Status on BGA packages mounting on PCB : assembly and repair processes

2nd Technical Presentations Day / ESTEC

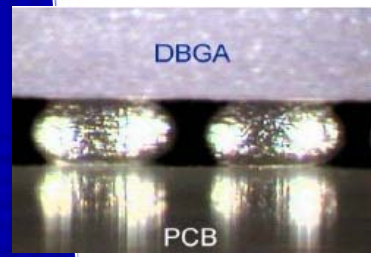
Noordwijk, April 27th 2005

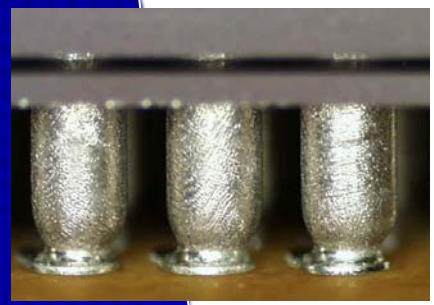
SUMMARY

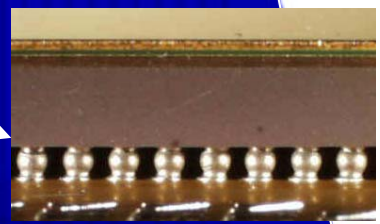
- Status of BGA assembly
  - Review of packages evaluated by EADS Astrium
  - Results of the different evaluations
- Results of ESA study “evaluation of 3 rework machines for area grid array packages”
  - Techniques for BGA rework
  - EADS Astrium specifications for rework
  - Principle of trials
  - Results of rework trials

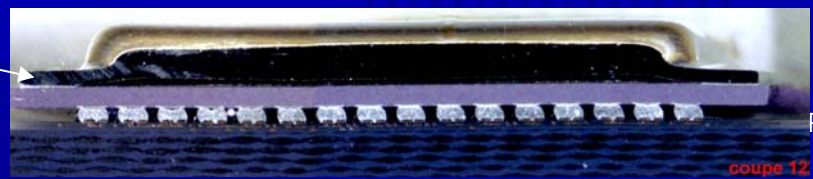
STATUS OF BGA ASSEMBLY

- EADS Astrium evaluated the assembly of :
  - DBGA 324 & DBGA 228 (Kyocera) assembled on polyimid board
  - MCGA from Atmel :
    - MCGA 349 assembled on polyimid board
    - MCGA 472 assembled on polyimid and thermount board
    - CBGA 472 assembled on thermount board
  - Hermetic and non hermetic CSP from Kyocera
    - CSP 256 assembled on low CTE epoxy (microvia technology)









STATUS OF BGA ASSEMBLY

- Results of evaluation of BGA assemblies :
  - All types of package were assembled on board according to EADS Astrium PID
  - Environmental tests during evaluation :
    - 1 test flow : Thermal cycles : 500 cycles [-55°C ; 100°C]
    - 1 test flow : random vibration + shocks + 500 cycles [-55°C ; 100°C]
      - Random vibration : 0.3g^2/Hz between 100Hz and 1000Hz (20.7grms), 10mn along 3 axes
      - Shocks : 600g, ½ sine, 0.5ms

STATUS OF BGA ASSEMBLY

- Results of evaluation of BGA assemblies :
  - DBGA packages assembled on polyimid board did not pass thermal cycles

DBGA 228 after 300 cycles

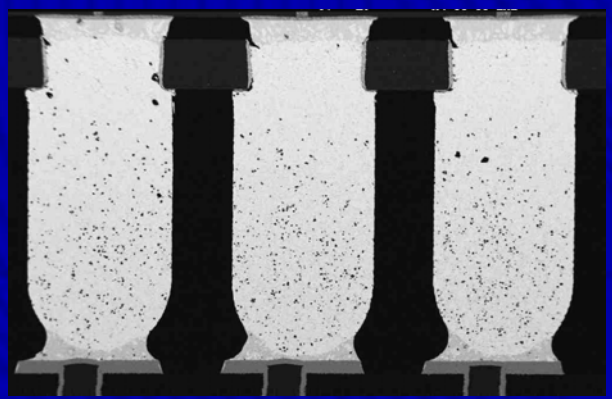
DBGA 324 after 100 cycles

  - CSP packages assembled on epoxy low CTE (microvia technology) did not pass thermal cycles

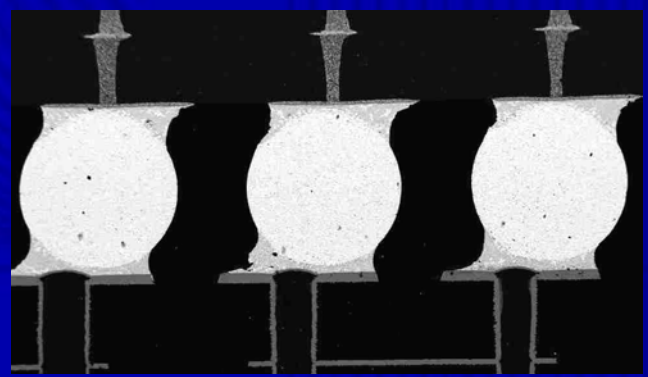
CSP 256 after 200 cycles

STATUS OF BGA ASSEMBLY

- Results of evaluation of BGA assemblies :
  - Configurations that passed environmental tests (2 test flows)
    - MCGA 349 assembled on polyimid board
    - MCGA 472 assembled on polyimid board with stiffener
    - MCGA 472 and CBGA 472 assembled on thermount board



MCGA assembled on thermount board after vibration +shock+ 500 cycles [-55°C ; 100°C]



CBGA assembled on thermount board vibration +shock+ 500 cycles [-55°C ; 100°C]

BGA ASSEMBLY AND REWORK

- Qualification status of BGA assembly requires also the control of rework process
- Rework equipments have been evolving so as to be compliant with area grid array packages
- In the frame of ESA study, EADS Astrium performed rework trials with 3 equipments, selected from a previous survey
  - BGA rework techniques
  - EADS Astrium specification
  - Principle of trials
  - Results of rework trials

TECHNIQUES FOR BGA REWORK

- 3 techniques exist :
  - Hot air convection : the most used
  - Infrared method : the cheapest
  - Laser method : « the most expensive »

TECHNIQUES FOR BGA REWORK

- Hot air convection :
  - Hot air is brought on top of package with a nozzle
  - Need of adapted nozzle for each type of package
  - Use of nozzles implies to have some area left around the package
  - This method is adapted to boards with ground planes and with high thermal inertia
  - Large cost range : from 25 keuros for a manual equipment to 200 keuros for a full automatic equipment

TECHNIQUES FOR BGA REWORK

- Infrared equipment :
  - Heat comes from infra red light
  - Heat area is defined by the focusing of the beam ⇒ better localisation of the heat on the package
  - No tool needed according to the type of package to be reworked
  - Not adapted to large packages
  - Not adapted to white ceramic or packages with metallic cover (reflection of the infrared radiation)
  - Cost of infrared equipment : around 40 keuros

TECHNIQUES FOR BGA REWORK

- Laser equipement
  - The heat comes from the laser YAG beam
  - Laser is coupled with a pyrometer to measure the temperature every 10msec (equipment LS 100 from Vi Technology)
  - The heat is focused on the package : no area left needed around the package
  - No tool needed according to the type of package to be reworked
  - Expensive equipment ~ 220 keuros

EADS ASTRIUM SPECIFICATIONS

- EADS Astrium specifications for rework :
  - Rework of plastic and ceramic BGA packages
  - Rework of large packages (until 35mm*35mm)
  - Rework of microBGA packages : need of assembly accuracy adapted to fine pitch
  - Rework of packages assembled on large boards : max 300mm*300mm
  - Heat capacity adapted to boards with ground planes
  - Need to control the reflow profile $\Rightarrow$ closed loop system
  - Possibility to reflow under air or nitrogen

EADS ASTRIUM SPECIFICATIONS

- EADS Astrium specifications :
  - Lead free process (ballistic applications)
    - Higher soldering temperature (~220°C) : adapted heat capacity so as to reach range of temperature [240°C-250°C]
    - Soldering under nitrogen
    - Controlled cooling

⇒ Considering all EADS Astrium specifications, infrared technique appeared not adapted

CHOICE OF REWORK EQUIPMENTS FOR EVALUATION

- In the frame of ESA study, EADS Astrium performed a survey on rework equipments
- Considering specifications and characteristics of these equipments ⇒ selection of 3 rework equipments for rework trials :
  - 2 hot air convection equipments :
    - Onyx 29 from Zevac
    - APR-5000XLS from Metcal
  - 1 laser equipment :
    - LS100 from Dyamant/Vitechnology

7. DESCRIPTION OF TRIALS

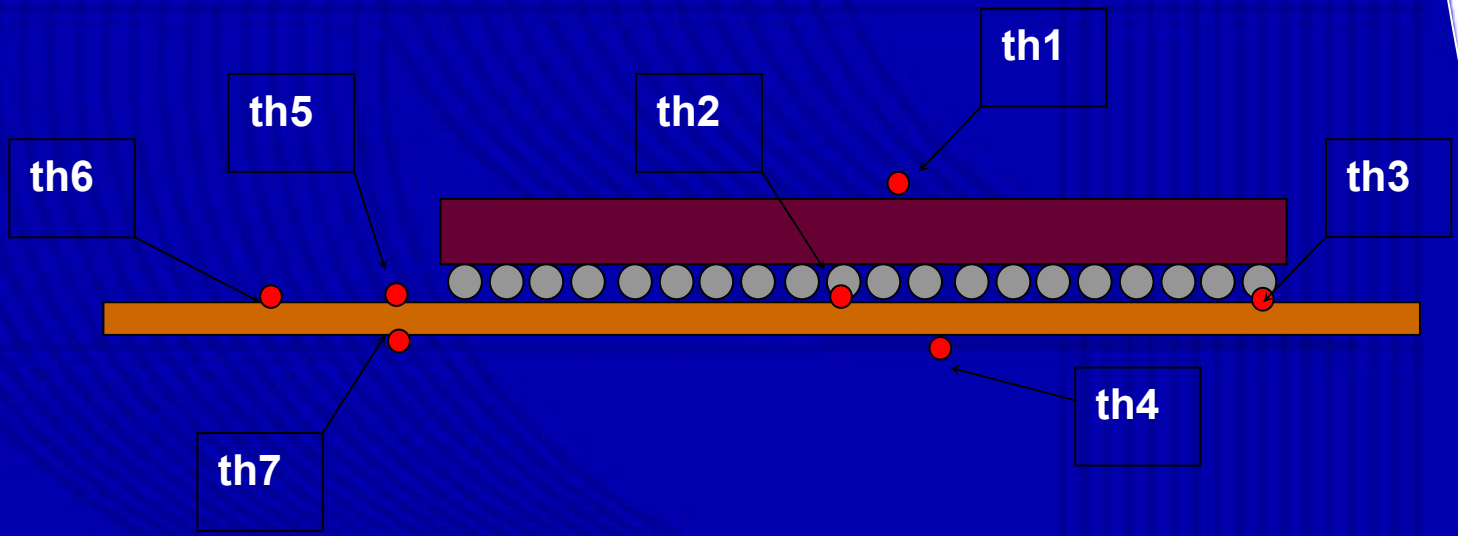
- Principles of rework trials :
  - Hot air convection equipment were tested at manufacturer plants and trials with laser equipment were achieved by a subcontractor.
  - All trials were performed in presence of three persons from EADS Astrium, representing methods, quality and technology departments.
  - Test vehicles : assembled boards coming from previous evaluation
    - Dimensions : 125mm*80mm
    - Thickness : 2.4mm without Mo core nor copper planes
      3mm with Mo core
    - 2 types of package :
      - MCGA 472 assembled on polyimid board
      - DBGA 324 assembled on polyimid board

DESCRIPTION OF TRIALS

- Principles of rework trials :
  - Simulation of desoldering of package assembled on polyimid board using thermocouples
  - Remove the package from polyimid board
  - Cleaning of the solder residues remaining on board
  - Mount a new package :
    - No deposition of solder paste available during these trials
  - Soldering
  - If time, simulation of desoldering of package assembled on polyimid board with Mo core ⇒ assessment of heat capability of the equipment
  - Because of limited time spent at manufacturer plant, thermal profiles could not be optimized

DESCRIPTION OF TRIALS

- Principles of rework trials :
  - for each type of package, simulation of rework process of a board with monitoring of temperature at different areas of the board



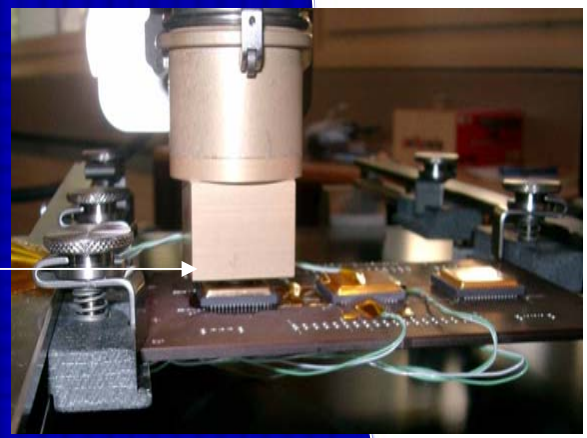
RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

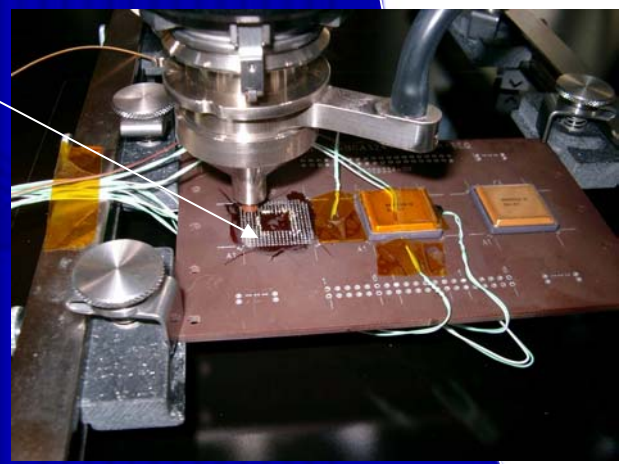
- Trials with Zevac equipment
  - Zevac equipment : Onyx 29
  - Semi automatic hot air convection
  - 2000 W top heater
  - 4 zones of preheating (4*1000W)
  - Regulation of temperature by closed loop control

    (reach the triggers defined by the operator)
  - Board cooling system
  - Site solder removal (automatic cleaning)
  - 7 automated axes
  - Dimensions max of boards : 500mm*500mm
  - Thickness of board : 6mm max
  - Cost ~ 100 keuros

7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

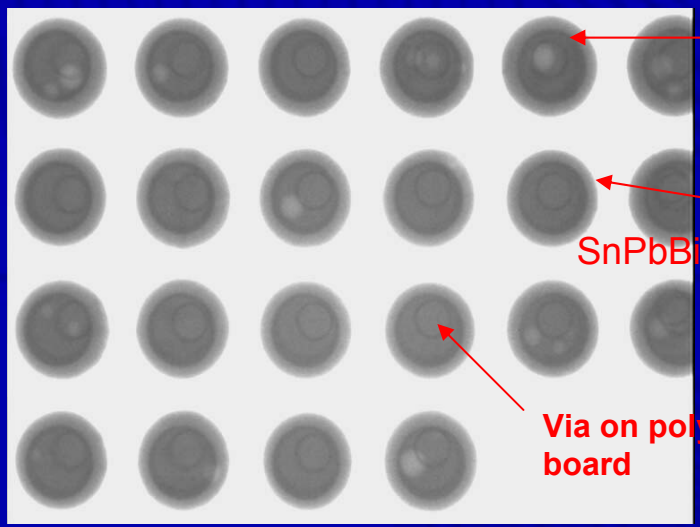
- Trials with Zevac equipment
  - Complete rework of DBGA package assembled on polyimid board :
    - Desoldering according to the profile defined by simulation : SnPbBi solderballs remained on the board
    - Cleaning of solder residues on board
    - Depositing of flux with a brush
    - Assembly of a new package
    - Soldering

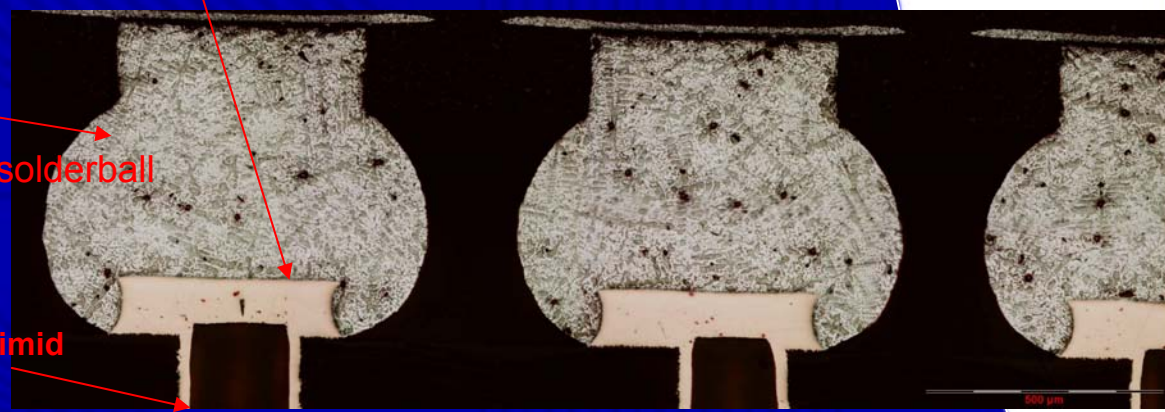




7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with Zevac equipment
  - Complete rework of DBGA package assembled on polyimid board :
    - Inspections of the reworked board :
      - X-ray +microsection : good assembly of the package on the board and no assembly defect observed



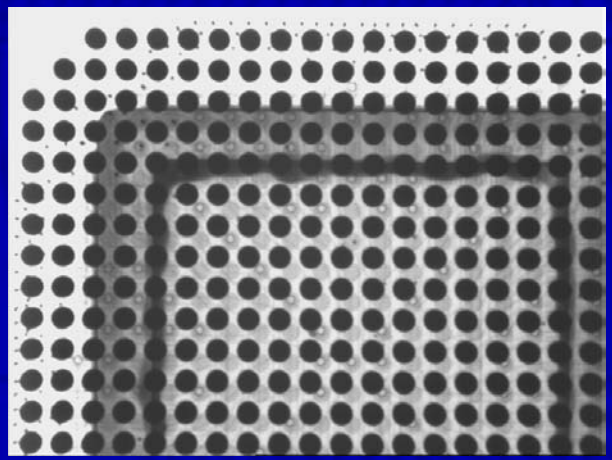


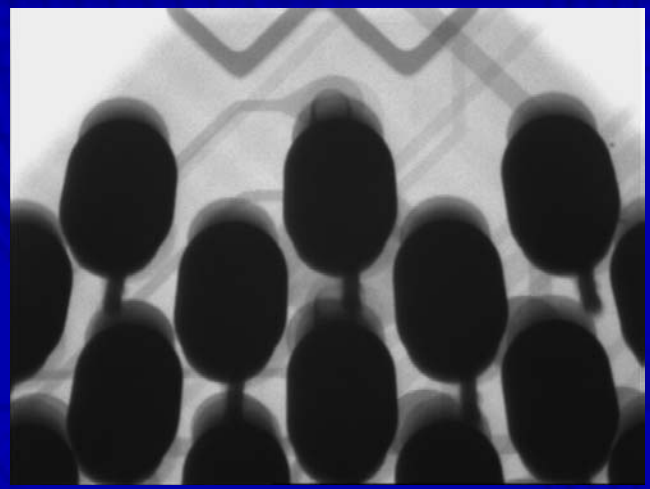
7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

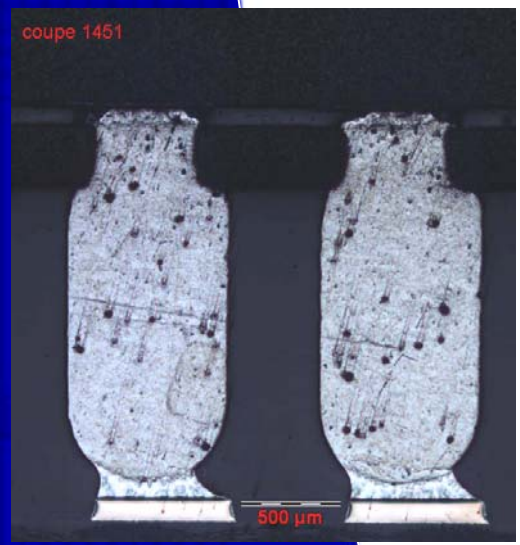
- Trials with Zevac equipment
  - Rework of MCGA assembled on polyimid board :
    - Remove of MCGA package according to profile resulting from simulation
    - Depositing of flux on the remaining solder residue
    - Assembly of the removed package
    - Reflow
    - Visual inspection : good alignment of the MCGA on the pattern and correct solder joints

7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with Zevac equipment
  - Rework of MCGA assembled on polyimid board :
    - X-ray inspection and microsection confirmed good alignment of the package on board

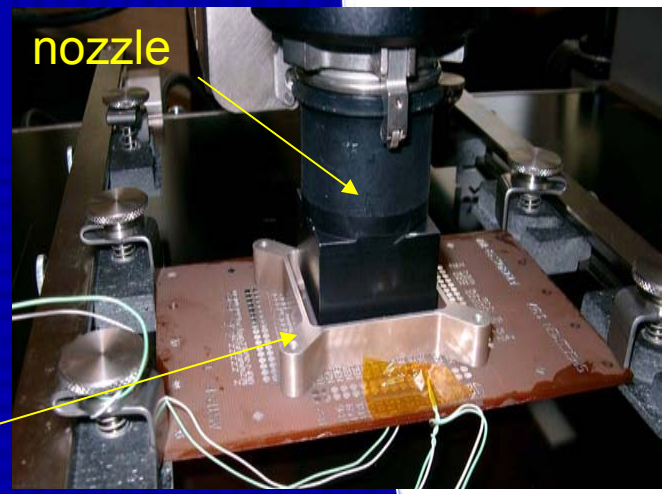






7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with Zevac equipment
  - Desoldering was also tried on board with stiffener and mapsil coating on backside of board :
    - Desoldering was performed keeping the stiffener on the board
    - Lower temperature were measured outside the stiffener
    - Desoldering did not damaged the coating
    - Cleaning of residue with the adapted nozzle could be performed keeping the stiffener
    - The assembly of a new package could not be performed as printing and dispensing were not available at Zevac's plant



7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

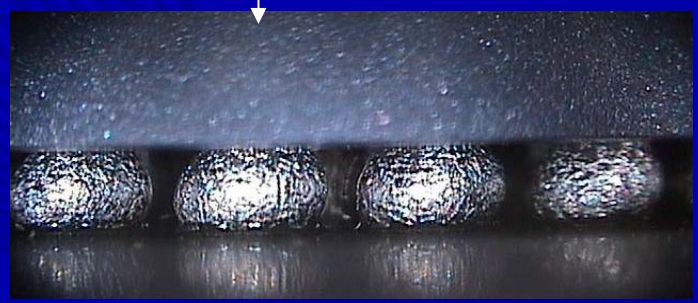
- Trials with Zevac equipment
  - Simulation of rework of a MCGA and DBGA package assembled on polyimid board with Mo core
    - Definition of thermal profile was achieved : heater temperatures were increased in order to reach eutectic temperature in the solder joints
    - The total duration of the profile remained twice higher ; optimization of parameters should help to decrease duration of this reflow profile
- Conclusion of trials with Onyx 29 from Zevac
  - the Onyx 29 allowed to rework MCGA and DBGA package and the heat capacity of this equipment allowed to define thermal profile for rework on polyimid with Mo core

7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with Metcal equipment
  - Metcal equipment : APR-500 XLS
  - Semi automatic hot air convection
  - 550 W top heater
  - 2800W preheater
  - Regulation of temperature by a closed loop control in order to reach temperatures set at top heater and preheater
  - 7 automated axes
  - Dimensions max of boards : 622mm*622mm
  - Thickness of board : 6,35mm max
  - Cost ~ 45 keuros

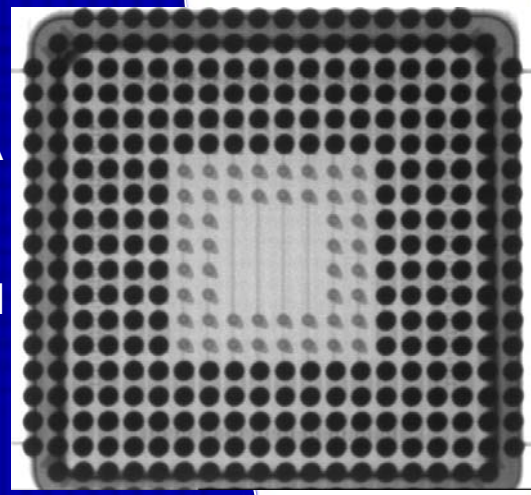
7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

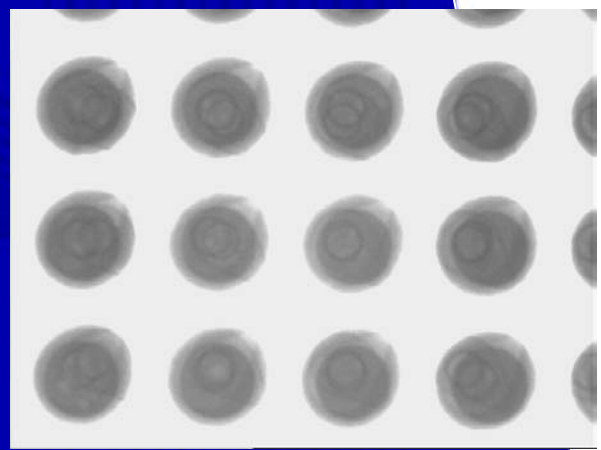
- Trials with Metcal equipment
  - Complete rework of DBGA package
    - Desoldering of DBGA package according to thermal profile resulting from simulation
    - Solder residues remained on the board and on the package
    - Fluxing of a new pattern available on the same board (SnPb finition on pattern)
    - Soldering of new package on this new pattern :
      - good alignment of the package on its pattern



7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

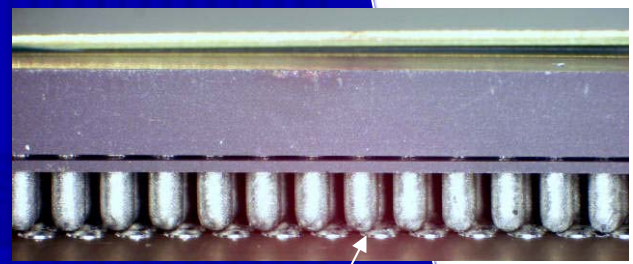
- Trials with Metcal equipment
  - Complete rework of DBGA package was performed :
    - X-ray inspection confirmed the correct alignment of DBGA on its pattern and no assembly was observed
    - Microsection was also performed on the rework board and no defect was observed





7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with Metcal equipment
  - Complete rework of MCGA package assembled on polyimid board
    - Desoldering : only the CLGA part was removed ; the interposer with columns remained on board
    - Solder residues on top of the interposer were cleaned manually with a braid and soldering tip
    - Metal foil was mounted on the interposer with kapton so as to help the vacuum pick up to remove the interposer
    - Second desoldering removed the interposer
    - Soldering of new package on the same pattern
      - Deposition of flux FR601 on solder residues remaining on PCB pads
      - Soldering : « rotation » of the package occured at the end of thermal profile



7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with Metcal equipment
  - Complete rework of MCGA package assembled on polyimid board coated with mapsil on backside and with stiffener :
    - Same process was repeated : kapton adhesive film was assembled on the four sides of the interposer so as to maintain the whole MCGA during desoldering
    - Desoldering was performed like 1st trial : the whole device was removed
    - Visual inspection of the board :
      - mapsil coating was not altered by desoldering process
      - the board was not damaged
    - Soldering of new package :
      - Solder connections of MCGA package were dipped with tacky flux from a fluxer plate with a calibrated thickness of 300µm
      - Like 1st trial, rotation of the package occured during the soldering

7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

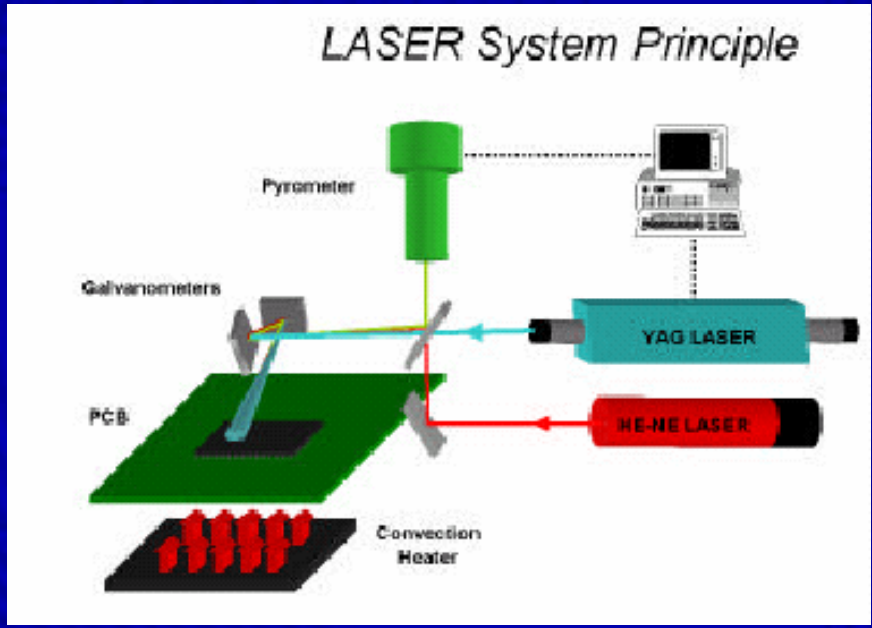
- Trials with Metcal equipment
  - Simulation of desoldering of DBGA assembled on polyimid board with Mo core :
    - Definition of thermal profile was achieved : heater temperatures were increased in order to reach eutectic temperature in the solder joints
    - As observed with Onyx 29, the total duration of the profile remained twice higher ; optimization of parameters should help to decrease this reflow profile
- Conclusion of trials with APR5000-XLS from Metcal
  - the APR5000-XLS allowed to rework DBGA package but rework trials on MCGA gave poor results compared to results obtained with the Onyx 29
  - the heat capacity of the equipment allowed to define thermal profile for boards with Mo core

7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with laser LS100 equipment
  - Laser equipment : LS 100 from Vi Technology (initiall manufactured by Dyamant)
  - The heat comes from the YAG laser beam
  - A pyrometer is coupled to the laser so as to regulate temperature on top of component
  - The heat is focused on the package : no area left is needed around the component
  - No tool adjusted to the component is needed
  - Preheating system is available
  - No thermocouples on this equipment
  - Dimensions of boards 500mm*400mm but preheating zone is 130mm*130mm
  - Cost : 220 keuros

2. METHODS FOR BGA REWORK

- Laser equipment
  - Principle of functioning of the BGA repair with laser equipment :



7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

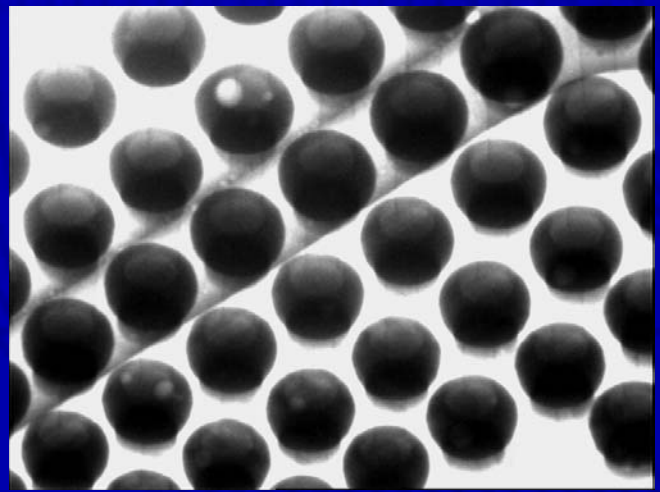
- Trials with laser LS100 equipment
  - Simulation of desoldering and soldering of DBGA and MCGA packages :
    - No thermocouples are available on the equipment
    - Thermocouples were plugged on a tracker system, connected to a computer
    - For the MCGA package : many simulations were necessary to define the right thermal profile for soldering and desoldering processes as the power of laser beam is controlled by the temperature measured by the pyrometer on top of the package (here, the laser mainly impacted the kovar lid)
    - For the DBGA package, only two simulations were necessary to define the right profile as reflow temperature is lower (170°C)

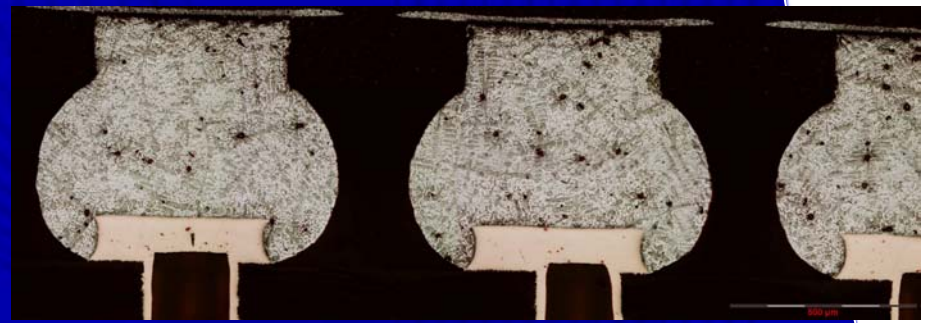
7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with laser LS100 equipment
  - Complete rework of DBGA package :
    - Desoldering :
      - the vaccuum pressure of the pick up nozzle was not sufficient to remove the package ; the package was removed manually with a pipette
      - Solder residues remained on board and on the package
    - Soldering of a new package on a new pattern
    - Depositing of flux with a brush
    - the new DBGA was mounted manually : according to the subcontractor, the assembly option of the laser equipment was not accurate nor repeatitive
    - Correct alignment of DBGA on its pattern

7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

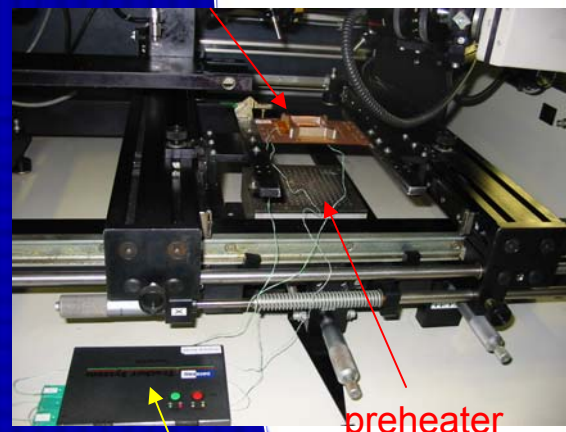
- Trials with laser LS100 equipment
  - Complete rework of DBGA package :
    - X-ray inspection as well as microsection highlighted the good alignment of the package on board and the absence of assembly defect





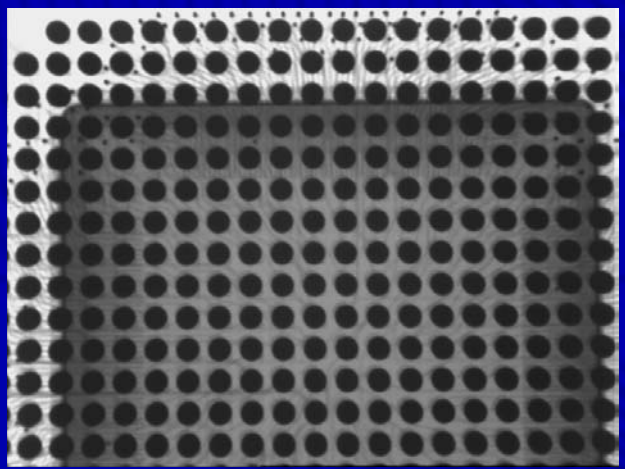
7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

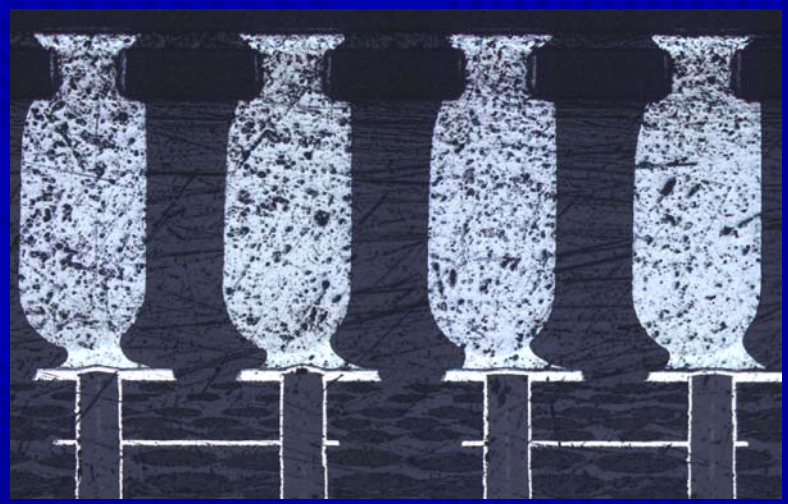
- Trials with laser LS100 equipment
  - Complete rework of MCGA package assembled on polyimid board with mapsil and stiffener :
    - Desoldering :
      - like for DBGA, package was removed with a pipette
      - All columns remained on the package ; board and mapsil coating were not damaged by the soldering
    - Soldering :
      - flux FR 601 was deposited on the residue of solder on the board
      - A new MCGA package was mounted manually
      - After soldering, the MCGA was characterized by good alignment on its PCB pattern and the mapsil coating remained intact



7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with laser LS100 equipment
  - Complete rework of MCGA package assembled on polyimid board with mapsil and stiffener :
    - Despite the manual assembly, the MCGA was correctly mounted on board
    - As assembled on solder residues, solder joints remained thin





7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with laser LS100 equipment
  - Simulation of desoldering of MCGA assembled on polyimid board with Mo core :
    - Many trials were performed without success :
      - it was very difficult to reach the reflow temperature in solder joints
      - difference of 30°C was recorded between inner solder joints (centre of the package) and external solder joints
      - the last profile allowed to reach reflow temperature but the temperature on top of MCGA was about 246°C ; at the end of this profile, warnings of the equipment turned off

7. RESULTS OF TRIALS WITH SELECTED EQUIPMENTS

- Trials with laser LS100 equipment
  - Simulations of desoldering of a DBGA assembled on a polyimid board with Mo core
    - Like for the MCGA package, many trials were achieved without success even if the reflow temperature of SnPbBi solderballs is lower (170°C)
- <u>Conclusion of trials with LS100 equipment :</u>
  - The laser system allowed to desolder and solder MCGA and DBGA package on board without Mo core
  - But some limitations were identified in this equipment :
    - Heat capacity is not adapted for boards with cores
    - Accuracy of placement was told mediocre by subcontractor
    - Vaccuum pick up is not performant

8. CONCLUSION

- From a survey of rework equipments, 2 hot air and one laser machine were selected for rework trials
- Rework trials were performed on DBGA and MCGA packages with each selected equipment
- On one hand, the hot air equipment Onyx 29 from Zevac gave satisfactory results with the rework of MCGA and DBGA packages
- On the other hand, the rework of MCGA remained difficult with the Metcal equipment and the laser equipment presented significant limitations such as heat capacity, placement accuracy