Addressing the mechanical deformation of flexible stamps for nanoimprint lithography on double-curved surfaces

Sonne, Mads Rostgaard; Hattel, Jesper Henri; Kristensen, Anders

Publication date:
2012

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
Addressing the mechanical deformation of flexible stamps for nanoimprint lithography on double-curved surfaces

M. R. Sonne¹*, J. H. Hattel¹ and A. Kristensen²

Resolution limits due to distortion, and complications regarding deformations of the flexible stamps, has been addressed as a major concern by several authors dealing with nanoimprint on not planar surfaces. Here, a mechanical engineering approach for tracking mechanical deformations of flexible stamps for nanoimprint lithography on double-curved surfaces is presented. The basic idea is that by tracking the deformation of a square grid pattern on the stamp, it is possible to calculate the principal strains.

Maximum principal strains plotted on top of the deformed flexible stamp

Herold’s method [1] is for this task very suitable, where the stretch ratio for a square is given by

\[ \frac{\lambda_1}{\lambda_2} = \frac{\lambda_1^2 + \lambda_2^2}{2} \pm \sqrt{\left(\frac{\lambda_1^2 + \lambda_2^2}{2}\right)^2 + \lambda_1^2 \lambda_2^2 \sin^2 \gamma_{xy}} \]

, and the principal strain then can be found by

\[ \varepsilon_a = \ln(\lambda_a) \]

Deformation of a square into a parallelogram in a homogeneous strain field

Deformed PTFE flexible stamp

To make high resolution nanoimprints on curved surfaces, the mechanical deformation of the flexible stamp must be taken into account – you cannot wrap an orange without folding or stretching the wrap material.

An experiment was performed, which shows the capabilities of the developed algorithm for determining principal strains in the mechanically deformed flexible stamp. A stamp was made of 190 µm thick PTFE folio. From a silicon master stamp, the square grid pattern was transferred to the PTFE sheet by embossing. The pattern consisted in this case of 2 µm wide grid stripes with a center to center separation of 40 µm distance. The flexible stamp was deformed in a biaxial (double-curved) stretching by a steel sphere with a radius of 4.5 mm mounted in an uniaxial tensile test machine. After deformation, the surface of the flexible stamp was characterized using a Sensofar Pli neox 3D Optical Profiler. For the confocal measurements an EPI 50X/NA 0.80 objective was used. Data files of the topology were then put into the developed deformation code in MATLAB, and it was then possible to plot the principal strains on the deformed flexible stamp.

Fabrication of the master silicon stamp and the flexible stamp was performed by NIL Technology ApS, a partner in the NANOPLAST project. This work is financially supported by The Danish National Advanced Technology Foundation, which is highly acknowledged.

¹Department of Mechanical Engineering, Section of Manufacturing Engineering, ²DTU Nanotech, Department of Micro- and Nanotechnology, Productionstien 420, DK-2800, Email: mrso@mek.dtu.dk