Hot Embossing of micro- and nanoscale devices

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Abstract

The LiMiNT facility at SSLS is employing different lithography techniques for micro- and nanofabrication. Synchrotron radiation based X-ray lithography for high aspect-ratio micro- and nanostructures make the processing capabilities unique in South-East Asia. Electron beam lithography and direct laser writing which primarily serve the making of X-ray masks are also applied for direct fabrication. While all of the above lithography processes imply relatively long processing times and yield issues, quick and inexpensive micro- and nanofabrication become possible when lithographically obtained resist structures are transferred into a metal mould by electroplating which then allows replication into polymers by hot embossing. Moulds produced at SSLS range from nanoimprint moulds with feature sizes of a few hundred nm to LIGA moulds with structure heights of a few hundred μm.

Fabrication of micro- and nanomoulds

The LiMiNT facility (Lithography for Micro- and NanoTechnology) is utilizing the intense and parallel X-rays from SSLS' synchrotron radiation source for micro- and nanofabrication with the LIGA process [1][2]. Deep X-ray lithography, i.e. patterning of a resist layer of up to mm-thickness, is commonly understood as integral part of the LIGA process, the outstanding features of which are achievable aspect ratios of more than 100 with highly vertical sidewalls of low surface roughness. In the following steps of the LIGA process cycle, the voids of the resist structure are filled by electroplating. Further electroplating beyond the resist height is joining the individual microstructures with a solid backplate. Upon removal of the initial substrate and the resist from the electroplated microstructures a mould is obtained which is eventually used for replication of the original resist structure by hot embossing as one technical option of a moulding process. Mastering the full LIGA process cycle is seen as key to meaningful micro- and nanofabrication, since hot embossing facilitates the output of microstructures in numbers and at costs relevant to many applications.

Due to the lack of an X-ray lithography industry, commercial mask shops do not carry X-ray masks in their product lines. The LiMiNT facility is therefore equipped with pattern generation tools for in-house mask making. X-ray mask patterns for the conventional LIGA process are generated by a direct write laser system. In addition, SSLS is attempting to extend the available feature sizes of the LIGA process to the nanoscale while maintaining the prominent characteristic high aspect ratio [3]. Mask patterns for nano X-ray lithography are written by electron beam lithography in an SEM conversion set-up. The use of both, the direct write laser system and the electron beam lithography tool, are not restricted to mask making but are also employed in alternative techniques for mould fabrication.

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