

Metal-Assisted Chemical Etching of Si for Fabrication of Nanoimprint Stamps

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Nanoimprint lithography (NIL) is one of the most promising methods of high resolution, high throughput nanopatterning techniques.¹ However, its performance is determined by the quality of the NIL stamps. The conventional method of fabrication of the stamps includes patterning by electron beam lithography (EBL) and anisotropic reactive ion etching (RIE).² In the present work we report on fabrication of Si NIL stamps using a newly developed metal-assisted chemical etching (MaCE) technique.³ Advantages of the MaCE of Si include high etch anisotropy, simplicity and possibility to control etch rate and surface morphology easily.⁴

The NIL stamps were produced from n-type, 10 Ohm cm, 1" Si (100) wafers. A thin (20 nm) Au film was used as a catalyst in the MaCE process. The Au film was patterned by EBL and lift-off. The Si wafer with the pattern was etched in a mixture of HF:H₂O₂:H₂O (4:1:40) at ambient conditions. Depending on the etch time, it was possible to fabricate structures with various depth (up to 20 μm), but for fabrication of the NIL stamps the etching was intentionally limited to 60-170 nm. The MaCE process results in very anisotropic etching with high aspect ratio of up to 1:21. The final fabrication steps include removal of the Au catalyst by wet chemistry and antisticking treatment.⁵ Figure 1 shows the SEM images of one of the NIL stamps with both large (500 nm) and small (≈150 nm) features.

Replication of the stamp was performed in a PMMA (950 K) resist using a thermal NIL process at temperature of 200°C, pressure of 50 bar and imprint time of 10 min. The NIL experiments showed that the fabricated stamp can be used for a reliable pattern transfer, see Figure 2.

¹ S. Chou, P. Krauss, P. Renstrom, *Appl. Phys. Lett.* **67**, 3114 (1995)

² I. Maximov, E-L. Sarwe, M. Beck, K. Deppert, M. Graczyk, M. Magnusson, L. Montelius, *Microelectronic Engineering*, **61-62**, 449 (2002)

³ K. Peng, A. Lu, R. Zhang, S-T. Lee, *Adv. Funct. Mater.* **18 (19)**, 3026 (2008)

⁴ Y. Qu, L. Liao, Y. Li, H. Zhang, Y. Huang, X. Duan, *Nano Letters*, **9**, 4539 (2009)

⁵ M. Beck, M. Graczyk, I. Maximov, E-L. Sarwe, T. Ling, M. Keil, L. Montelius, *Microelectronic Engineering*, **61-62**, 441 (2002)

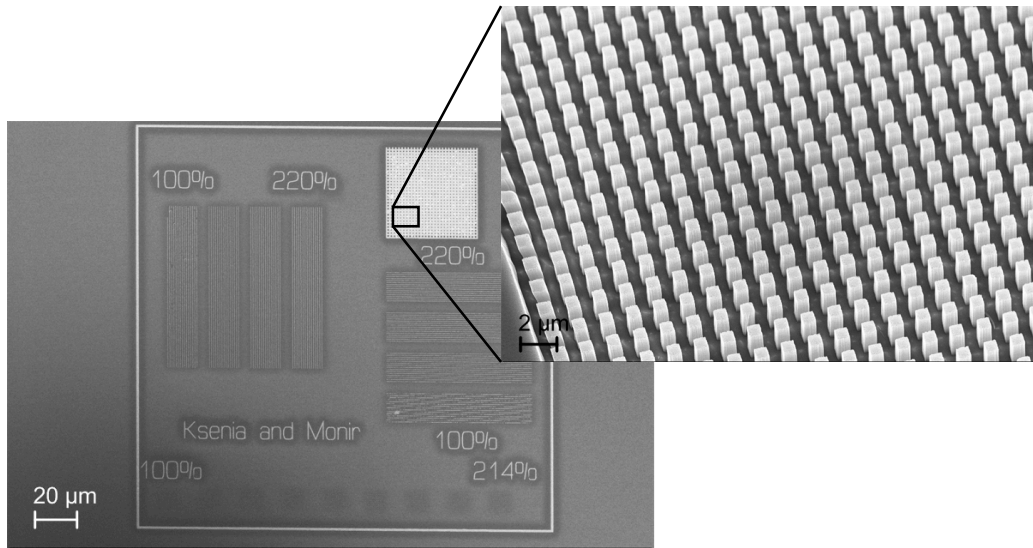


Figure 1: SEM images of the test NIL stamp made using Metal-assisted Chemical Etching (MaCE) of Si. Left: overview of the stamp area ($200 \times 200 \mu\text{m}^2$), right: zoomed-in detail of the stamp features with well-defined 500 nm wide columns. The etching depth is 2.3 μm .

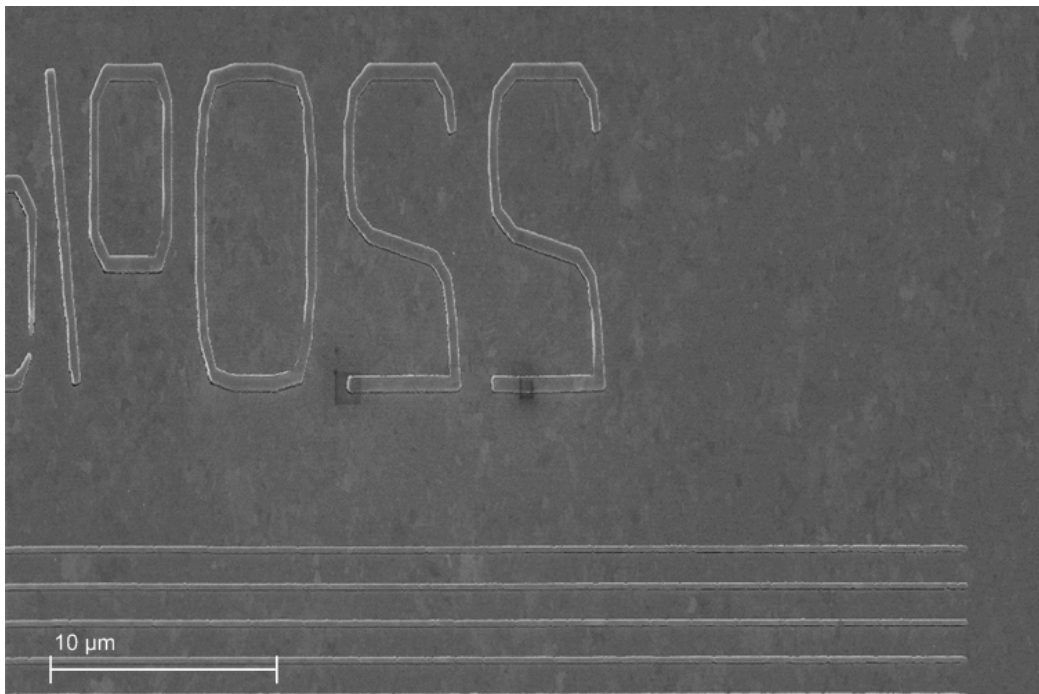


Figure 2: An example of the imprinted stamp features in 180 nm thick PMMA resist. Four horizontal lines in the bottom have a width of 150 nm.