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

Citation (APA):
Sonne, M. R., Hattel, J. H., & Kristensen, A. (2012). Addressing the mechanical deformation of flexible stamps for nanoimprint lithography on double-curved surfaces. Abstract from NNT 2012, Napa, CA, United States.

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

M. R. Sonne[1*], J. H. Hattel[1] and A. Kristensen[2]

[1]*Technical University of Denmark, Department of Mechanical Engineering, Section of Manufacturing Engineering*
[2]*Technical University of Denmark, DTU Nanotech, Department of Micro- and Nanotechnology*

[*]*Produktionstorvet, Building 425, DK-2800 Kgs. Lyngby*
E-mail address:mrso@mek.dtu.dk

A mechanical engineering approach for tracking the mechanical deformations of the flexible stamps, when nanoimprint lithography is used on a double-curved surface is presented. The resolution limit due to distortion of the flexible stamp when the pressure is applied, and complications regarding deformations of the flexible stamp, has been addressed as a major concern by several authors dealing with flexible stamps on not planar surfaces[1,2,3]. In order to make high resolution imprints on curved surfaces, this mechanical deformation must be taken into account –you cannot wrap an orange without folding or stretching the wrap material. The principles behind this way of addressing the mechanical deformations come directly from forming of metal plates, where deformation analysis has been used for decades. However, the length scale and material behavior are in this case much different. A stamp with a predefined square pattern is deformed into the desired double-curved geometry, and by numerical deformation analysis, results in terms of principal strains gives information about the mechanical stretch of the deformed flexible stamp. In order to verify the numerical calculations of principal strains, the numerical algorithm was compared with an analytical solution for a simple uniaxial stretch, consisting of a flat plate deformed into a half cylinder shape. A comparison between the analytical and numerical results is shown in Fig. 1. After preliminary validations, an experiment was performed, where a flexible stamp made of 190 µm thick Teflon folio (PTFE, polytetraflouroethylene) was embossed with a 40x40 µm square grid and deformed into a hemisphere. The surface of the deformed stamp was then measured using a 3D Optical Profiler. The data files from the 3D measurements were put into the developed deformation analysis code in MATLAB. In FIGs. 2a and 2b, the maximum and minimum principal strains for the top of the deformed flexible stamp are shown. The presented approach on determining the mechanical deformation is of great importance in the future development of nanolithography, as high accuracy on double-curved surfaces now is possible to obtain.

---

[1] Y-P Chen et al., J. Vac. Sci. Technol. B, 2008, p. 1690

[2] Ji et al., Microelectronic Engineering, 2010, p.963

[3] M. Bender, U. Plachetka, R. Ji, A. Fuchs, B. Vratzov, H. Kurz, T. Glisner, F. Lindner, J. Vac. Sci. Tech. B 22(6) (2004) 3229–3232

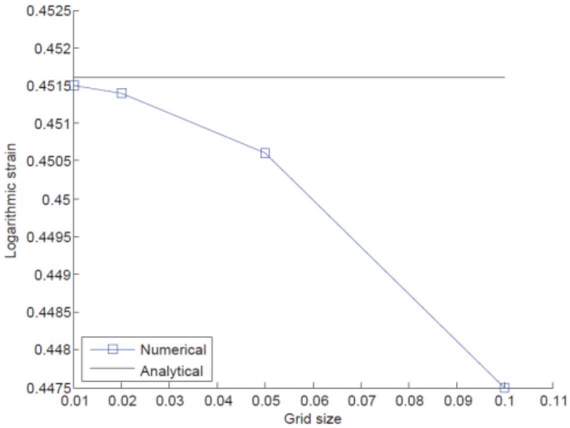
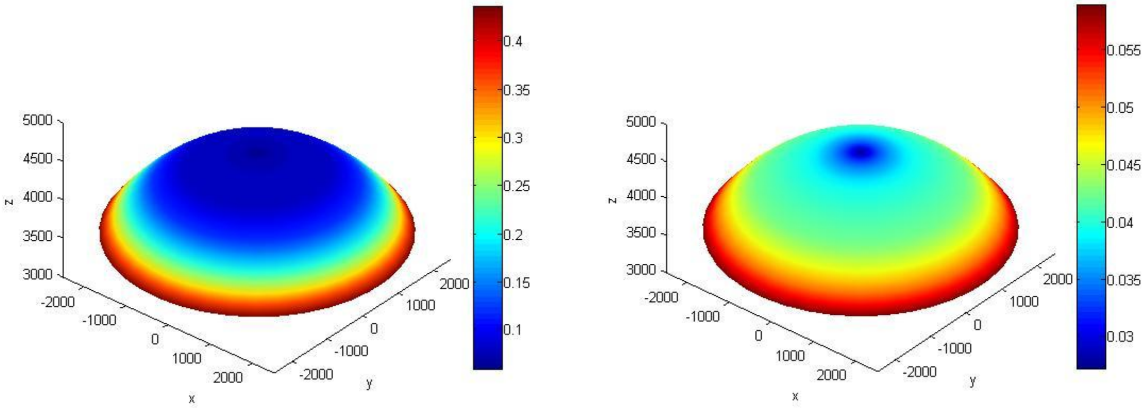


FIG. 1: Accuracy of the numerically calculated maximum principal strain with grid size of 0.01, 0.02, 0.05 and 0.1. The grid size has a second order effect on the accuracy of the calculated strains, and this has to be taken into account when the size of the square pattern on the stamp is decided



a) b)

FIG. 2: a) maximum principal strains, b) minimum principal strains measured on top of the deformed flexible stamp. The most critical principal strains in the experiment were found down at the edge of the deformed stamp, with the values of ε_1 = 0.42 and ε_2 = 0.06. One square in the grid close to the edge will after the mechanical deformation have the center to center dimensions of 42.47x60.88 µm. This is a huge difference in size compared to the initial planar geometry (40x40 µm), and if this is not taken into account, the nanostructured features will have other effects than what was the intention.