Embossing of concave micro-structures in metals as moulds for the replication of micro-lens arrays

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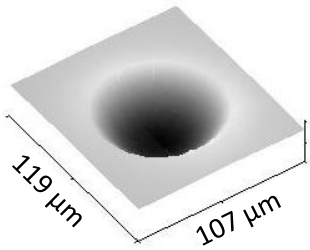
Abstract

Micro-lens arrays (MLA) in comparison to single aperture optics have the benefit of combining a large field of view with a small optical component volume. Therefore, they are common in light field cameras, sensors, laser-beam homogenizers and other photonic devices. The production of MLAs can be distinguished in direct or indirect methods. The indirect production route combines mould production and replication to manufacture MLAs. Mould production is commonly carried out through photolithography or ultraprecision machining. Photolithographic processes are more time efficient but have a reduced freedom of form. Ultraprecision machining processes allow an enhanced freedom of form but requires considerable effort in terms of production time and machine requirements. A barely described alternative process in order to manufacture moulds cost-efficient is micro-embossing. In micro-embossing structures are produced through forming. This process uses cheaper corundum tools and needs less machine requirements than ultraprecision machining processes.

This presented research work focuses on the micro-embossing process to form concave structures in Aluminium RSA-501, NiP layers and Au layers as moulds for the replication of MLAs. Concave structures were embossed using plunger coil actuators and tools made of corundum and NiP. The effect of the embossing force F and the tool radius R_r on the diameter d_e, depth h_e, pile-up height w and pile-up width c of the concave structures were investigated. The difference in tool radius R_r and structure radius R_s due to the elastic spring-back was investigated. The structures remain spherical, which allows to overcome the challenge of elastic spring-back by using a model. Using these models an adjusted tool radius R_r can be calculated for each material to emboss a certain structure radius R_s. In this way concave structures with specific radius can be produced as moulds for the replication of MLAs.



Process	Micro-embossing
Tool	Corundum sphere
Tool radius	0.15 mm
Embossig force	5 N
Workpiece	RSA-501
Preparation	flycut
Orientation	cross section

Figure 1: WLI measurement of a micro-embossment