22/01/2016 – High precision manufacturing update

The High Precision Manufacturing cluster consists of eight Factory of the Future (FoF) projects: HI-MICRO, 3D-HIPMAS, HIPR, SMARTLAM, MICRO-FAST, FABIMED, HINMICO, NEXTFACTORY. These projects have been brought together through FOCUS to work collaboratively and interact with industrial partners, especially with SMEs. These project clusters are working together to develop innovative processes and equipment for the manufacture of 3D micro-parts/systems with increased precision and accuracy, ensuring small tolerances for the products, high quality standards and enhanced product reliability.

The projects in this cluster have demonstrated the potential and solutions for high-throughput, cost efficient manufacturing for European stakeholders. To date, the projects have identified the following challenges:

<table>
<thead>
<tr>
<th>Technical</th>
<th>Economic</th>
<th>Societal</th>
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<tbody>
<tr>
<td>• Manufacturing of high precision 3D multi-material components</td>
<td>• Reducing manufacturing costs</td>
<td>• Maintaining Europe’s leadership in micro fabrication and high-value products</td>
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<tr>
<td>• In-process measurement in industrial environment</td>
<td>• Harnessing the potential of mass customization</td>
<td>• Enabling easy access to smart systems and manufacturing technologies</td>
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<tr>
<td>• Integrating design and manufacturing</td>
<td>• Creating new products to strengthen innovative European SMEs</td>
<td>• Enabling novel devices that address the societal challenges of the future (e.g. healthcare)</td>
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<tr>
<td>• Establishing standardized and flexible process chains</td>
<td>• Enabling Europe’s local manufacturing</td>
<td>• Establishing technological barriers to keep highly skilled jobs in Europe</td>
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Customers and targets

The table below outlines the target markets and potential customers for each of the individual Factory of the Future (FoF) projects. The majority of solutions target manufacturing and production markets. The High Precision Manufacturing cluster has a strong focus on process chains for micro-replication in Europe.

<table>
<thead>
<tr>
<th>Project</th>
<th>Target</th>
<th>Customers</th>
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<tbody>
<tr>
<td>Hi-Micro</td>
<td>High-end consumables products, electronics, bioscience and the healthcare industry</td>
<td>OEM of electronics consumables, plant manufacturer/operators of micro-injection moulding, surgeons, bioscience and pharmaceutical companies</td>
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<tr>
<td></td>
<td>Electronics, consumer goods and personal healthcare</td>
<td>OEM of automotive components and material companies</td>
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</table>
Current state-of-the-art

Manufacturing is a very broad topic which covers a wide variety of process technologies. This cluster has identified that the miniaturisation of products and production equipment will be key issues for manufacturing in the future. Micro-manufacturing is in fact characterized by a very high quality of products, achieved by an accurate production and assembly phase.

Innovative manufacturing technologies, such as rapid micro-manufacturing will contribute to increasing productivity, lowering costs and increasing production flexibility, to guarantee the margins for small batches and customized products.

The technological limitations in this cluster are in the following areas:

- Quality inspection in micro-manufacturing chain (e.g. for micro-parts with high aspect ratio features, 3D-metrology);
- Approaches for 3D micro-parts production of wide range of materials (e.g. metallic alloys, composites, polymers, biopolymers, ceramics, smart materials) and in large volume production;
- Process chains integrating different process technologies (e.g. micro-forming, machining by µEDM, micro

1EFFRA, http://www.effra.eu/index.php?option=com_content&view=article&id=60&Itemid=68
powder injection moulding, micromilling, stereo micro lithography and printing);

- Tolerance system for micro parts and micro topography to evaluate the accuracy and/or precision which can be the base for standardization;
- Development of new microfactory and micro-manufacturing concepts and systems capable to reduce finishing operations;
- Configurable assembly lines taking up a small space to assemble and test small parts (e.g. MEMS, devices, sensors, actuators, micro reactors); and
- Modular macro/meso/micro machine tools and fast, accurate and energy efficient robots with self-adaptive and reconfigurable capabilities to implement a portable and easily configurable factory for manufacturing and assembly of high tech miniaturised devices.

For example, the Europe injection moulding manufacturing industry is led by Germany, and across EU-27 there are about 200 producers active in polymer injection moulding and 120 in powder injection moulding. In today's global economy, and ongoing redistribution of the injection moulding market around the world, there is continuing pressure on injection molders in European countries to produce lower cost parts, faster, and with higher quality to maintain a competitive edge and/or gain market share. A typical characteristics of the μIM process chain is shown in Figure 1.

![Figure 1: Status of the current micro-injection moulding process chain](image)

**Cluster advances beyond the state-of-the-art**

The projects of the high precision manufacturing cluster are working to support Europe in the important challenges of remaining competitive in the manufacturing sector and increasing the job opportunities for new generations. From a technical perspective, in fact, these projects will provide European industry with innovative technologies and "digital" manufacturing technologies for high productivity and flexibility at low cost, through micro-replication with reconfigurable and monitored high precision tools, together with advanced tool-making technology.

Sustainability is another important keyword for the cluster. European manufacturing could now find alternatives to silicon and other dangerous chemicals. Furthermore, energy savings could be found by replacing thermal treatments with faster and more efficient process, avoiding the use of binders for forming micro-components and improving recyclability.
## State-of-the-art and challenges

- Lack of quality inspection in micro-manufacturing chain,
- Lack of approaches for 3D micro-parts production of wide range of materials in large volume production,
- Shortage of process chains integrating different process technologies,
- Lack of tolerance system for micro parts and micro topography to evaluate the accuracy and/or precision,
- Insufficient development of new microfactory and micro-manufacturing concepts and systems capable to reduce finishing operations,
- Shortage of configurable assembly lines taking up a small space to assemble and test small parts, and
- Lack of modular macro/meso/micro machine tools for manufacturing and the assembly of high tech miniaturised devices.

## Cluster advances

- AMed tool inserts with conformal thermal management for µIM
- Non-destructive X-ray CT equipment for multi-material metrology
- Novel production system integrated with high-speed in-process quality control
- Enhanced toolmaking technologies for high-precision micro-forming of complex 3D parts
- Improved tool core and coating materials and different product materials to be forged
- Improved 3D measurement system for production QA and process inspection
- High precision assembling and pilot line for prototyping
- Modular and flexible and scalable system combining additive technologies and printing technologies and structuring technologies
- Robot / assembly technologies for integration of discrete parts
- Innovative and fast manufacturing process combining micro-forming and electrical-field activated sintering technology
- Directly using loose powder to manufacturing components
- Low cost and high quality micro-replication technology
- Fast and precise µ-replication-assembly processes with new tooling concepts
- All-in-one, fully automated and highly generic solution for miniaturized smart product in package production

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**Figure 2: HiPr project - Laser ablation sample: Ra<100 micron achieved on steel**

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**Delcam | tecnalia | PHILIPS  | NTNU | IK4 IDEKO | IMPROVE-P | FRAUNHOFER | IWU | KU LEUVEN | CNMPR**
<table>
<thead>
<tr>
<th>Project</th>
<th>Documentation</th>
<th>Project end date</th>
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<tbody>
<tr>
<td>Hi-Micro</td>
<td>Click here to access project-specific documentation</td>
<td>2015-09-30</td>
</tr>
<tr>
<td>3D HIPMAS</td>
<td>Click here to access project-specific documentation</td>
<td>2015-09-30</td>
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<tr>
<td>SMARTLAM</td>
<td>Click here to access project-specific documentation</td>
<td>2016-01-31</td>
</tr>
<tr>
<td>μ-FAST</td>
<td>Click here to access project-specific documentation</td>
<td>2017-02-28</td>
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Editors’ notes:

FOCUS
The FOCUS project brings together 11 partners from 7 European countries to combine their expertise and knowledge to determine the state of the art within the given clusters. The clusters within FOCUS are: zero defect manufacturing (4ZDM), clean factories, robotics, high precision manufacturing (high micro), and maintenance and support. The FOCUS partners share their experiences to identify common ground and formulate methodologies for effective cluster creation and industrial exploitation of project results. The FOCUS partners are also pro-active in disseminating tangible outcomes from their activities.

This project has received funding from the European Union Horizon 2020 Programme (H2020) under grant agreement n° 637090. For further information please visit ec.europa.eu/research/index.cfm?lg=en

Factories of the Future
Factories of the Future is a EUR 1.2 billion program in which the European Commission and industry are collaborating in research to support the development and innovation of new enabling technologies for the EU manufacturing sector. For further information please visit: ec.europa.eu/research/industrial_technologies/factories-of-the-future_en.html

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