UV-NIL with a DUV-Fabricated Silicon Template as a Flexible Tool for Nanopatterning

Stijn Scheerlinck, Dries Van Thourhout, Roel Baets

IMEC - Ghent University, Department of Information Technology,
Sint-Pietersnieuwstraat 41, 9000 Gent, Belgium
phone: ++3292643447 e-mail: stijn.scheerlinck@intec.ugent.be

Key words: UV-NIL, stamp fabrication, nano-imprint methods, DUV lithography, gold nanopatterning

UV-based nano-imprint lithography (UV-NIL) is a very promising technique for rapid and large-scale patterning at very high resolution and at low cost [1]. UV-NIL is performed under low pressures (< 1 bar) and does not need thermal cycles. Moreover, the use of a transparent stamp offers the advantage of precision alignment. Therefore, UV-NIL offers a cheap and flexible technology for sub-micron patterning and is of high interest not only for very demanding applications such as micro-electronics and photonics but also for a variety of research and industrial applications such as in chemistry and biotechnology.

Getting access to nanostructured stamps is not straight-forward and rather expensive. E-beam lithography is needed to attain the high-resolution and often also silica etching is required. However, the technology for silica etching is not as mature as for silicon etching and therefore, resources for very high-resolution silica etching are rather limited. Moreover, the long writing times typical for e-beam lithography are a limiting factor for fabricating very large areas of nanopatterns in the laboratory.

We demonstrate that nanostructured silicon chips made by standard mass-production technologies, in particular deep-UV lithography, used for the fabrication of very large scale integrated (VLSI) electronic circuits CMOS fabrication, can as well be used as templates for fabricating transparent stamps suitable for UV-NIL. The fabrication scheme itself - also based on UV-NIL - is easy-to-implement, does not require accurate control of the applied pressure and should be expandable to a wafer-scale process. The fabrication scheme is schematically shown in Fig. 1. First the silicon chip is treated to prevent adhesion. Then a drop of a commercially available nano-imprint resist (PAK-01, *Toyo Gosei Co.*) is squeezed between the silicon chip and a glass substrate, so that the polymer gets imprinted. After UV-curing through the glass substrate and removal of the silicon chip, the transparent two-layer UV-NIL stamp is ready. Fig. 2 shows the result.

We demonstrate the use of such a stamp for gold nanopatterning on top of silicon. Gold is a very interesting chemically inert material for immobilization of biomolecules and the investigation of gold nanopatterns for applications in chemistry and biotechnology is an important challenge. A resist drop of very low viscosity based on a mixture of benzylmethacrylate and poly-dimethyl-siloxane is squeezed between the silicon substrate and the UV-NIL stamp. Next, the resist is cured by UV illumination through the stamp and the stamp is removed. A short oxygen plasma etch removes the residual layer. After evaporating gold the patterns are defined by lift-off. Fig. 3 shows images of the various fabricated gold micro- and nanopatterns. They are all fabricated in the same single step.

These results illustrate that very high-resolution patterns over very large areas can be obtained starting from a nanostructured silicon template fabricated by standard technologies. The described UV-NIL processes are easy-to-implement in a laboratory environment and allow for a flexible choice of materials offering a cheap nano-imprint method to be used for a variety of applications including fabrication of nanopatterned substrates which can be used for immobilization of biomolecules.

[1] M. Bender, M. Otto, B. Hadam et al., "Multiple imprinting in UV-based nanoimprint lithography: related material issues", *Microelectronic Engineering*, vol. 61-62, pp. 407-413, 2002.

UV-NIL with a DUV-Fabricated Silicon Template as a Flexible Tool for Nanopatterning

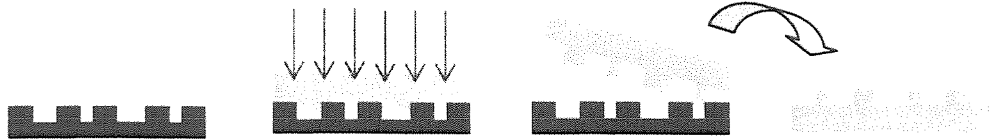

Figure 1. Fabrication scheme of a UV-NIL stamp starting from a silicon template.

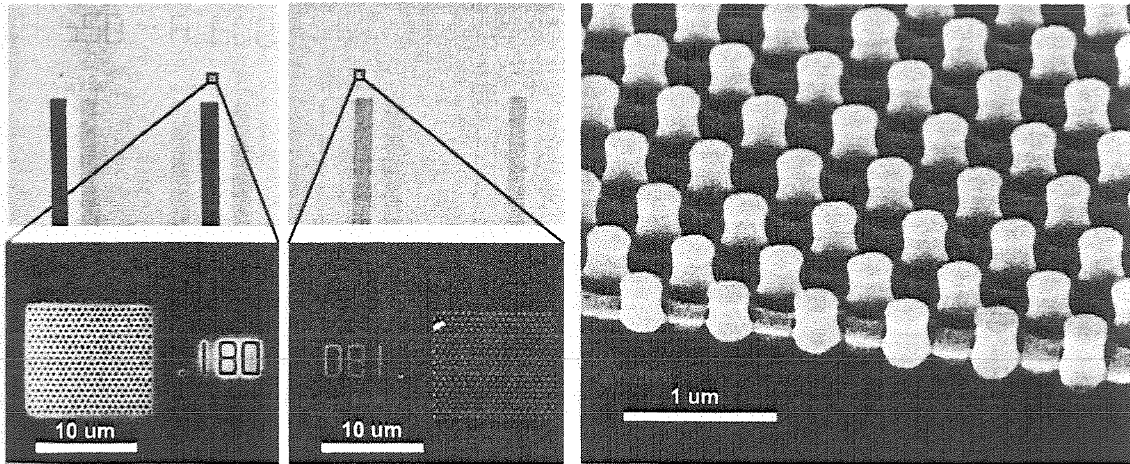

Figure 2. Images of template and UV-NIL stamp. Left: 1 mm^2 and detail of the template and 1 mm^2 and detail of the fabricated stamp. Right: Cross-section image of the fabricated stamp.

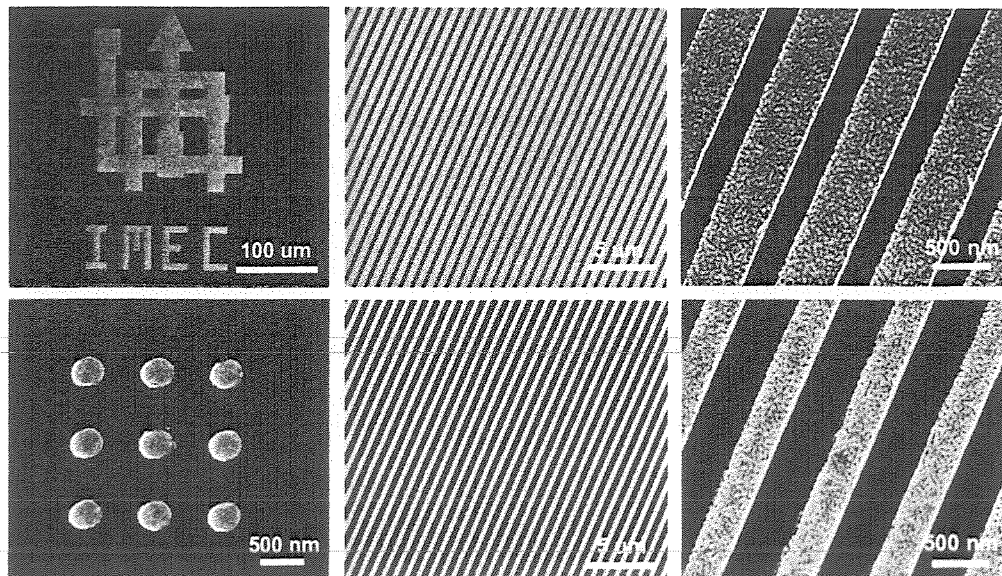

Figure 3. Demonstration of fabricating gold micro- and nanopatterns on top of silicon by UV-NIL using a UV-NIL stamp fabricated with our method. All pictures show parts of one single chip.

MNE 2006

Micro- and Nano-Engineering 2006
32nd International Conference

17-20 September 2006
Barcelona, Spain

ORAL PARALLEL SESSIONS

Micro- and Nano-systems for Biology 2 — 4A

Session Chairs: Evangelos Gogolides. NCSR Demokritos. Greece
Alejandro Pérez-Rodríguez. Univ. Barcelona. Spain

15:45 **Integrated magnetic micro-columns for cancer cell capture and sorting** 107

4A-1 Yan-Jun Liua [b], Shi-Shang Guo [a], Zhi-Ling Zhang [b], Wei-Hua Huanga [b], Damien Baigl [a], Dai-Wen Pang [b], Yong Chen [a]
[a] *Ecole Normale Supérieure, France*
[b] *Wuhan University, People's Republic of China*

16:05 **Bioimprint: cellular replication for nanoscale imaging** 109

4A-2 James J. Muys [a], Maan M. Alkaisi [a], John J. Evans [b]
[a] *MacDiarmid Institute for Advanced Material & Nanotechnology, New Zealand.*
[b] *Dept. of Obstetrics & Gynaecology, New Zealand*

16:25 **Patterning of hydrophilic micro arrays with super-hydrophobic surrounding zones** 111

4A-3 S.S. Guo [a,b], M.H. Sun [a], J. Shi [a], W.H. Huang [a], C. Combellas [b], Y. Chen [a]
[a] *Ecole Normale Supérieure of Paris, France*
[b] *Ecole Supérieure de Physique et de Chimie Industrielles France*

16:45 **Biofluid transport on hydrophobic plasma deposited fluorocarbon films** 113

4A-4 P. Bayiati [a], A. Tserepi [a], P. S. Petrou [b], K. Misiakos [a], S. E. Kakabakos [b], E. Gogolides [a]
[a] *Institute of Microelectronics-NCSR "Demokritos", Greece*
[b] *Institute of Radioisotopes & Radiodiagnostic Products-NCSR "Demokritos", Greece*

Nanoimprint Lithography 1 — 4B

Session Chairs: Hella C. Scheer. University of Wuppertal, Germany
Helmut Schift. PSI. Switzerland

15:45 **A new way of manufacturing high resolution optical encoders by nanoimprint lithography** 115

4B-1 S. Merino [a], A. Retolaza [a], A. Juarros [a], S. Landis [b]
[a] *Fundación Tekniker. Spain*
[b] *CEA-LETI. France*

16:05 **Step and flash imprint lithography templates for the 32 nm node and beyond** 117

4B-2 Gerard Schmid [a], Ecron Thompson [a], Douglas J. Resnick [a], Deirdre L. Olynick [b], J. Alexander Liddle [b]
[a] *Molecular Imprints, Inc., USA.*
[b] *Lawrence Berkeley National Laboratory, USA*

16:25 **Structure size dependent recovery of thin polystyrene layers in thermal imprint lithography** 119

4B-3 Nicolas Bogdanski, Matthias Wissen, Saskia Möllenbeck, Hella-Christin Scheer
University of Wuppertal, Germany

16:45 **UV-NIL with a DUV-fabricated silicon template as a flexible tool for nanopatterning** 121

4B-4 Stijn Scheerlinck, Dries Van Thourhout, Roel Baets
IMEC - Ghent University, Belgium

Pattern transfer 4C

Session Chairs: Fu-Hsiang Ko. National Chiao Tung University. Taiwan
Philippe Godignon. CNM-CSIC. Spain

15:45 **Silicon cryo-etching of deep holes** 123

4C-1 T. Tillocher[a], R.Dussart[a], X. Mellhaoui[a], P. Lefaucheux[a], M. Boufnichel[b], P. Ranson[a]
[a] *GREMI/Polytech'Orléans, France*
[b] *STMicroelectronics, France*

16:05 **Dry etching of a device quality high-k $Ga_xGd_yO_z$ gate oxide in CH_4/H_2-O_2 chemistry for the fabrication of III-V MOSFETs** 125

4C-2 X. Li, H. Zhou, R. Hill, C.D.W. Wilkinson, I.G. Thayne
Nanoelectronics Research Centre, Glasgow University, UK

16:25 **The passivation layer formation in the cryo-etching plasma process** 127

4C-3 R. Dussart[a], X. Mellhaoui[a], T. Tillocher[a], P. Lefaucheux[a], M. Boufnichel[b], P. Ranson[a]
[a] *GREMI/Polytech'Orléans, France*
[b] *STMicroelectronics, France*

16:45 **Mechanisms of surface roughness formation and evolution during Si etching** 129

4C-4 G. Boulousis, P. Angelikopoulos, G. Kokkoris, V. Constantoudis, E. Gogolides
Institute of Microelectronics, National Center for Scientific Research NCSR – "Demokritos", Greece