Nanometrology and nanofabrication using a tip-based system combined with a planar nanopositioning machine (NFM-100)

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Abstract

As the structure widths for the fabrication of complex nanostructures have become smaller and smaller over the past decades and the demand for research of nanofabrication technologies has risen further, numerous alternative fabrication techniques in contrast to optical lithography have become established. In order to also guarantee the repeatability and reproducibility of such new nanotechnologies over macroscopic workspaces on wafer sizes, the demand for high-precision positioning has steadily increased [1]. To enable high-precision measurement of nanostructures, tip-based techniques offer a distinct advantage over other methods. Nevertheless, ordinary atomic force microscopy systems are limited to a range of motion of a few hundred µm. In this contribution, a significantly larger measuring range is obtained by combining a planar nanofabrication machine with a range of motion of 100 mm in diameter and a resolution of 5 pm of the interferometric length measuring system with a tip-based measuring and fabrication system. This way, required for current structures, nm-resolution is achieved for the necessary large working areas, corresponding to wafer size. By using active microcantilevers, it is easy to switch between the measuring and writing modes of the tip-based system without having to change or realign the tool. Thus, it is possible to inspect the surface to be structured, create nanostructures by a Fowler-Nordheim emission current and then observe the result of nanostructuring in macroscopic workspaces.

In this work, in addition to long range AFM scans, the focus is specifically on nanofabrication with the smallest possible structure widths, but at the same time also on markoscopic working ranges. Using a spirally generated nanostructure with a total length of 1 mm, a very low path deviation was achieved through the high-precision positioning of the NFM-100. Furthermore, the focus was on the generation of structure widths < 50 nm.

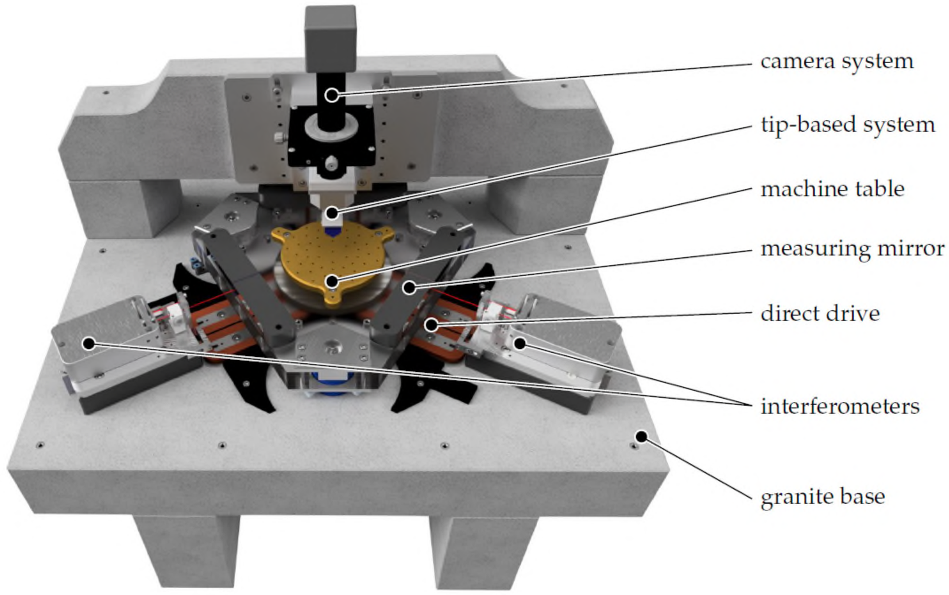

Figure 1. Setup of the NFM-100 and the tip-based system. The machine table is specially designed for wafer sizes up to 4 inches. [2]

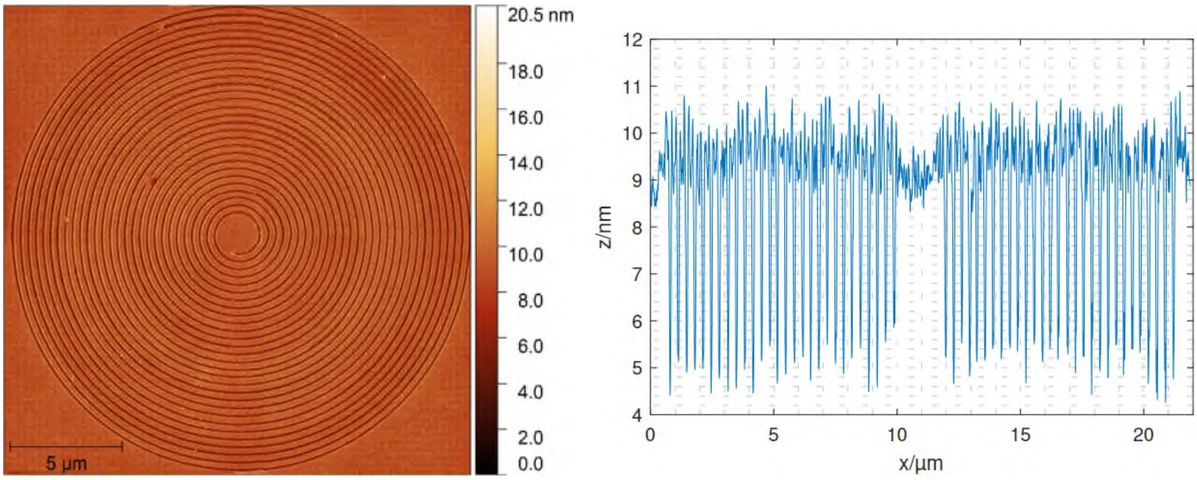

Figure 2. AFM images of the fabricated spiral path with the Nanofabrication Machine and its tip-based system. The total length of the fabricated structure is 1 mm. The constant line width 60 nm ± 3.16 nm and the line distance of 330 nm ± 14.4 nm shows the high potential of the combined systems. [3]

Literature:

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[3] Stauffenberg, J.; Reibe, M.; Krötschl, A.; Reuter, C.; Ortlepp, I.; Dontsov, D.; Hesse, S.; Rangelow, I.W.; Strehle, S.; Manske, E.; Tip-based nanofabrication below 40 nm combined with a nanopositioning machine with a movement range of Ø 100 mm. Micro and Nano Engineering, Volume 19, 2023, 100201, ISSN 2590-0072, https://doi.org/10.1016/j.mne.2023.100201.