Nanoimprint Lithography from CHARPAN Tool exposed Master Stamps with 12.5 nm hp

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Central issues in the nanoimprint process are the quality and durability as well as the availability of the stamps. The quality of the final imprint critically depends on the quality of features on the stamp. The durability of the stamp influences the process costs. Using electron beam lithography and subsequent reactive ion etching makes the fabrication stamps with small features on large areas extremely time consuming and therefore expensive. Using this valuable stamp in an imprinting process and risking damaging it has to be avoided especially in high throughput processes.

We have a dual approach to address this problem. On the one hand we use working stamps to do the actual imprinting and on the other hand we use parallel charged particle beams to fabricate the master stamp.

The use of copies from the original master stamp to do the actual imprinting greatly reduces the risk to damage the original. Furthermore there is the flexibility of master and stamp material choice, which do not have to be the same and consequently can be chosen in such a way that the properties for their individual purposes are optimized.

Our master stamps are fabricated using the CHARPAN (Charged Particle Nanopatterning) Tool [1]. This tool uses massively parallel ion beams to either expose a resist or directly pattern a substrate. Silicon wafers are used as master stamp materials. We use 2 kinds of masters: Silicon that has been directly patterned by Ar^+ ion sputtering and hydrogen silsesquioxane (HSQ) resist on Silicon which has been exposed using 10 keV H_3^+ ions. Both processes are direct processes, which do not require any reactive ion etching steps.

Details of recent CHARPAN Tool fabricated master stamps are shown in Figures 1 - 6, where 20nm HSQ resist was exposed with 10 keV H_3^+ of 8.3nm beam size. With substantial overexpose there was the possibility to realize 12.5nm hp dots, lines and crossed lines within 20µm x 20µm exposure fields. The lines and crossed lines were realized with precise multipole steering of the ion multi-beams. The HSQ resist was developed in TMAH and NaOH/NaCl, respectively. Details of daughter stamp fabrication and NIL replication studies will be reported.

For the fabrication of the working stamps we use two different kinds of materials. On the one hand we use the organic hybrid material Ormostamp of microresist technologies GmbH.[2][3] Our second material is a UV-curable fluorinated polymer.

We fabricate our working stamps on glass backplanes from 25x25mm² in size to 100mm in diameter. The liquid stamp material is dispensed in a puddle before bringing master stamp and backplane together. The master stamp is treated with an appropriate anti sticking layer [4].

From both types of masters working stamps have been successfully fabricated. These stamps can also be used in UV-based nanoimprint processes.

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References:

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[4] BGL-GZ-83, http://www.profactor.at/en/nano/produkte-verfahren-lizenzierbares/bgl-gz-83.html

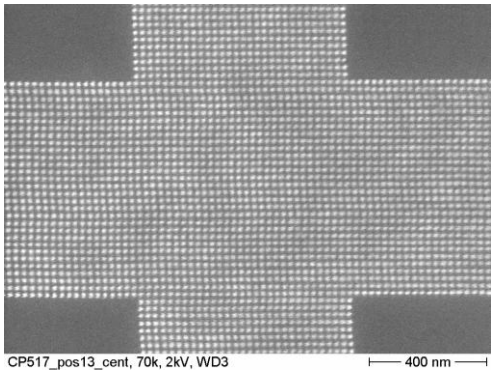

Figure 1. 80 µC/cm^2 exposure dose, TMAH development

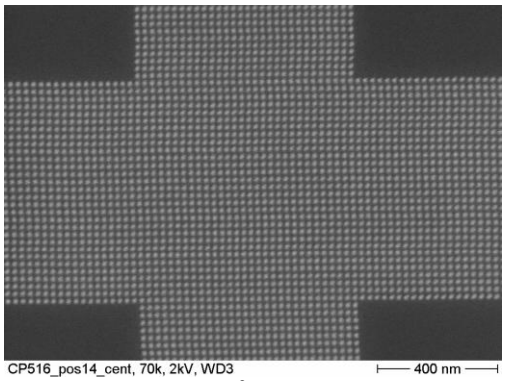

Figure 2. 320 µC/cm^2 exposure dose, NaOH/NaCl development

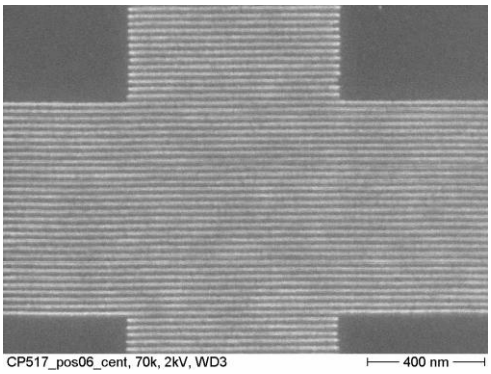

Figure 3: 22 µC/cm^2 exposure dose, TMAH development

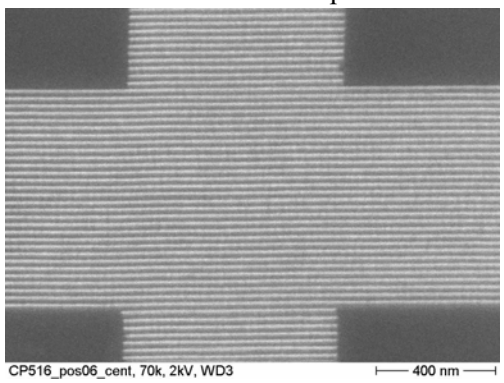

Figure 4: 71.5 µC/cm^2 exposure dose, NaOH/NaCl development

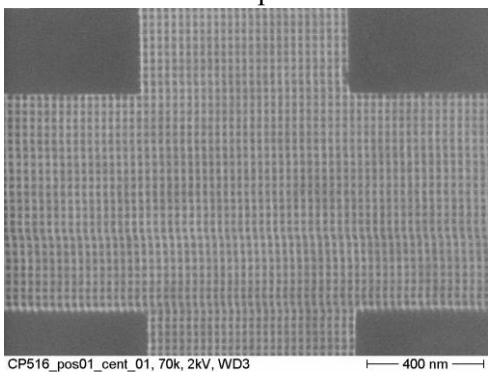

Figure 5: 45 µC/cm² exposure dose, NaoOH/NaCl development

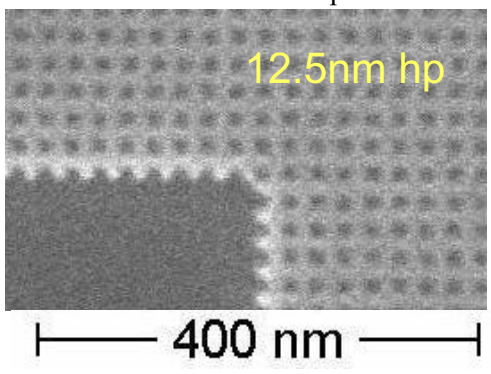

Figure 6: 55 µC/cm² exposure dose, NaOH/NaCl development