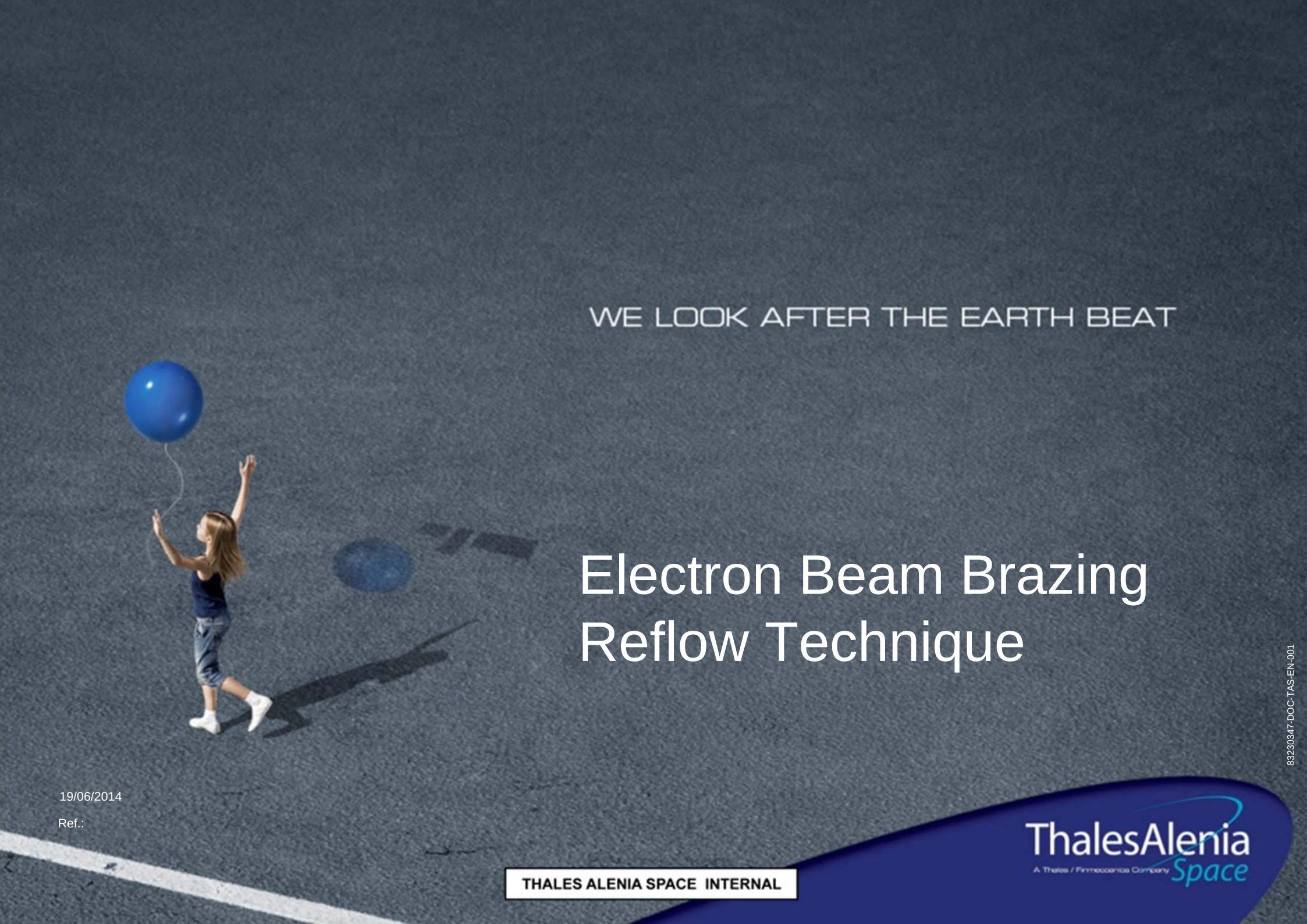


Electron Beam Brazing Reflow Technique

19/06/2014

Ref.:

THALES ALENIA SPACE INTERNAL

ThalesAlenia Space
A Thales / Finmeccanica Company

83230347-DOC-TAS-EN-001

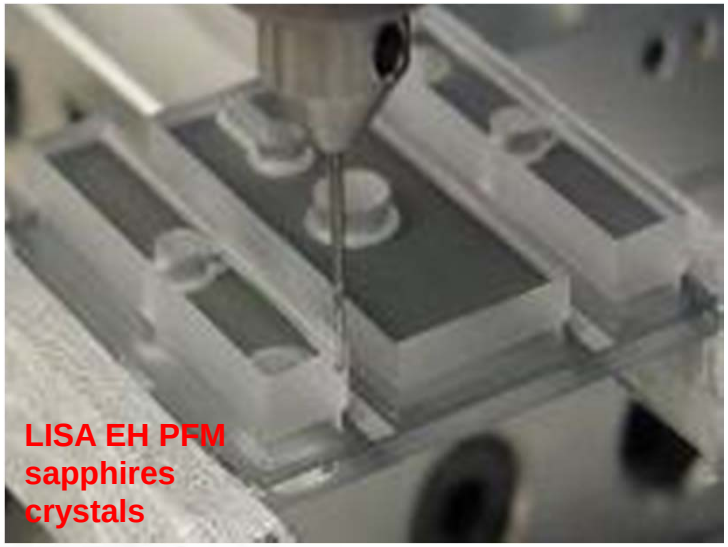
SUMMARY

- INTRODUCTION
- PROBLEM IMPOSSIBLE?
- PROBLEM THAT SEEMS IMPOSSIBLE MAY E ALSO OPPORTUNITIES: THE ELECTRON BEAM BRAZING!
- THE RESULTS
- CONCLUSIONS & PROSPECTIVES FROM SPACE TO GROUND AND AGAIN BACK TO SPACE

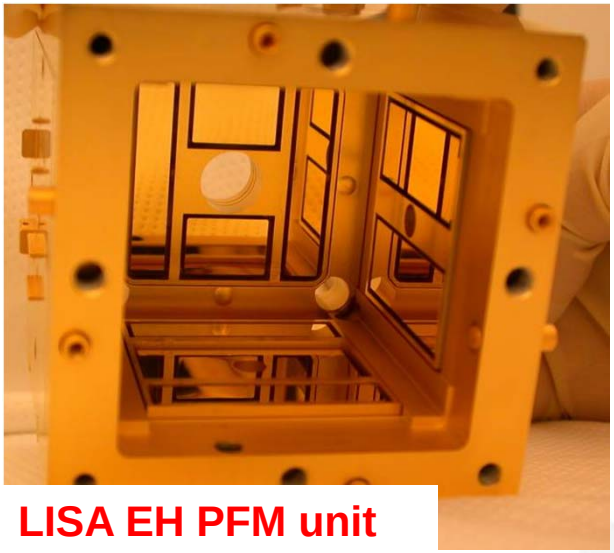
INTRODUCTION

Here the **ELECTRODE HOUSING** an **INNOVATIVE 3D CAPACITIVE SENSOR** developed in the frame of **LISA PATHFINDER ESA MISSION**:

- **Extremely demanding requirements**: microns tolerance alignments, magnetic cleanliness, molecular contamination, ultra high vacuum and thermo-elastic stability
- Manufactured with **Sapphires crystals optics & sinter molybdenum**



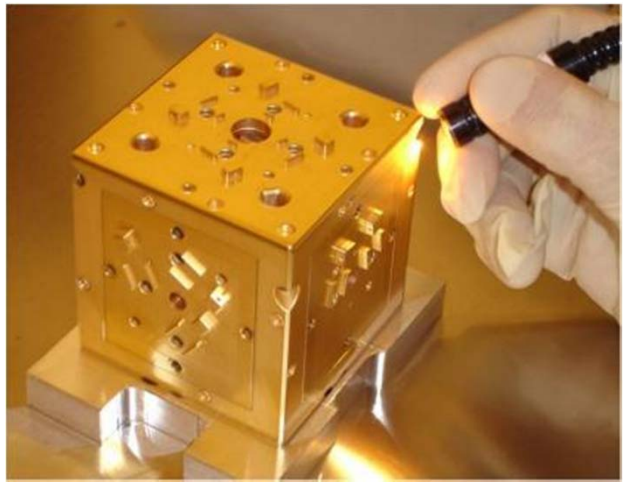
LISA EH PFM sapphires crystals

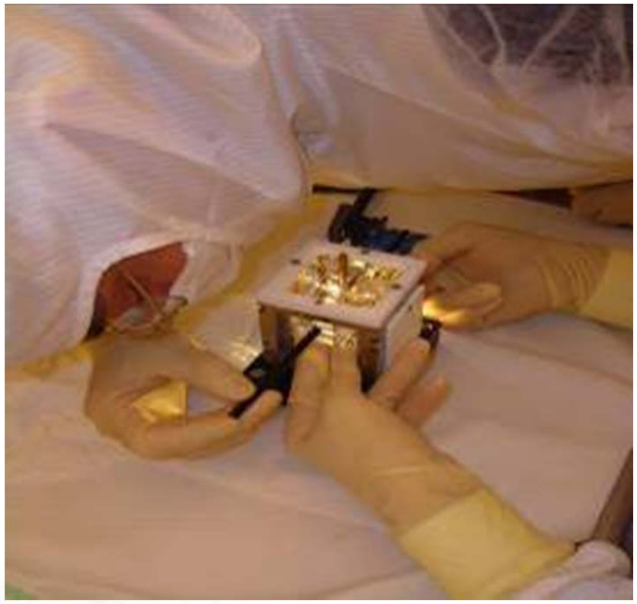


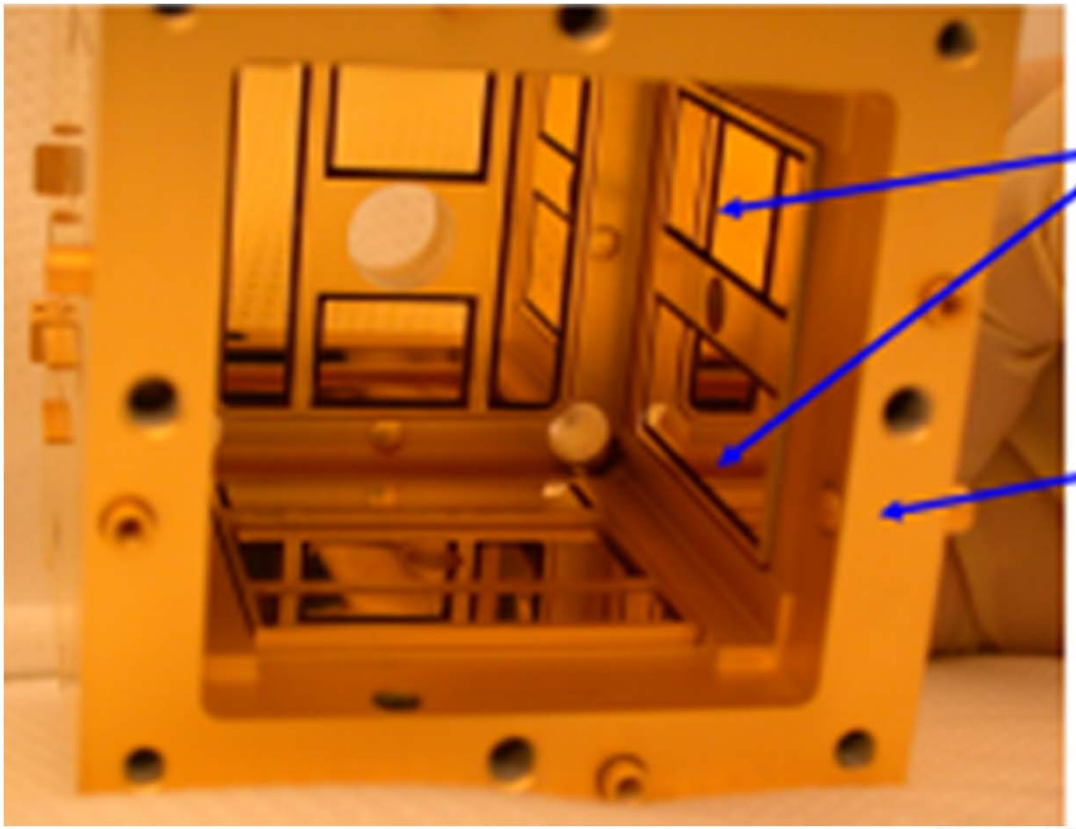
LISA EH PFM unit

LISA EH micron technologies

INTRODUCTION







PROBLEM IMPOSSIBLE?

THE PROBLEM WAS TO ADD STRUCTURAL JOINTS among Electrode Housing molybdenum parts already integrated with sapphire crystal optics and finished by gold coatings

- The process to create joints had to be applied **ON FINISHED FLIGHT HARDWAR** without degrade the extreme requirements…

- **RESTRICTIVE CONTRAINTS:** No joint glue allowed, No screw joint allowed, No welded joint allowed (Mo weld T> 2600°C), No Oven Brazing Allowed

SOMEONE HAVE A SOLUTIONS???

PROBLEMS SEEMS IMPOSSIBLE? MAY BE A OPPORTUNITY…

SOLUTION: DEVELOP A BRAZED JOINT AMONG MOLYBDENUM BY ELECTRON BEAM?

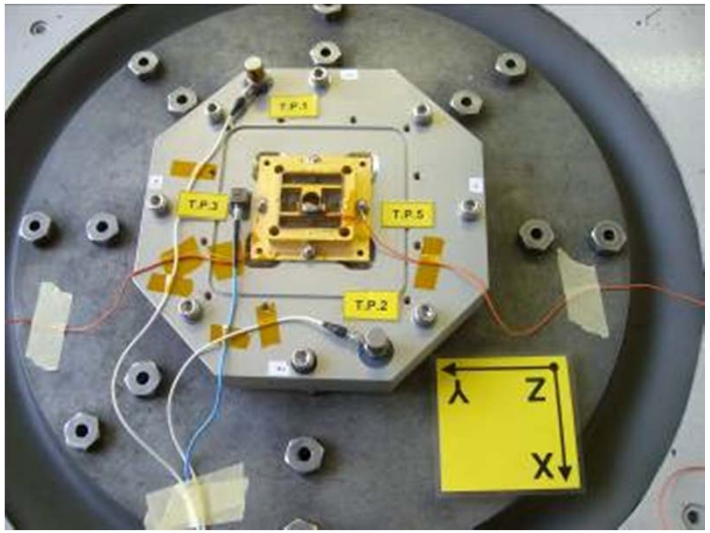
- **STRONG TEAM:** All TASI sites expertizes together with several high technology suppliers (Istituto Italiano della Saldatura (IIS), Genova; the High Technology Centre (HTC), Foligno; RTM Breda, BPS, Centrotecnica, Milano)
- **HUGE ACTIVITY:** Extensive Electron Beam test campaigns, hundred of samples, several materials and electron beam parameters tested, pull test, micro-sections. A huge analytical work has been performed together with metallurgical laboratories and experts: destructive and Non-destructive inspections (NDI), SEM/EDX, FEM analyses, extensive mechanical vibration test campaigns and strength testing.

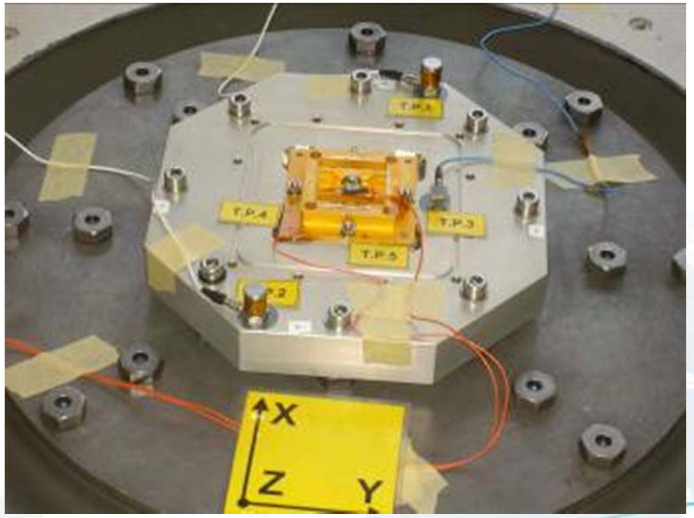
THE DEVELOPMENT

EB development Team

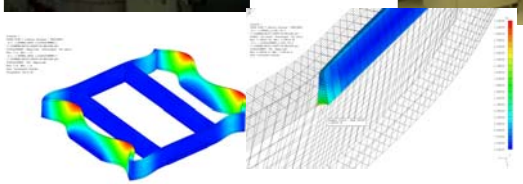
Pull test

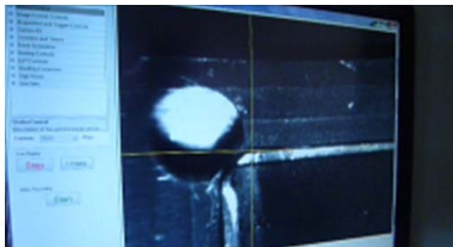
EH faces vibration test

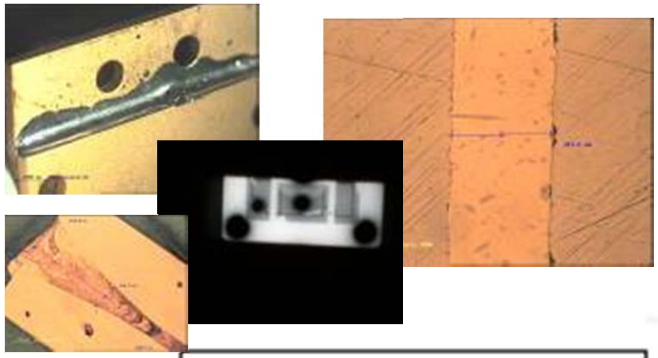




EB test, samples, Micro-section metallurgical investigations, NDI

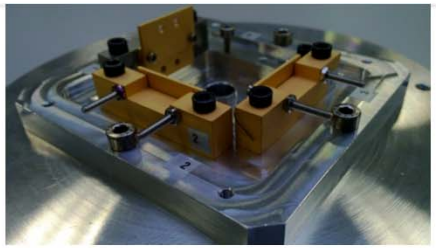


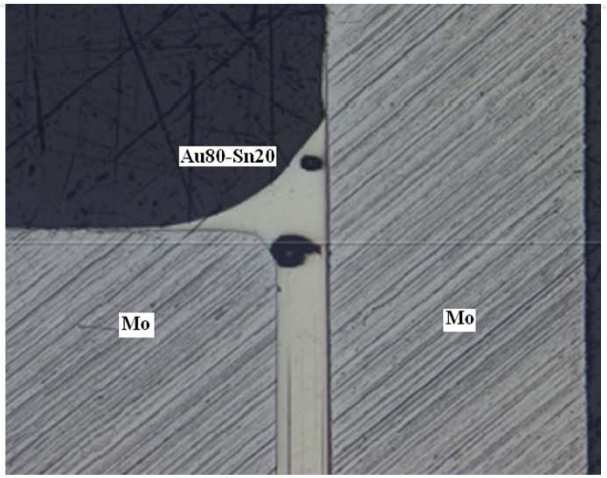


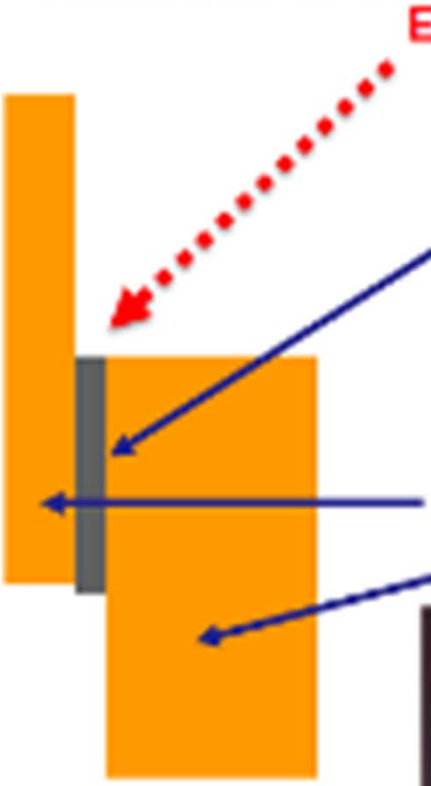


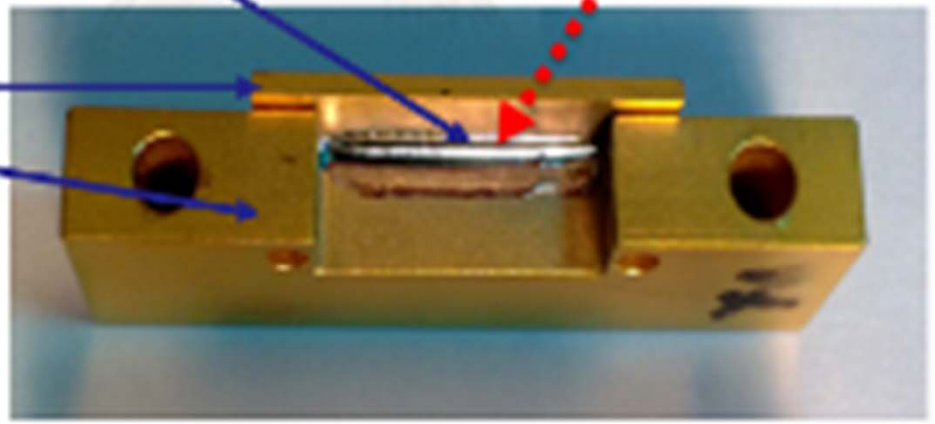
EH faces Electron Beam

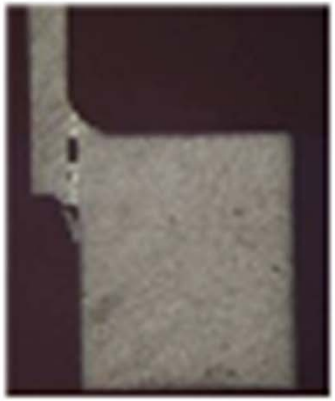
THE RESULTS











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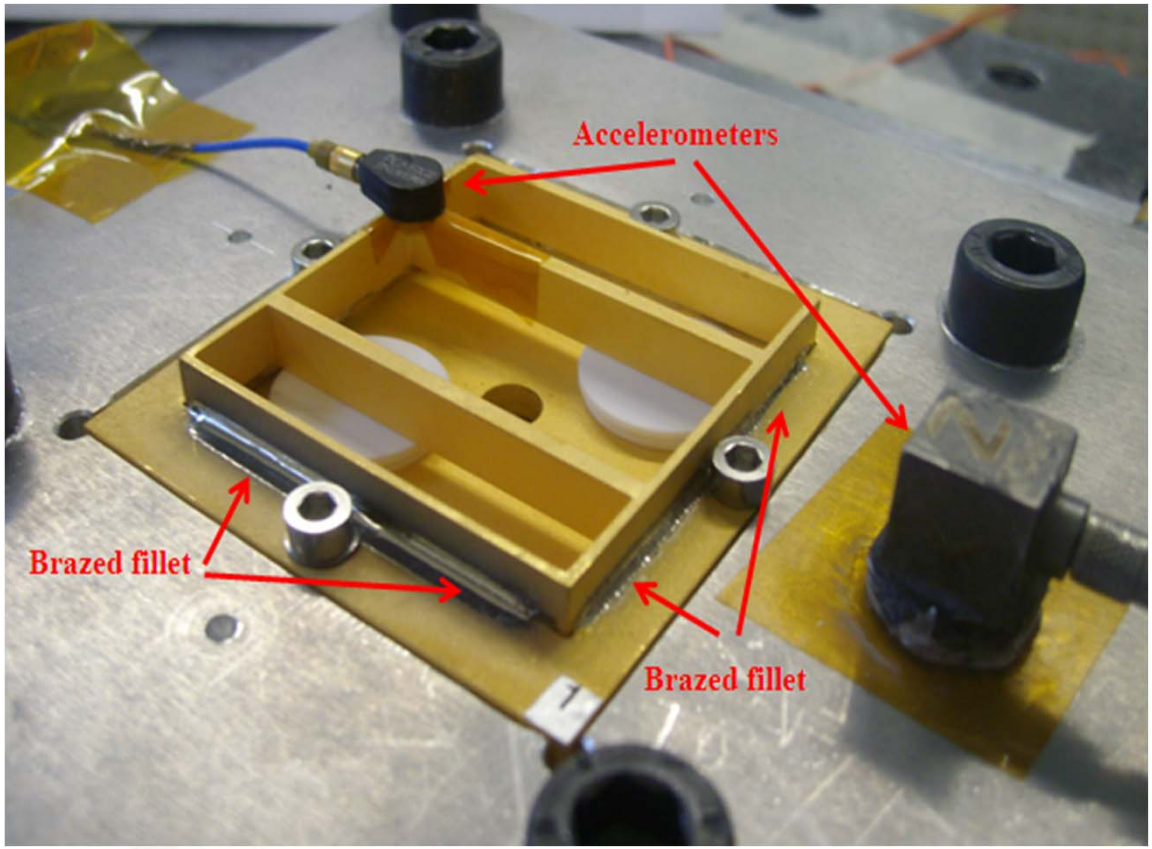
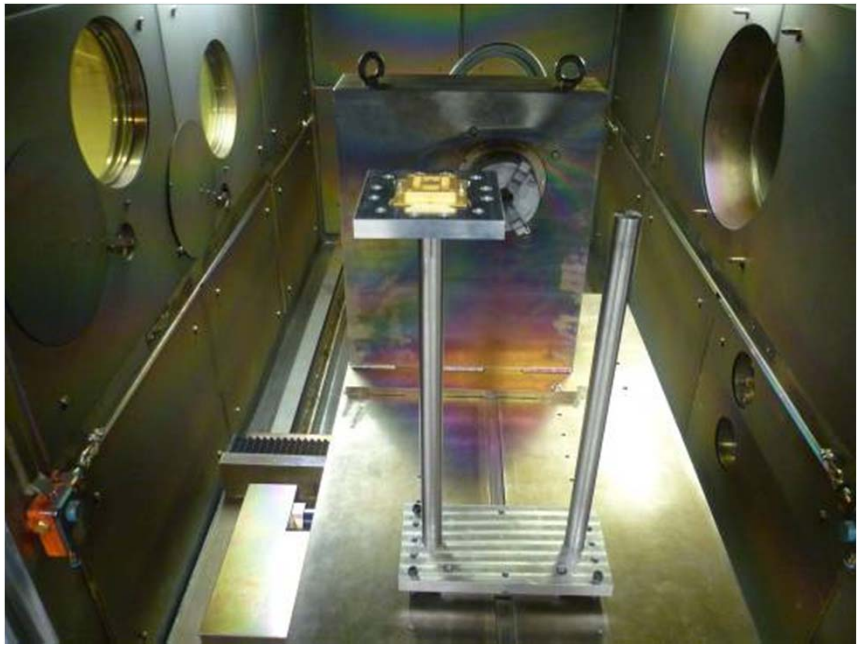
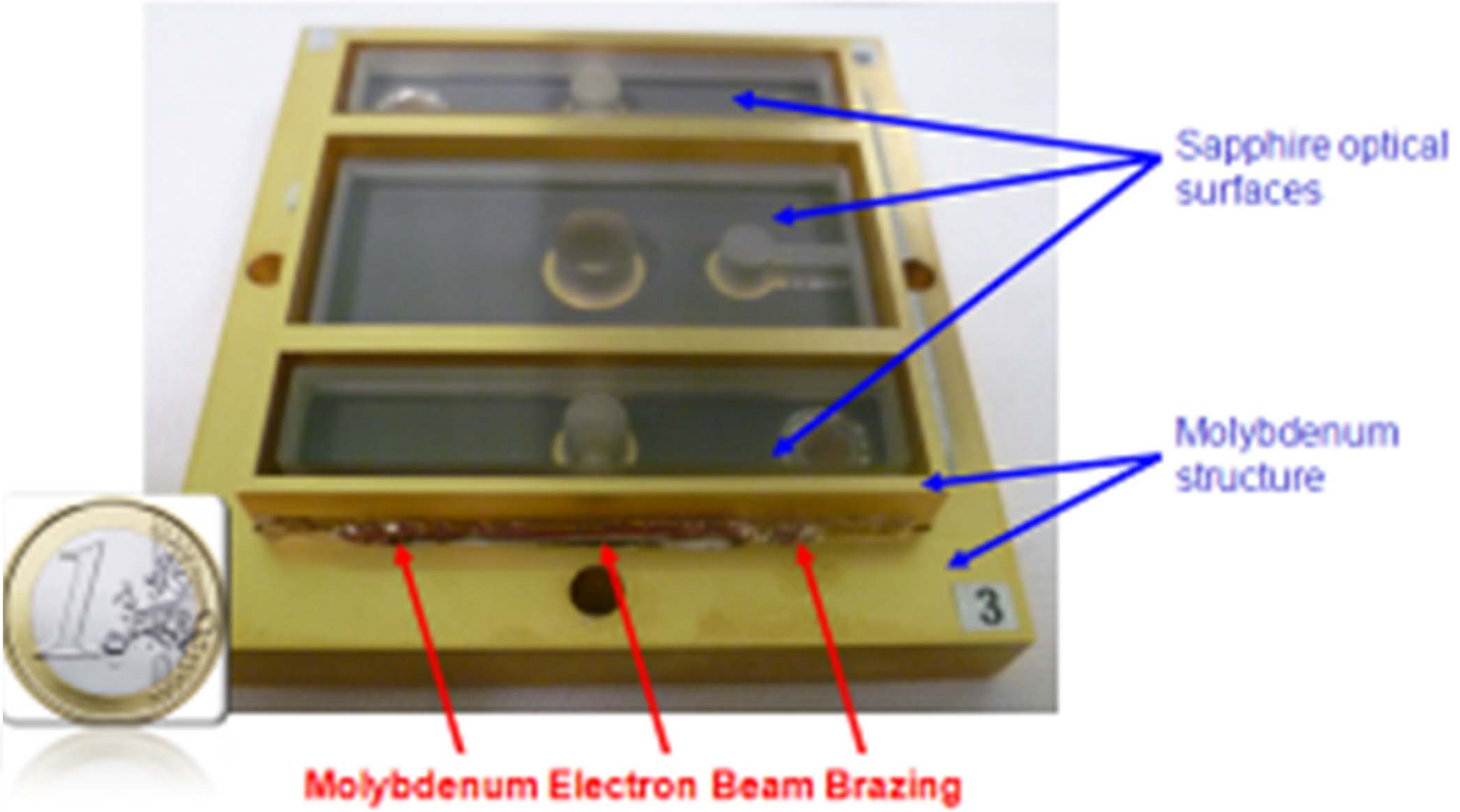


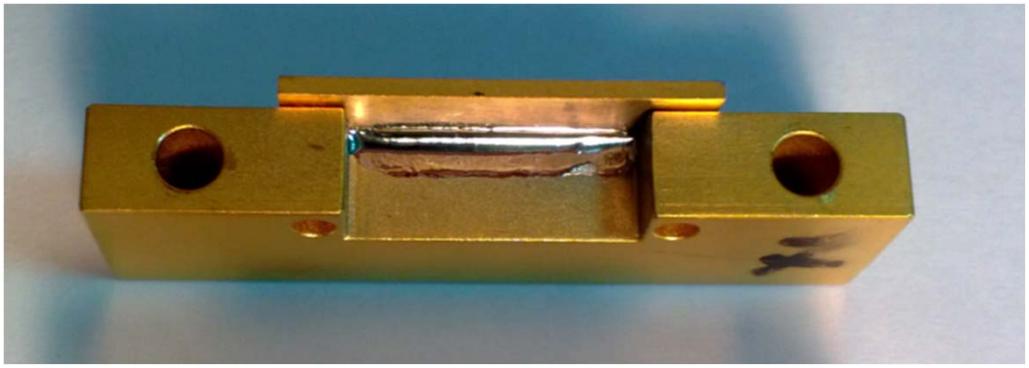


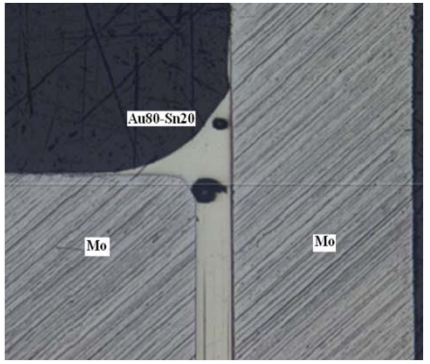
THE RESULTS



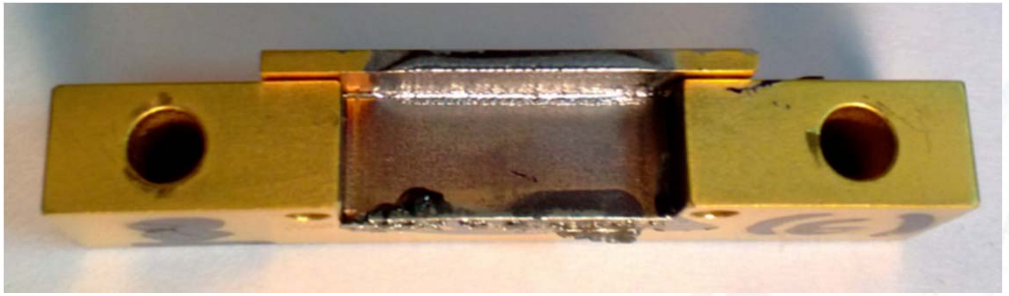
RESULTS: TWO MOLYBDENUM EB BRAZING PROCESS SET

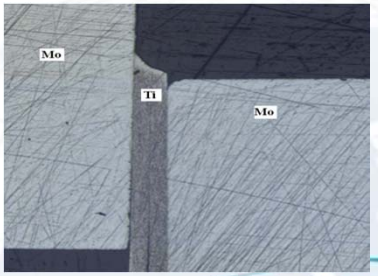
- **LOW THERMAL IMPACT PROCESS:** (T 300°C about) Mo EB brazing by Au-Sn based alloys with very successful tried and developed (strength>10 Mpa)





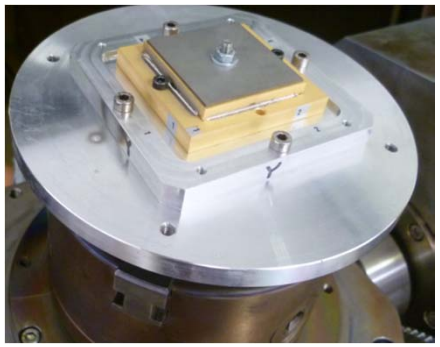
- **MEDIUM THERMAL IMPACT PROCESS**: (T 700°C about) Mo EB brazing using Titanium alloy filler metal with successful tried as this promised higher strength joints (strength>>30 Mpa)

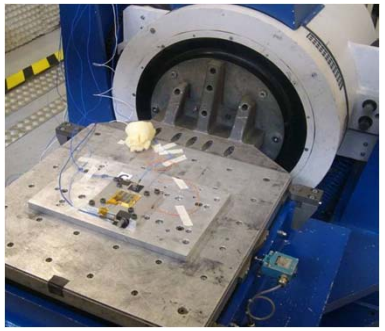




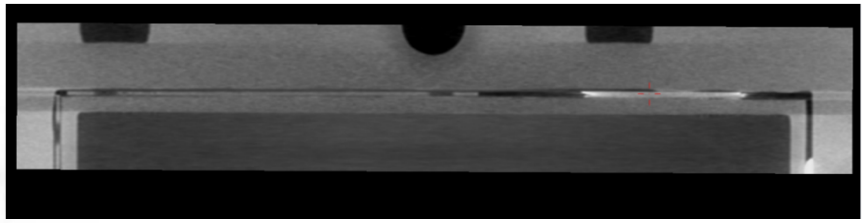
RESULTS: PROCESS IMPLEMENTED

- **THE LOW TEMPERATURE PROCESS IMPLEMENTED** and successfully proved on EH qualification face models by severe random vibration test campaigns

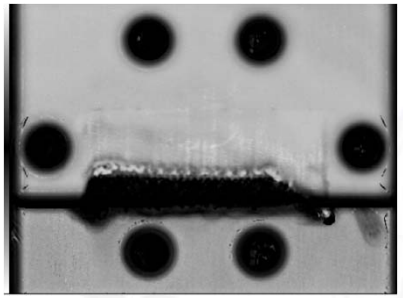




- **SEVERAL NDI TECHNIQUES FOR EB BRAZED JOINTS** was successfully selected like X-ray micro focus CT system and ultrasonic techniques (Sonoscan). Other was as well tried: eddy currents, X ray, penetrants liquids.



X-ray micro focus CT



sonoscan

EB BRAZING TECHNIQUE MERITS

- **SUITABLE FOR TEMPERATURE SENSITIVE COMPONENTS OR DEVICES:** No oven heating is needed. Brazing is local and rapid (few seconds). The most heating is confined the whole structure stays cold:

- **SUITABLE FOR SMALL DIMENSION APPLICATION**: Very small dimensions joints (mm) can be obtained. No special machining, such as hole drilling is needed

- **SUITABLE FOR HIGH VACUUM OR CONTAMINATION SENSITIVE APPLICATIONS**: No flux (normally used for brazing) is needed

- **REDUCE THE SUSCEPTIBILITY OF BULK CRACKING**: Instead the Electron beam welding brazing

CONCLUSIONS & PROSPECTIVES

- **AN INNOVATIVE JOINING TECHNIQUE** has been developed for the EB brazing of molybdenum piece-parts, but not only…

- **FROM SPACE TO GROUND:** A process procedure developed for a space mission (LISA Pathfinder) is suitable for other developments and applications in aerospace or ground technology fields. This application showed the possibility to simplify design implemetation of structure joints where thermal stresses & cleanliness are critical as in Micro-Electronics, Optical Sensors and Payloads or any special ground equipment
- **BACK TO SPACE:** NASA Goddard Space Flight Center identified the Electron Beam (EB) vacuum brazing has been as one of the best joining processes for in-space joining, may be be used for robotic as well as human-assisted construction in space.