Newsletter

Issue 4 September 2006

Editorial

September 2006

Welcome to the fourth edition of the Masmicro newsletter, the result of a close collaboration with partners to inform SMEs, researchers, potential investors and users of the new production facility, about the progress of the project.

Launched in July 2004, Masmicro is an Integrated Project supported by the European Commission under the Framework Programme 6 (FP6).

With a total budget of €21.5 million, the four-year Masmicro project will develop an integrated production facility for the mass-manufacture of miniature and micro-products.

Dorothée Loziak

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FP6 Program

In-situ materials testing techniques

A better understanding of deformation mechanisms

Today, in the age of miniaturisation, scaling effects gain more and more in importance. Material properties of small parts, e.g. for mechanical watches or micro-electro-mechanical systems (MEMS), undergo significant changes as some characteristic length scales approach a critical value; they cannot be extrapolated from the larger components. Testing techniques of small volumes with different state of stresses both in the micro- and in the nanometre range are required. One possibility for mechanical testing of small specimens is to scale down conventional testing techniques; another one is to develop new techniques, e.g. nanoindentation or micro-compression testing. Using these testing techniques in-situ for direct observations in microscopes yields a better understanding of deformation mechanisms in the material.

Compact devices for in-situ material testing that can be customized for industrial applications go beyond standard tests and allow the combination of instruments that have complementary results, e.g. compression test and scanning electron microscopy (SEM), tensile test and transmission electron microscopy (TEM), or nanoindentation and Raman micro spectroscopy.

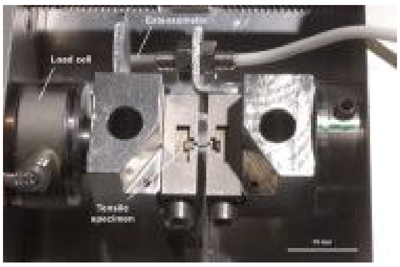


Figure: Detail of the tensile tester with gripping device adapter and tensile specimen.

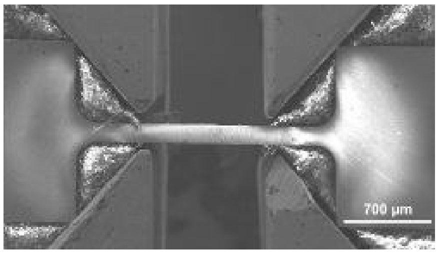


Figure: SEM micrograph of tensile specimen.

Micro-tensile testing

Tensile testing is the most important mechanical testing method; it is a more direct and convenient method without the need of assumptions in the analysis of the measurement data compared with other techniques. Within MASMICRO, in-situ SEM micro-tensile tests have been developed at Empa. The most important advantage is, apart from the measurement of the complete load-displacement curve of micro-sized specimens, the quasi real-time observation at the same time. In-situ testing yields additional information, which is not available from ex-situ investigations.

The high resolution and depth of field of the quasi real-time SEM observation is suitable for the investigation of deformation and fracture mechanisms during the test.

Micro-compression testing

At Empa, a novel micro-compression test method that allows for the efficient testing of a large number of specimens and the statistical assessment of materials properties has been developed. The method consists of performing instrumented compression tests on micro-pillars inside the SEM.

The method consists of performing instrumented compression tests on micro-pillars inside the SEM. Performing these tests in-situ facilitates positioning greatly and allows the direct observation of the deformation of the pillars during the experiment. This gives access to information concerning the deformation and failure mode such as buckling and/or cracking.

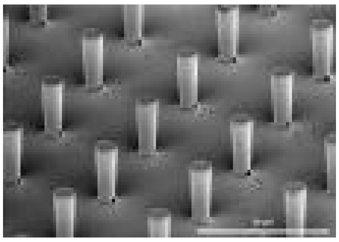
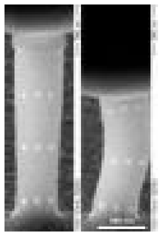


Figure: Overview of an array of micro-machined silicon pillars with a diameter of roughly 7 μm and a pillar to pillar distance of around 40 μm.

To assess the potential of the method compression tests on micromachined pillars with diameters ranging down to 800 nm were performed. Using the SEM video, strain measurement is possible and the fracture behaviour can be investigated.

Figure: Frames extracted from the SEM video sequence recorded during the compression testing of silicon pillars showing the first (left) and the last frame (right) just before failure of specimen.



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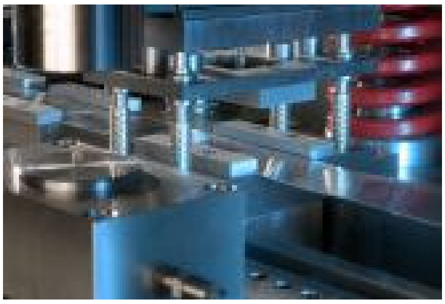
Metal forming

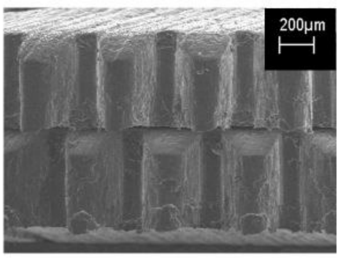
New tool technology by direct heating with laser radiation

Modern metal forming technologies enable the mass production of the smallest parts for micro-technical applications. A common method to enhance the geometrical complexity of micro parts is the preheating of the workpiece.



Picture 1 Tool module

Conventional preheating processes are time consuming, decrease the productivity and heat the complete workpiece. By a direct heating with laser radiation the temperature of local regions of the workpiece can be increased quickly and the achievable process limits can be extended. Transparent tool parts made of sapphire permit the guidance of the laser radiation directly onto the workpiece within the closed tool during the process.



Picture 3 Gearwheel (d=5mm, AZ31); Upper picture: With laser assistance; lower picture: Cold formed

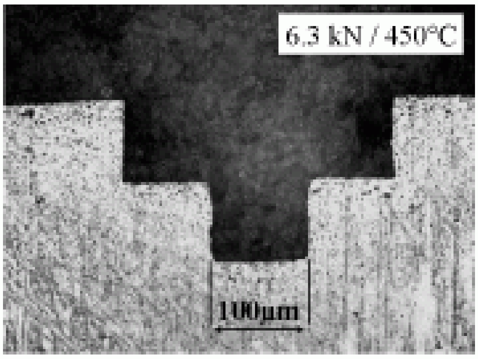
During the last two years of the Masmicro project the tool technology for this approach were designed and manufactured. All devices, the laser and the press are controlled by a Labview based software. The software controls the laser depending on the position of the punch to the tool and the required temperature and turns it out after exceeding a defined distance or time. Load-displacement diagrams can be generated by integrated sensors.

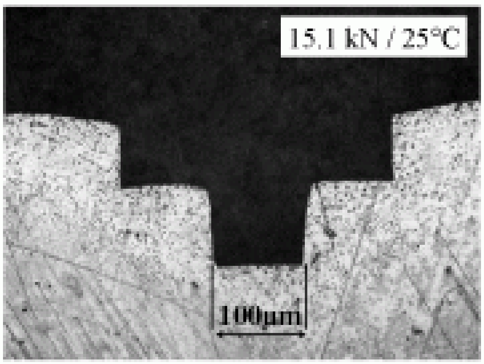
To gain a constant temperature of the sheet metal and to ease the operation of the system a temperature control is used. The controller compares the signal of a pyrometer with the demanded temperature and determines an according value for the laser system.

Picture 2 shows the results of laser assisted embossing in AZ31. The punch has a total height of 200µm and a total width of 300µm divided into a step-like structure with an edge length of 100µm.

The structure is embossed into the material with different expenditures of force and therefore different penetration depths. Although the hole structure is reproduced in the material there is a clear visible roll over in the outer region of the structure. The heating of the material prior to the forming process offers two advantages. Beside a saving in power of more than 50% at a temperature of around 450°C the roll over nearly disappeared.

Other results were achieve in stamping of a gear-wheel made of AZ31 (f5mm). The material has a light weight and a higher specific stiffness than Aluminium, but is limited in its formability which leads to break-outs (lower part of the picture) which can be avoided at elevated temperatures (upper part).





Pictures 2a/2b Comparison of a cold and warm embossed structure in AZ31

Handling for micro machining applications

Update on research and new developments

A review on existing systems for handling micro-parts was carried out recently by the author [Sanchez05]. The work was focused on the analysis of the main problems which limit the emergence of automated micro-handling-systems. A key problem area limiting the emergence of automated micro-handling technology is lack of flexible and high-precision micro-handling machinery. Another problem is the lack of standardization due to which equipment makers spend an excessive amount of time and resources on custom automation solutions.

The main objective in this article is to show the design of different handling and transport devices for mass-manufacturing applications. Two important issues have been described:

- The design of handling devices for a standard carrier.
- The design of a flexible vibratory micro-part feeder.

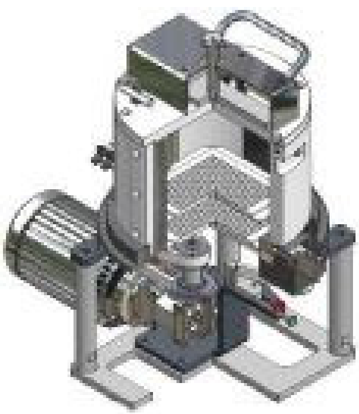


Figure 1. - Cassette device.

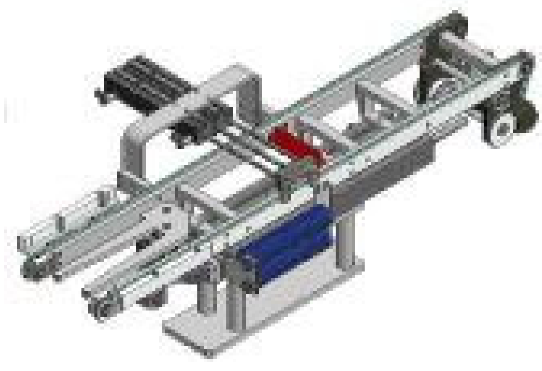


Figure 2. - Transport system for the standard carriers.

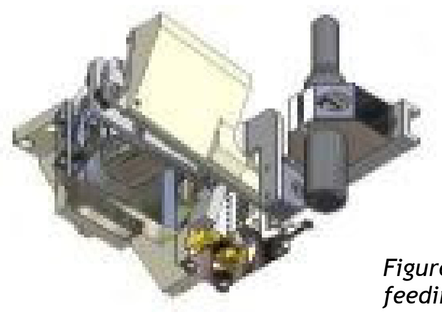


Figure 3. – Vibratory micro-parts feeding device.

The global system will be used to arrange the micro-parts into the cells of the standard carrier. This intermediate handling process will simplify the next manipulation tasks performed in the inspection or in the assembly stations.

An empty carrier will be transported from a cassette (see figure 1) by different conveyors (see figure 2) and will be fixed to a X&Y table. This table will move the carrier under the micro-part feeder subsystem, so that the empty cells in the carrier are exactly down the feeder machine permitting the pieces to fall into the cells.

Vibratory micro-part feeders are used in inspection or assembly machines [Mitani05]. In the micro-world context the adhesion forces have a larger effect on the motion of small micro-parts than the inertial force. Therefore in micro-parts feeding, the driving force applied on each part must overcome the adhesion force.

Some traditional feeders employ horizontal and vertical vibration of the feeder surface [Frei02]. We have designed a micro-part feeding system (see figure 3) to control the micro-parts flow on a specific slope with the vibration amplitude and frequency.

[Sanchez05] A.J. Sanchez-Salmeron, R. Lopez-Tarazon, R. Guzman-Diana and C. Ricolfe-Viala, “Recent development in micro-handling systems for micro-manufacturing”, Journal of Materials Processing Technology, (167) pp 499-507, 2005.

[Mitani05] A. Mitani, N. Sugano and S. Hirai, “Micro-parts feeding by a saw-tooth surface”, Proceedings of the 2005 IEEE International Conference on Robotics and Automation, Barcelona, Spain 2005.

[Feri02] P.U. Frei, “An intelligent vibratory conveyor for the individual object transportation in two dimensions”, Proceedings of the 2002 IEEE/RSJ International Conference on Intelligent Robots and Systems, pp. 1832-1837, 2002.

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