IMPACT

MANUFACTURING A COMPETITIVE FUTURE FOR EUROPE

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Process Fingerprint for Zero-defect Net-shape MICROMANufacturing

HORIZON 2020

European Commission

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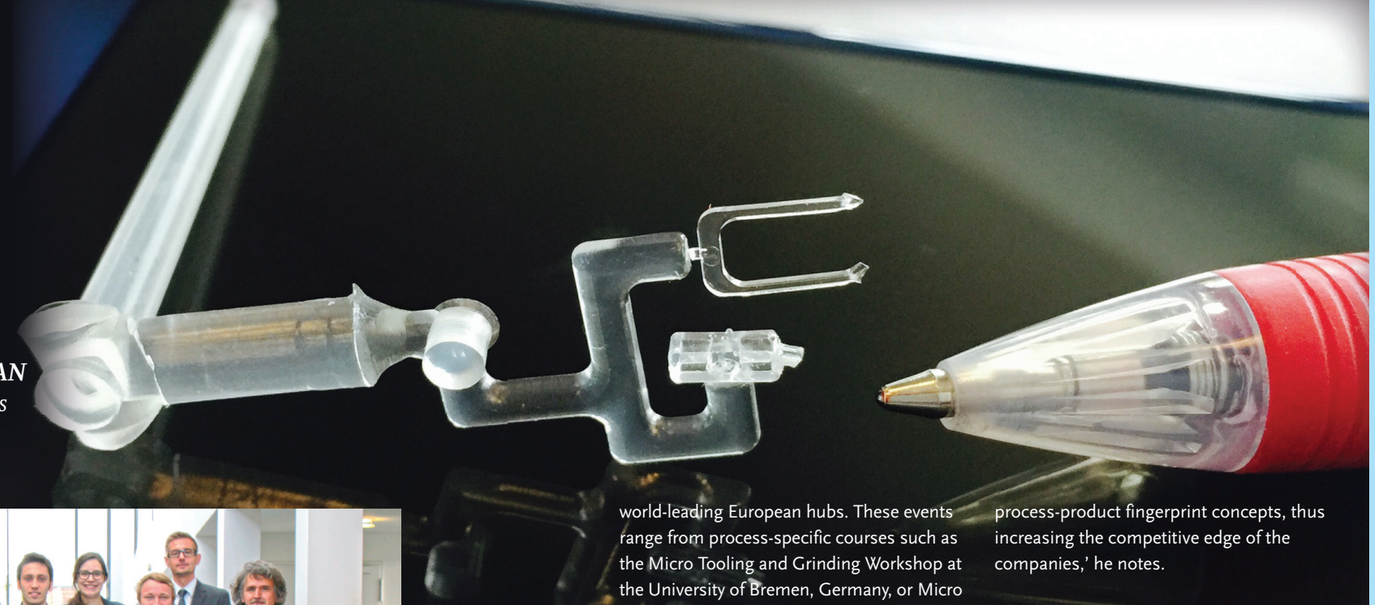
Manufacturing a competitive future for Europe

*By fostering collaboration between universities and industry, **MICROMAN** has set out to improve Europe's manufacturing sector through boosting its already considerable expertise in the production of micro-components*



When it comes to manufacturing, Europe is faced with a problem. The manufacturing sector is entrenched within the economy, culture and society of the region, and yet there has been a gradual decline in the number of manufacturing jobs for the past four decades. Europe needs to stay competitive, and to do that it needs to play to its strengths.

One such strength is the production of micro-components. Thanks to a trend towards miniaturisation in many everyday devices, this area is predicted to continue growing in value in the coming years, and European industry is well placed to take advantage of this. 'Europe is certainly a global leader when it comes to micro manufacturing,' says Professor Guido Tosello of the Technical University of Denmark (DTU). He points to an array of notable hubs across the region to illustrate his point, from the watch industry of Switzerland to Denmark's excellence in the production of hearing aid devices. Tosello explains that competitiveness cannot be fostered in Europe by lowering wages, or the price of locally made products. Rather, it is crucial that European industry invests on quality and innovation, focussing on making products of high quality, as well as developing new ones.

To achieve this, Tosello is leading a European Marie Skłodowska-Curie Innovative Training Network project called 'Process Fingerprint for Zero-defect Net-shape MICROMANufacturing' (MICROMAN). This is a pan-European project coordinated by DTU that involves seven other universities and 13 industrial partners. The goal of this initiative is to build on Europe's competitive advantage and provide an injection of expertise into its micro manufacturing industry.

The MICROMAN project team

THE ZERO-DEFECT CHALLENGE

MICROMAN is, first and foremost, a research training programme. At its heart are 13 Early-Stage Researchers (ESR) undertaking research-based training programmes in collaboration with their industrial partners. The project began in earnest back in 2015, and after an initial recruitment period the participants have already undertaken at least a year of research into their assigned area of micro manufacturing. Each researcher focused on a different 'micro' process within Europe's machine, medical and tool industries. These range for example from micro injection moulding, with its applications in non-invasive brain surgery, to micro mechanical polishing, which is useful for the machine tool and micro die industry.

Since the project conception, considerable progress has already been made by MICROMAN's ESRs. 'They have accomplished the experimental characterisation and validation of the micro manufacturing technologies that are the focus of their projects,' explains Tosello. 'By completing this in-depth analysis of the different processes, they have established a fundamental understanding of the process and formulate the process fingerprint.' The 'fingerprint' of a manufacturing product refers to the unique dimensional outcome, surface topography and form error of the component in question. The 'process manufacturing fingerprint' on the other hand, refers to the process parameters that particularly influence product variation.

By integrating both the product and process fingerprints, the researchers can develop products that are of high and consistent quality. The ultimate goal is to achieve zero-defect micro manufacturing processes across all 13 researcher-industry pairings – that is, production technologies that are capable of creating micro components that totally comply with specifications. Getting rid of defects means less waste, to maximise production quality and decrease costs, and at the same time makes the processes more environmentally friendly with less scrap and lower energy consumption.

BETTER RESEARCHERS, BETTER INDUSTRY

Along the way, the researchers involved with MICROMAN are given professional training and attend workshops across the network's world-leading European hubs. These events range from process-specific courses such as the Micro Tooling and Grinding Workshop at the University of Bremen, Germany, or Micro Metrology at the University of Nottingham, UK, to programmes that focus on a broader range of skills such as leadership, self-management and social skills in an industrial environment. The training strategy is based on the 70-20-10 principle, in which each researcher develops a core technological competence, one or two complementary competences, plus a broad competence in all of the areas addressed by the project, with the ratio of research effort between the three strands split 70-20-10. In total the participants will attend eight workshops that develop their technical and soft skills, and ultimately all of these activities will produce a cohort of researchers who are perfectly placed to make a tangible positive difference to Europe's micro manufacturing industry in the years to come.

While the main beneficiaries of the project will be the researchers themselves, who will emerge as multi-faceted experts, poised for fruitful careers in micro manufacturing; it will also provide a boost for Europe as a whole. When choosing the industrial partners, MICROMAN primarily focused on SMEs because this is where Tosello and his colleagues felt they could have the biggest impact. If an SME does well thanks to the improvements made by MICROMAN, it will be able to hire more people.

These improvements are not just abstract ideas, but realisable objectives of the initiative. Tosello notes that current process and product optimisation is a lengthy and costly process, and besides its basic aim to train European micro manufacturing specialists, MICROMAN has the wider goal of developing reliable methods for increasing productivity and quality in the sector. 'The early stage researchers will be instrumental in the industrial implementation of the process-product fingerprint concepts, thus increasing the competitive edge of the companies,' he notes.

To demonstrate the impact that has taken place, when the project comes to an end there will be a comparison between the best practices that existed at MICROMAN'S onset, and those which exist at the end thanks to the research and development undertaken by its 13 participants. The initiative is pushing the boundaries of what is even possible within the processes it is focusing on improving. For example, some of the changes the researchers are implementing in terms of miniaturisation, measurement speed and optimisation time are being done for the very first time.

INDUSTRY 4.0

With around a tenth of all enterprises in the EU's non-financial economy classified as manufacturing, it is fair to say that Europe is dependent on a strong manufacturing sector. To ensure that jobs and wealth continue to flow, it is important that industry in the region does not grow complacent. Micro manufacturing is one area which is bound to continue its steady rise as we enter the 'Industry 4.0' era, or the '4th Industrial Revolution'. Big data, virtual reality and digital manufacturing will define our progression in the coming years, and micro-components will be at the core of many of these developments.

In this changing world, Europe has the capacity to weather the storm but it will need people like the 13 MICROMAN researchers if it is to remain competitive. 'Europe has the knowledge, the skills, the infrastructure and the innovation ecosystem of industries and universities to maintain and improve its position in the manufacturing sector worldwide,' Tosello concludes. Though the project is only set to last until 2019, MICROMAN will ensure that this remains the case in the years to come.

Project Insights

FUNDING

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PROJECT PARTNERS

Alicona Imaging GmbH (Austria) • Beckmann-Institut für Technologie-Entwicklung E.V. (Germany) • DESMA TEC (Germany) • ECM Technologies (The Netherlands) • Enki S.r.l. (Italy) • IPU Innovation Factory (Denmark) • Katholieke Universiteit Leuven (Belgium) • Marposs S.p.A (Italy) • Microsystems Ltd (UK) • Ortofon Microtech (Denmark) • Pascoe Engineering Ltd (UK) • Politecnico di Milano (Italy) • Polyoptics GmbH (Germany) • Sarix SA (Switzerland) • SIOS Meßtechnik GmbH (Germany) • Strecon A/S (Denmark) • Technische Universität Chemnitz (Germany) • Technical University of Denmark (Denmark) • Ultrasion, S.L. (Spain) • University of Bradford (UK) • University of Nottingham (UK) • University of Strathclyde (UK) • University of Bremen (Germany)

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PROJECT COORDINATOR BIO

Professor Guido Tosello is Associate Professor at the Technical University of Denmark, Department of Mechanical Engineering, Section of Manufacturing Engineering. He is senior lecturer, research manager, supervisor of education projects, industrial consultant. Besides his role as Coordinator of MICROMAN, Tosello is currently the Work package Leader for Additive Manufacturing and Advanced Process Technologies of the Danish National Platform MADE (Manufacturing Academy of Denmark). MADE is the largest research initiative in Denmark in the field of manufacturing engineering, involving the five most important Danish Universities and more than 100 industrial partners.

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Impact Objectives

- Provide world excellent research training to 13 Early Stage Researchers in the field of micro manufacturing
- Deliver innovative process fingerprint framework for zero-defect net-shape micro manufacturing for the production of micro components

Small components, big impact

As the Project Coordinator of an initiative that is aiming to increase European micro manufacturing capacity, ***Professor Guido Tosello*** *from the* ***Technical University of Denmark*** *explains what micro manufacturing is, as well as its significance for the region*

Can you tell us what micro manufacturing is, and why is it so essential to the European economy?

Micro manufacturing refers to the industrial production of miniaturised components that have overall dimensions in the sub-millimetre range and tolerances in the micrometre range. Micro-components as a manufacturing industry is an area of engineering expertise where Europe currently has a leading role globally, and can develop its competitiveness further. Micro-components are always parts of larger and complex systems, and in order to access them it is necessary to take the bigger product apart making reverse engineering very difficult, hence ensuring high barriers to entry for copycats and competitors.

Is there currently a significant deficit in the necessary skills among European researchers?

The leading role in the micro manufacturing European industry is played by close to 40,000 SMEs, which employ around 2 million people and present a turnover close to 200 billion euros. However, even though European industry is among the worldwide technology leaders, the increasing market demands suggest a need for expansion of micro-fabrication process capabilities for mass manufacture of micro-components and miniaturised parts. This will be crucial if Europe is to make high quality products and significantly reduce both the time to market and production costs in order to succeed in the global market place. A necessary condition for the European productive sector to be at the global forefront of technology, ensuring job creation and sustainable growth, is to have access to innovative, entrepreneurial, highly skilled research engineers in the fields of micro manufacturing and micro product/process development. The goal of the European Marie Skłodowska-Curie Innovative Training Network project called Process Fingerprint for Zero-defect Net-shape MICROMANufacturing (MICROMAN) is to provide access to these types of engineering profiles as they are not currently readily available.

Can you give some examples of micro manufacturing technologies, and how they are applied in day-to-day life?

Highly miniaturised systems (in healthcare, mobility, communications, etc.) manufactured using a wide variety of materials and represent a global market of several tens of billions of euros with a significant annual growth. In the healthcare sector, for example, the use of hearing aid systems – which are made of 20 to 30 micro components – have increased at a rate of 8-10 per cent annually for the past 10 years. Another example is smart communication devices, which include an ever-increasing number of micro sensors and where, for example, micro Fresnel lenses are used as lighting component for super-high quality imaging, experience and will continue to have annual growth of 20-40 per cent per year.

What is your professional background, and why are you passionate about micro manufacturing?

I graduated in 2008 from the Technical University of Denmark's Department of Mechanical Engineering with a PhD thesis titled 'Precision Moulding of Polymer Micro Components (Process Optimization, Simulation, Tooling, Quality Control and Multi-Material Applications)'. The whole field of non-silicon micro manufacturing was taking shape at that time, with particular emphasis on polymer and metal production. My thesis was very successful and I was awarded the annual prize for the best PhD project across the whole university. At the same time, together with several other leading institutions in Europe (many of them are also partners in MICROMAN), we joined the FP6 Network of Excellence on Multi-Material Micro Manufacture (4M), a very successful collaborative project that created the basis for many research developments in the field of micro manufacturing. Since then I have undertaken five European projects in the field of micro manufacturing, and created a lot of momentum and interest from industrial and scientific networks. The interesting part of all this is that the research we have carried out recently on micro manufacturing technologies in the University's laboratories are now at the level required by the industrial sector. This condition has created and continues to create the perfect environment for highly successful industrial collaborations and strong public-private research project partnerships.