Application Information

Electrochemical Milling (ECF)

Micro-Structuring of Steel

Electrochemical micromachining with ultrashort voltage pulses (ECF) is an innovative technique for milling of hard materials at micrometer feature size, especially steels. 3D-forming of the workpiece is achieved by moving the tool similar to conventional milling machines. Nevertheless ECF is an electrochemical process, i. e. tool and workpiece are submerged in an electrolyte and the surface is electrochemically etched by a galvanic current (s. fig.1 a). Therefore no mechanical forces are applied. Due to the use of ultrashort voltage pulses in the range between 10 ns and 200 ns the electrochemical process is confined to a small area around the tool. The corresponding gap between tool and workpiece, the working distance, can be controlled by the pulse on time below 10 µm

Micro system technology is a steadily growing market. Miniaturised sensors and actuators are demanded in all fields from automotive and medical to customer industry. The ECF process is one of the most promising techniques for the production of microparts or mould inserts for injection moulding of such parts.

To make the ECF technique available for industry HSG-IMAT developed a fully CNC-driven ECF machine. CAM files — like these for conventionally milling machines — can be processed. Although the ECF technique is still in the beginning and new developments are implemented it is already used in industrial applications.

Due to the fact that no forces act on tool or workpiece, arbitrary shaped tools can be used and bars can be processed with a width below 5 µm. The SEM image in fig. 1 b) shows a 100 µm high wedge with a tip radius of roughly 3.5 µm ECF-processed into stainless steel 1.4301.

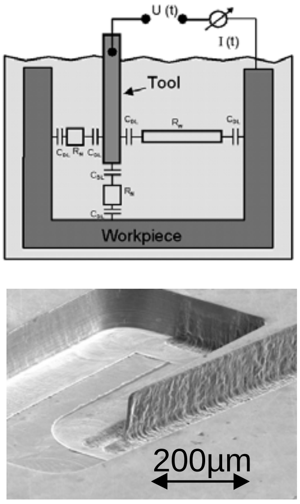
Figure 2 shows an example of a micro mould insert for a microfluidic device for blood plasma separation. It was designed at IMTEK (Freiburg) and produced at HSG-IMAT. The reservoir is connected to the bent bar (i. e. channel in the demoulded part) by two 20 µm wide bars. While large areas of this insert can be made by conventional milling the separation of the two 20 µm bars was made by ECF to prevent the bars from bending. Furthermore the radii between the two bars and the main bar were reduced from 150 µm to 25 µm by the ECF process. Only these small dimension guarantee the performance of the device.

Characteristics

- Electrochemical milling process
- Tool diameter 50 µm down to 2 µm
- 3D free form surfaces
- Processing of hard materials like steel
- No forces on tool or workpiece
- No tool wear

Applications

- Micro mold inserts for medical sensors
- Micro mold inserts for microfluidic applications
- Nozzles with diameters below 20 µm
- Specially formed micro parts



a) b)

Fig. 1: a) Sketch of the setup, b) 100 µm high wedge

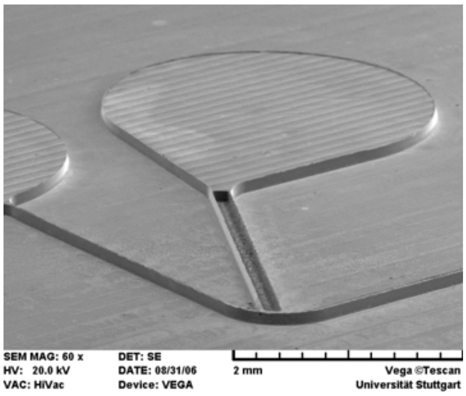


Fig. 2: Mould insert for a medical device with two 20 µm bars (together with IMTEK)

Technical Data of the ECF Process

material removing rate	approx. 1000 $\mu m^3/s$
Minimal drill diameter	10 µm
Maximal depth	500 µm
Aspect ratio	20
Accuracy	1 µm
Maximal size of the workpiece	50 x 50 x 10 mm^3

Since the process is still under development, the given data may change.

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P02V080529