Process chains for the production of micro-structured functional surfaces in plastics and metals

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Abstract

The functionalization of technical surfaces by microstructuring opens a variety of interesting possibilities, i.e. the generation of stain-resistant surfaces, the specific modification of the tribology of sheet metal or biomechanical optimized implant surfaces. While research in the physical and technological fundamentals of the effects has progressed already far, the realization of suitable production technologies and equipment for the commercial fabrication requires new innovative solutions. Not only plastics but increasingly also high-strength materials such as steel or titanium have to be microstructured economical and process sure. Therefore, process chains for the replication of functional structures especially by embossing or rolling techniques including the necessary equipment technology and tool manufacturing are developed at the Fraunhofer IWU. The functionalization of prototype surfaces by chipping complete the field of activity.

1 Surface topographies with hydrophobic characteristics

For the fabrication of surface topographies with hydrophobic characteristics in high-strength materials, a ceramic tool was microstructured by laser and subsequently hot-embossed inside a process chamber, integrated in a precision press equipment, developed at the Fraunhofer IWU. With this system a precise, isothermal tempering can be ensured at forming temperatures up to 1000 °C in an inert atmosphere. Hydrophobic surface topographies were successfully embossed both into aluminium and pure titanium for the prosthetics. The realized microstructure (figure 1) consists of protruding pins (11 µm diameter, 15 µm height), which are arranged in a raster distance of 23 µm on the entire embossing area.

Applications of microstructured plastic sheets with a hydrophobic surface are seen especially with coated textiles, tarps, conveyors, foils for the furniture sector, for medical equipment and the food industry. The focus of this further research project lies on technology

development for the fabrication of the microstructured forming tools (figure 2). To determine the influence of structure geometry, -size and surface finish on the functionality, tools were fabricated by laser, micro drilling and fly cutting, subsequently formed galvanically and tested. For the production of economical yard goods, microstructuring of an embossing roller with structure sizes under 25 µm is investigated (figure 3).

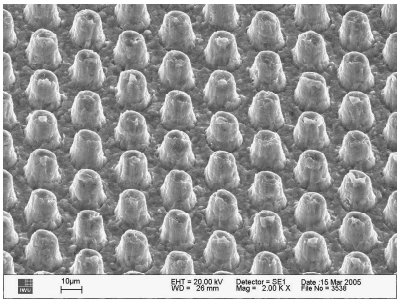

Figure 1: Micro embossed surface

Figure 2: Embossing mould

2 Protheses with microstructured surfaces

The modern implantology sets highest requirements on production engineering. Prostheses evince often complex geometries, which have to be realized economically in high precision and surface quality into difficult-to-machine materials. The miniaturization of implant components represents a special challenge. At the Fraunhofer IWU the still recent research field medical technology and biotechnology becomes more and more important. Thus, a new prosthesis concept for the tympanic surgery was developed within a joint project, supported by the Federal Ministry of Education and Research (BMBF), together with the University Hospital “Carl Gustav Carus” Dresden, the Institute of Material Science of the TU Dresden and the NRU precision technology GmbH Neukirchen.

A substantial component of the developed prosthesis is a so-called prosthesis shoe. It consists of titanium and is manufactured by micro milling [1]. Its volume amounts to approx. 1/30 of a pinhead (figure 4). The special requirements in terms of the machining result from the high miniaturization degree, the difficult-to-machine material titanium and the complex and highly precise geometry, which require 5-axis micro milling [2]. The production of the implants needed for the animal experimental investigations were realized on plates, each with 40 pieces. An additional surface finish was done on the basis of plasma technical processes.

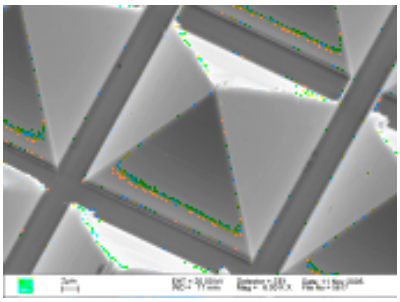

Figure 3: Pyramidal structured tool 25 x 25 µm

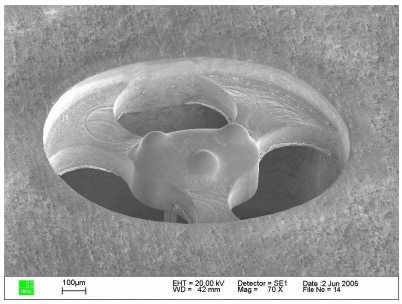

Figure 4: Prototype of an implant for the ear surgery

At present, research work is prepared to manufacture the prosthesis with micro forming processes. Apart from the prosthesis geometry a biomechanically suitable surface microstructure is to be generated for the improvement of cell adhesion. Both regarding the manufacturing of heavily loaded moulding forms and regarding the equipment necessary for the high-temperature micro-forming there still exists a large demand for research and development. Thus for example the realization of a suitable tempering system keeping the moulds at a consistent precise temperature poses a big challenge. The Fraunhofer IWU can thereby built on experiences in the development of tempering systems for the wafer processing for micro structuring of inorganic glasses [3] as well as for high-temperature micro-forming of high-strength metallic materials. Within these research projects laminar effective tool heaters lying in the press axle were realized, which make forming temperatures up to 1100 °C possible. Also for the manufacturing of micro structured tools from high-strength active component materials, like nickel alloys (NIMONIC) and molybdenum alloys (TZM) could be fallen back to the experiences won in preceding projects.

3 Conclusion

The functionalisation of technical surfaces will become an increasingly applied and commercially successful method, if one can manage to establish process sure and cost effective technologies for near surface micro structuring. Replication technologies are especially promising to reach this goal.

For their utilization manufacturing of highly stressable micro structured moulds and production equipment for moulding and forming have to be developed and integrated into

existing process chains. To manufacture micro structured tools not only further development in chipping (micro milling, micro grinding) has to be done, but also ablation techniques (Laser, ECM, EDM) will continue to gain significance. The emphasis in development of manufacturing equipment for moulding and forming will be mainly in system tuning for the reduction of cycle times and in the realization of roll embossing technologies to micro structure large surfaces.

References:

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