Introduction to the 3D-HiPMAS project

Pilot Factory for 3D High Precision MID Assemblies
General project data

Title: Pilot Factory for 3D High Precision MID Assemblies (3D-HiPMAS)

Call: FoF.NMP.2012-5
High precision production technologies for high quality 3D micro-parts

Period: 01/10/2012 – 30/09/2015 (36 month)
Budget: 5,350,276,20€
Grant: 3,499,600,00€
Partners: 12
Coordinator: HSG-IMAT
The research leading to these results has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 314293.
Content:

- State of the art
- Objectives
- Building Blocks – Beyond state of the art
- Resources - Budget
- Impacts
- Dissemination
Subject: MID based 3D high quality, high precision 3D micro-parts

Process Flow:

- 3D plastics micro-parts
- Conductive tracks
- Components assembly
- Online monitoring / quality inspection

➔ Huge Potential for new Products and Production in Europe!
SoA: 2-shot MID Technology

Process Flow of 2-shot MID:

- Injection mould first shot
- Injection mould second shot
- Surface activation
- Full-build electroless copper
- Surface finish

Pressure Sensor Assembly:
- 2-shot MID saves ~50% of space
- 2-shot MID saves ~30% of cost
SoA: Laser Direct Structuring MID Technology (LDS)

Process Flow of LDS MID

- Injection moulding
- IR-Laser structuring
- Cleaning
- Electroless Cu
- Electroless Ni
- Immersion Au

Switch for Motor Cycle Handlebar

The research leading to these results has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 314293
SoA: Electroless Metal Deposition for 2-shot and LDS MIDs

- 2-Shot MID at 600 µm pitch
- LDS MID at 300 µm pitch
- Lateral metal over grow in 2-Shot MID
- Lateral metal over grow in LDS MID

The research leading to these results has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 314293
SoA: Assembling of Electronic Devices of 3D-MIDs

Motor cycle handlebar switch

Light sensor

SMD assembly

3D chip assembly with tilt of MID

Fabrication line

Light sensor for car environmental control
The research leading to these results has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement no 314293.
State of the art bottlenecks to be addressed:

- Plastics Material
- 2-Shot moulding process
- Laser technology
- Electroless metal deposition
- Assembly of electronic components on 3D bodies
- In-line monitoring of 3D micro-parts
- Experience of industries along the MID assemblies process chain
- Production cost
- Material consumption and environmental protection
Overall project objectives:

- **3D high precision 2-shot plastics micro-parts** with size reduction for conductive tracks from SoA 300µm to 150µm

- **3D high definition conductive tracks** by new generation of Laser Direct Structuring and plating technologies reduced from SoA 300 µm pitch in 3D (150 µm in 2D) to 150 µm pitch in 3D (75 µm in 2D)

- **3D precision electronic components assembly** with novel overall capability of positioning and alignment accuracy below 10µm compared to SoA 20µm

- **3D reliable and robust online monitoring and quality inspection system**, including quality management, and novel in-line 3D X-Ray tomography.

- **Integrating these 4 technologies to launch the future EU pilot factory** to save more than 50% of today’s production costs

- **Assessment of the pilot factory through 4 advanced products** in the energy, medical, communication and transport applications.
The research leading to these results has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 314293.

WP1: Technical specifications and design concepts (RTD)  
Leader: RADIALL

WP2: 3D System carrier (RTD)  
Leader: ENSINGER

WP3: 3D metal patterning (RTD)  
Leader: LPKF

WP4: 3D high precision assembling (RTD)  
Leader: HAECKER

WP5: Flexible 3D high precision MID Platform (RTD)  
Leader: HSG-IMAT

WP6: Demonstration (DEMO)  
Leader: ARAYMOND

WP7: Online process and quality control (RTD)  
Leader: PSL
Beyond SoA: 3D system carrier

New plastic materials with cost kept at present level:
- higher performance and precision 3D system carriers
- thermal expansion reduced by 30 %

New additives at size below 1 µm:
- enable LDS activation and plating phases
- good stability and perfect cohesion with the polymer matrix

Enhanced precision 2-shot molded 3D micro-parts:
- reduced wall thickness, line width and tolerances
- using rapid heat&cool, vacuum and compression moulding

Improved processing performance:
- reduction of material consumption by wall thickness and part size of 20%
- reduction of mould set up phase and time-to-market by 10%
- improved precision by 50%
Beyond SoA: 3D metal patterning

Improving laser machinery:
- Reducing laser spot size from 60 µm to below 25 µm
- Improving positioning accuracy from 10-20 µm (3 sigma) to 5-7 µm
- Enhancing Scanning velocity for same throughput (mm²/s)
- Reducing machining cost by 50%
- Image processing for online process control

Improved metal plating for LDS and 2-shot (roughness, adhesion):
- Reduced size of metal lines for LDS (100%) and 2-Shot MID
- Cleaning processes for 50% less CO₂ or chemicals consumption
- Replace Ni-P/Au by Ag for less chemicals / metals consumption
- More pieces per batch due to smaller device size (30 - 50 %)

Reduced cost:
- Laser machining ~50 %
- Metal deposition ~35 – 60 %
Beyond SoA : 3D high precision assembling

Improving precision and 3D capability of assembling machinery:
- Develop 3-D manipulation to work on a globe and around it to transfer parts, move parts, rotate parts and more
- Increase z-stroke from 45 mm to 150 mm for more complex MID
- Reduce cycle time at increased z-stroke while maintaining precision and accuracy
- Develop new sorting process for loose material parts to work piece carriers

Improving joining processes for new fine pitch MID:
- Establish new laser soldering capabilities for 3-D connections
- Develop joining processes for “bare dies”
- Develop joining processes for SMD
- Develop joining processes for micromechanical/micro optical components
- Develop automatic loading options for complex MID structures
- Implement image processing for real time control of assembly and dispensing results and reevaluate automatic error compensation.
Beyond SoA : Advanced product and process control

Advance software platform for engineers for 3D-µ-MIDs products:
- MID/3D-MID domain-specific language specification
- Software environments dedicated to 3D-MID/MID process engineering

Relevant online process and product quality inspection strategy for 3D-µ-MIDs products

In-line non destructive 3 dimensional metrology tool:
- enabling feedback on production process / quality achieved
- innovative concept of X-Ray tomograph
- Radio Synthetic Control (RSC) for non destructive 3 D analysis of complex volumes analysis of material content using real time X-ray imaging acquisition
- Reduced overheads in reconstructing 3D data sets by 80-90%
Demonstrator 1: 3D micro fuel cell

Beyond SoA:
Integration of a.m.a.p of control and safety parts into MID / package
- control electronics
- sensors
- piezoelectric actuators for valves / circuit-breakers

Miniaturization:
- lower number of parts
- smaller size
- lower power consumption
- reduced cost by 60% for control and safety part
Demonstrator 2: 3D micro hearing aids

Phonak BTE type hearing aid

**Beyond SoA:**
- Integration of antenna structures
- 3D integration of electronic components
- Integration of contact elements
- Evaluation of hard/soft material combination compatible to 3D MID process
Demonstrator 3 : 3D micro switches

Beyond SoA:
Cost reduction for new market opportunity (~30%)
- Improved assembly process
- Less higher precision of parts (15 to 8)
- Chance of automation
- Improved reliability

Improved RF performances
- New MID based design
- New RF line design for improved the frequency level (8 to 12 GHz)
- Improved harsh environment capability
Demonstrator 4 : MID based pressure sensor

Thanks to MIDs, this very robust pressure sensor based on a membrane / capacitive principle with an integrated temperature sensor display a smaller package volume and will provide a cost-effective solution for many sensor applications.
Assessment of pilot line performance during demonstration:

- Reduction of **plastics materials** input
- Reduction of **energy consumption** in materials compounding, injection moulding, metal deposition and laser machining
- Reduction of **CO₂ consumption** and/or chemicals in cleaning
- Reduction of consumption of process **chemicals** and **metals** in electroless plating (Au will be replaced to 100%)
- Improvement of **precision**
- Improvement of **yield**
## Planned resources

<table>
<thead>
<tr>
<th>Participant Nr</th>
<th>Organization short name</th>
<th>Organization country</th>
<th>RTD</th>
<th>DEMO</th>
<th>MGT</th>
<th>OTH</th>
<th>Total</th>
<th>Requested EU contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HSG-IMAT</td>
<td>DE</td>
<td>599.504</td>
<td>131.016</td>
<td>171.488</td>
<td>35.126</td>
<td>937.134</td>
<td>721.750</td>
</tr>
<tr>
<td>2</td>
<td>LPKF</td>
<td>DE</td>
<td>507.576</td>
<td>60.576</td>
<td>0</td>
<td>16.032</td>
<td>584.184</td>
<td>300.108</td>
</tr>
<tr>
<td>3</td>
<td>PSL</td>
<td>UK</td>
<td>396.349</td>
<td>184.794</td>
<td>1.500</td>
<td>20.283</td>
<td>602.926</td>
<td>411.441</td>
</tr>
<tr>
<td>4</td>
<td>HAECKER</td>
<td>DE</td>
<td>372.307</td>
<td>81.692</td>
<td>0</td>
<td>29.419</td>
<td>483.418</td>
<td>349.495</td>
</tr>
<tr>
<td>5</td>
<td>RADIALL</td>
<td>FR</td>
<td>171.618</td>
<td>249.034</td>
<td>0</td>
<td>18.577</td>
<td>439.229</td>
<td>228.903</td>
</tr>
<tr>
<td>6</td>
<td>PRAGMA</td>
<td>FR</td>
<td>46.930</td>
<td>120.192</td>
<td>0</td>
<td>14.178</td>
<td>181.300</td>
<td>109.471</td>
</tr>
<tr>
<td>7</td>
<td>PHONAK</td>
<td>CH</td>
<td>65.370</td>
<td>238.484</td>
<td>0</td>
<td>11.706</td>
<td>315.560</td>
<td>163.633</td>
</tr>
<tr>
<td>8</td>
<td>PEP</td>
<td>FR</td>
<td>506.000</td>
<td>142.600</td>
<td>1.500</td>
<td>32.800</td>
<td>682.900</td>
<td>485.100</td>
</tr>
<tr>
<td>9</td>
<td>CEA</td>
<td>FR</td>
<td>385.198</td>
<td>45.742</td>
<td>0</td>
<td>13.297</td>
<td>444.237</td>
<td>325.066</td>
</tr>
<tr>
<td>10</td>
<td>PLASTIPOLIS</td>
<td>FR</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>113.076</td>
<td>113.076</td>
<td>113.076</td>
</tr>
<tr>
<td>11</td>
<td>ENSINGER</td>
<td>DE</td>
<td>173.155</td>
<td>30.014</td>
<td>0</td>
<td>8.616</td>
<td>211.785</td>
<td>110.200</td>
</tr>
<tr>
<td>12</td>
<td>RAYCE</td>
<td>FR</td>
<td>79.978</td>
<td>266.362</td>
<td>0</td>
<td>8.187</td>
<td>354.527</td>
<td>181.357</td>
</tr>
</tbody>
</table>
Budget share

<table>
<thead>
<tr>
<th></th>
<th>Budget [€]</th>
<th>Share [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal</td>
<td>4094032</td>
<td>76,52</td>
</tr>
<tr>
<td>Consumable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>1205444</td>
<td>22,53</td>
</tr>
<tr>
<td>Travel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subcontracting</td>
<td>50800</td>
<td>0,95</td>
</tr>
</tbody>
</table>

Grant/Total Budget : 64%
Management Budget: 5%
3D-HiPMAS impacts:

Provide the industry with a pilot factory able to offer customised solutions in terms of technical and economical performances

▪ Supply chain:
  ➢ Consultation of companies on the Pilot Factory (precision, products size, shape, functions, materials, volume of production, time-to-market, product price, production costs …).
  ➢ Studies on efficient production for manufacturing of MID components
  ➢ Set up of fabrication lines within Europe

▪ Open the way to new future products not possible to be realized using SoA technology:
  ➢ Health care
  ➢ Mobility
  ➢ Communication
  ➢ Energy
Dissemination of the 3D-HiPMAS pilot line:

Specifications:
- Technical: precision, products size and shape, functions, materials, ...
- Economical: volume of production, time-to-market, product price, production costs, ...

End-users of 3D High Precision MID Assemblies → Consultation

- Delivery of parts
- Technological transfer

Production of the MID parts on the pilot factory site

OR

Production concept for integration on the end-user site

3D-HiPMAS Pilot Factory
HSG IMAT

Project end

1 additional Pilot Factory
PEP

Project end + 1 year

3 additional Pilot Factories
3 other locations

Project end + 3 years

Pilot Factory maintenance, Purchase of new equipments, ...

©, IPR

Pilot Factory economical sustainability:
- Incomes through series production, technological transfer, royalties, ...
- Intellectual Property Rights
**Dissemination of the results and IP:**

- **Communication:**
  Website, brochure, press releases, conferences journals

- **Pilotline:**
  Consulting, training courses, pilot production, production services...

- **Satellite Group:**
  Direct contact to interested industries

- **Workshop with contest:**
  Case studies, pilot production
THANK YOU FOR YOUR ATTENTION

A new high precision technology for new market opportunities

A European project supported through the Seventh Frame Programme under the “Factories of the Future“ initiative. The research leading to these results has received funding from the European Community’s Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 314293.