Optimization of the fabrication process of ultra thick, high aspect ration SU-8 structures using X-ray Lithography

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Abstract

SU-8 is an epoxy based, chemically amplified, negative resist suitable for UV- and X-Ray lithography [1-5]. SU-8 based deep x-ray lithography has been developed in CAMD and BESSY for fabrication of high aspect ratio and complex multi-level 3D microstructures [6-9]. In contrary to patterning of thinner SU-8 layers (several hundreds of micrometers thick), fabrication of high aspect ratio structures, especially containing narrow trenches, in thick layers (> 1 mm) still represents a technological challenge.

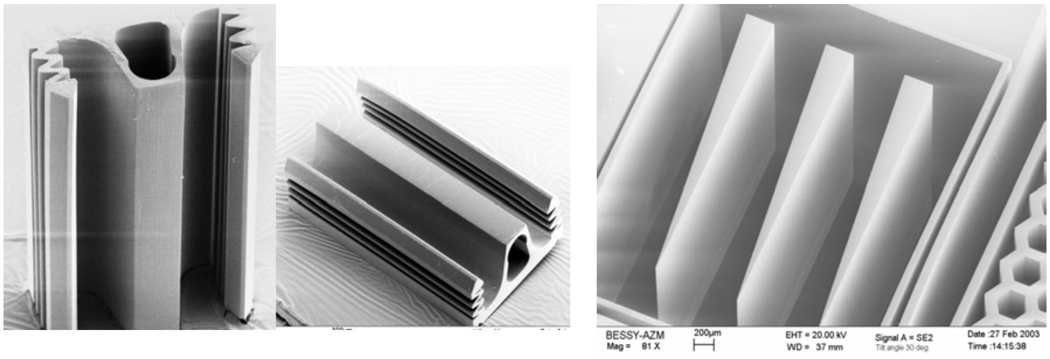
Due to a complex fabrication process there are a large number of influence parameters. Starting from the chemical composition of the resist over the preparation of the resist layer, the X-Ray exposure to the post-exposure treatment and development, all these steps include factors possibly influencing the final quality of the patterned structure.

An ongoing research is being performed in BESSY in order to improve the X-Ray fabrication process of SU-8 resist, especially for the ultra thick, high aspect ratio structures. Using a standard purchased SU-8 resist, pre- and post-exposure treatment and exposure parameters are being varied in order to determine the significantly contributing parameters and their influence on the performance of the resist.

These variations include different methods of thick resist layer preparation resulting in different solvent concentration distribution, different exposure modes and different post-bake conditions. Extreme-case studies were performed in order to determine the influence of these parameters.

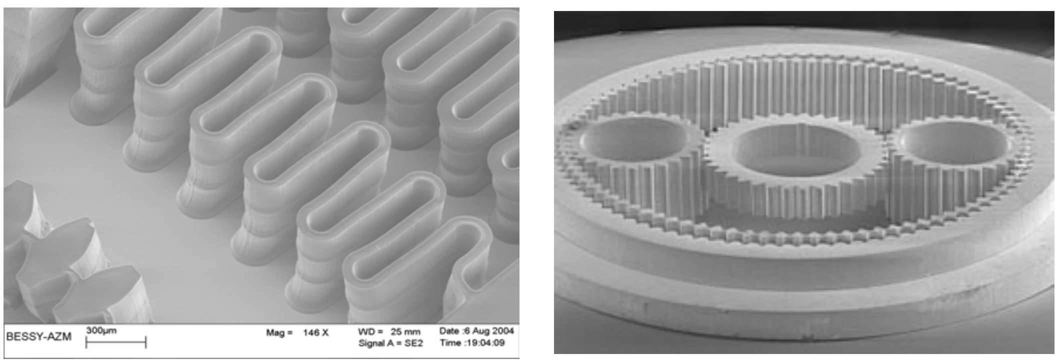
Results of these studies will be presented in the paper, together with examples of the ultra thick, ultra High Aspect Ratio micro structures with thickness of up to 4000 μm and aspect ration of up to 360.

Another important task in the optimization of the SU-8 process is the determination of the contrast curve regarding X-rays. Therefore, in Cooperation with Jenoptik Mikrotechnik Jena, a device is planned and will be realized, which allows the integration into a Jenoptik X-ray scanner DEX 02. All the measurements can be done shortly and the determination of the contrast curve is much faster than in the conventional way. The experimentally determined contrast curve and the resulting requirements for X-ray exposures with SU-8 will be shown in this paper. Furthermore, some results of the carried out experiments will be presented as well.



(a) 4 mm high SU-8 microstructures
(b) 3.6 mm high SU-8 microstructures with AR 360

Figure 1: Ultra thick (4 mm) SU-8 microstructures (a) Ultra thick (3.6 mm) SU-8 microstructures with 10 µm smallest feature size (Aspect Ratio: 360)



(a) Extreme-case study – solvent concentration
(b)

FIGURE 2: Extreme case study to determine the influence of solvent concentration (a) Micro Harmonic Drive® gear box, each gear wheel made of electro-formed alloy into SU-8 mold inserts (height 1000 µm, total diameter of gear box 10 mm)

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