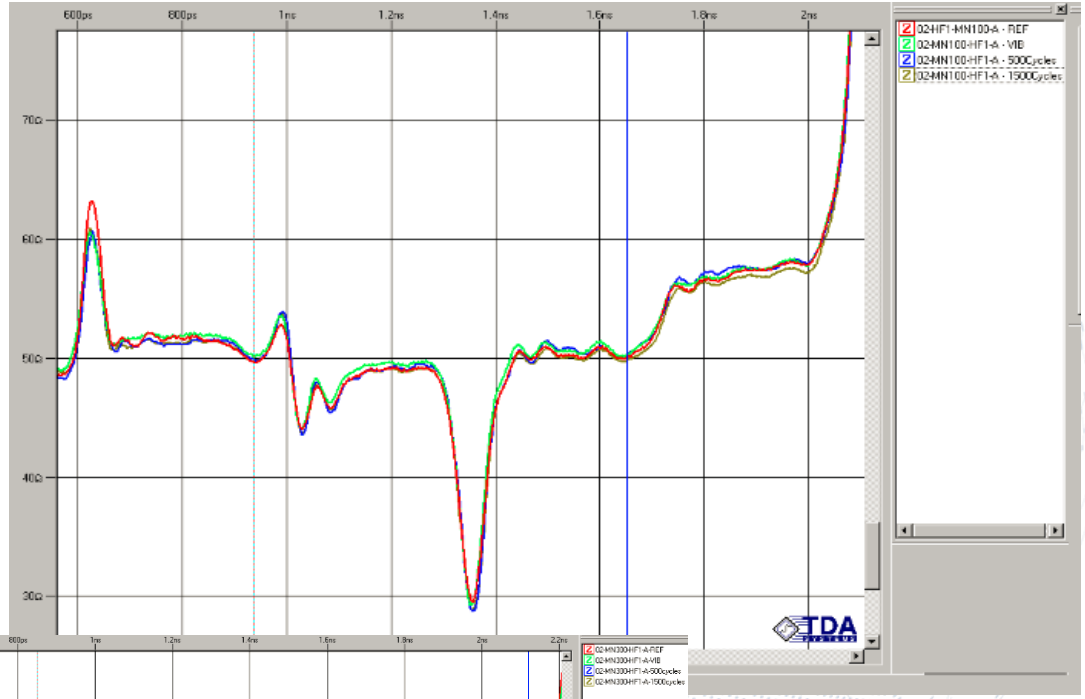
DC Continuity

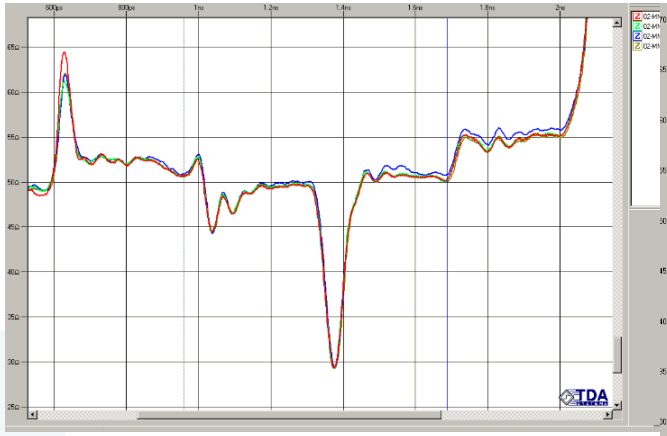
N° DUT	T0	After vibration	After 500 thermal-cycling	After 1500 thermal-cycling
DUT1	47,1	47,9	44,1	X
|DC Variation DUT 1| (%)		+ 1,7 %	- 6,4 %	
DUT 3	46,9	47,5	43,6	42,0
|DC Variation DUT 3| (%)		+ 1,3%	- 7%	- 10,4%
DUT 4	46	47,1	43,2	41,6
|DC Variation DUT 4| (%)		+ 2,5%	- 6%	- 9,5%
DUT 9	48,3	48,9	43,5	42,2
|DC Variation DUT 9| (%)		- 1,3%	- 9,9%	- 12,6%

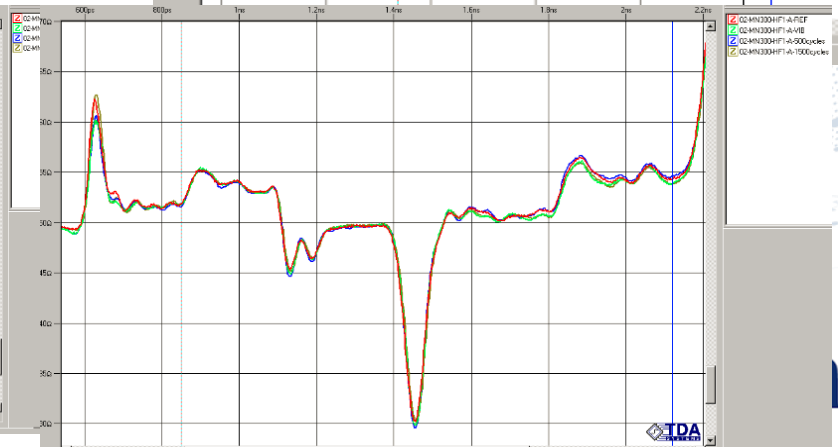
- Very low increase of DC resistivity after vibration (far away from + 10%)
- Decrease of resistivity after thermal-cycles

TDR on HF1

- No evolution of the curves after vibration, 500 an 1500 thermal-cycles
- Same results for the 3 DUT







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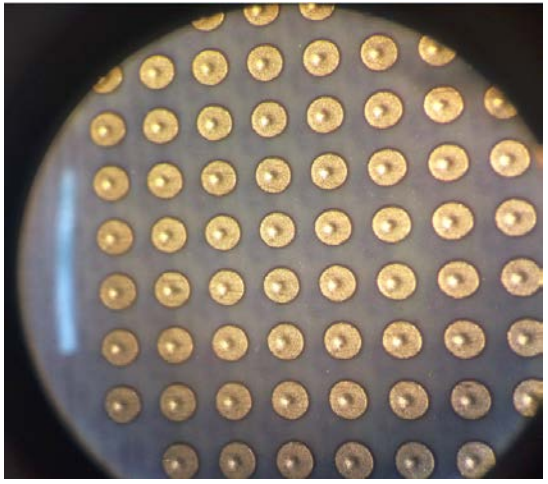
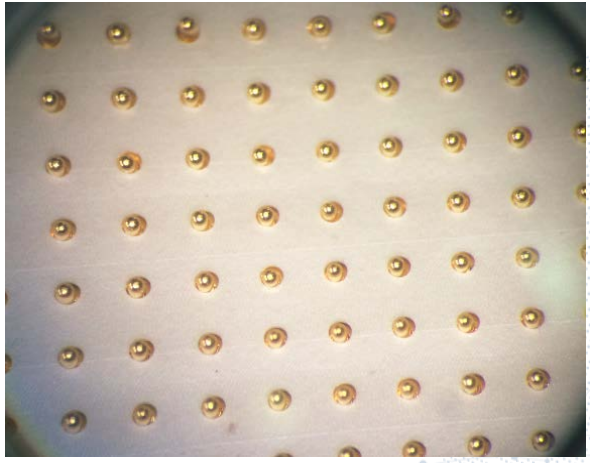
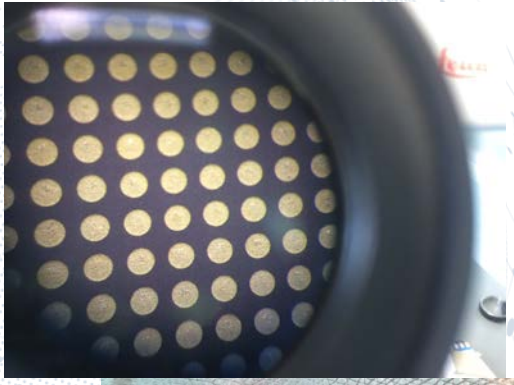
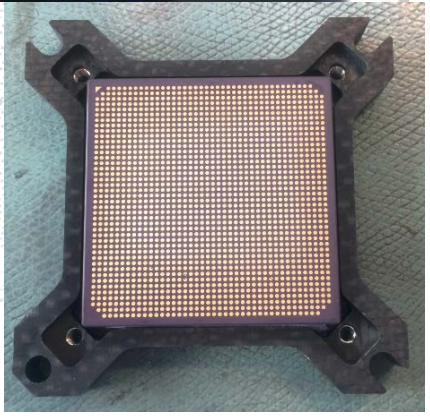
Visual inspection after vibration & 500 Thermal-cycles & 1500 Thermal-cycles





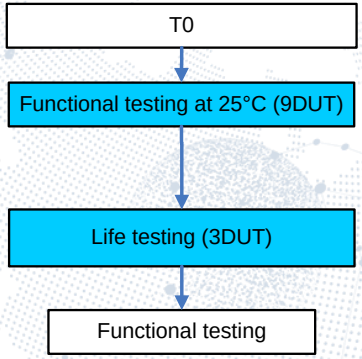




- Any defect observed on the foot print and on LGA pads
- Any scratch or mark observed on IDI contact as well as on the raw material of interposer
- All contacts are out of the housing material

TEST RESULTS

- Functional Test @T0
- Thermal-mechanical test results
- Life test results



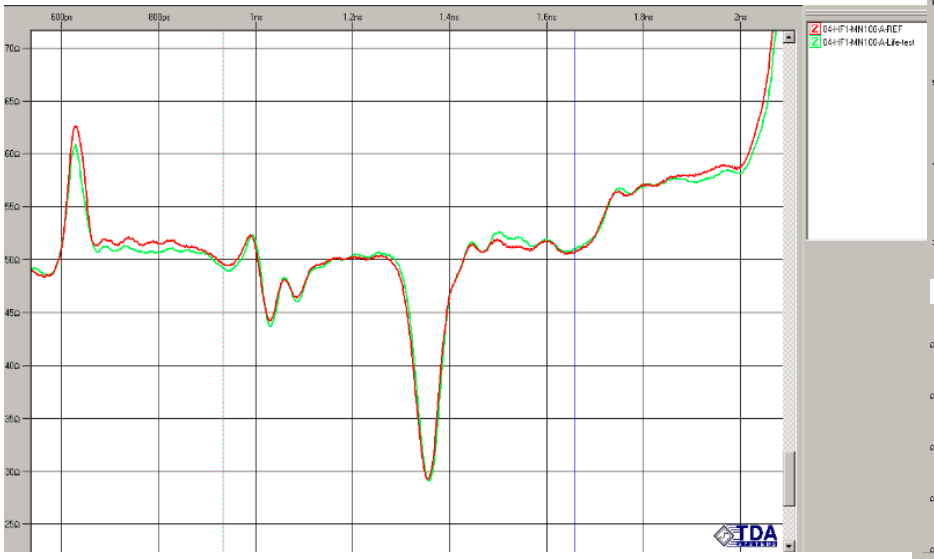
DC Continuity

- Test condition : 1000h@125°C

N° DUT	T0	After Life testing
DUT 6	44,9	46,4
Variation	REF	3,3 %
DUT 7	46,4	47,5
Variation	REF	2,4 %
DUT 8	47,2	48,7
Variation	REF	3,1 %

- Very slight increase of DC resistivity (far away from + 10%)

TDR on HF1



- No evolution of the measures after 1000h @ 125°C (same results for the DUTs)

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Conclusion

- **Trade-off & design of the solution**
  - The trade-off on solderless assembly on HDI PCB and results from mechanical and electrical simulations have led to the development of a Smiths Interconnect Interposer solution with IDI contacts, PEEK insulating material for interposer and a holding system with a stiffener with star shape.
- **Mounting :**
  - The 9 LGA with the interposer connector were successfully mounted on HDI PCBs. Assembly/ disassembly was easy and fast to carry out.
- **Assessment :**
  - The assembly was evaluated in term of electrical performance under harsh environment (vibration, thermal-cycling, life testing).
  - The system has highlighted electrical performance within the specification and high reliability under space environment

This electrical interposer and its mounting system is a reliable solderless solution to assemble high pin count packages (1752 I/Os) with high frequency interfaces.

THANK YOU FOR YOUR ATTENTION

Any question ?

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