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Investigations on Long-Range AFM Scans Using a Nanofabrication Machine (NFM-100) †

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Abstract: The focus of this work lies on investigations on a new Nano Fabrication Machine (NFM-100) with a mounted atomic force microscope (AFM). This installed tip-based measuring system uses self-sensing and self-actuated microcantilevers, which can be used especially for field-emission scanning probe lithography (FESPL). The NFM-100 has a positioning range of Ø 100 mm, which offers, in combination with the tip-based measuring system, the possibility to analyse structures over long ranges. Using different gratings, the accuracy and the reproducibility of the NFM-100 and the AFM-system will be shown.

Keywords: nanopositioning; nanometrology; AFM; self-sensing microcantilevers

1. Introduction

Most of the tip-based systems are using standard Atomic Force Microscope equipment and work with high resolution and reproducibility in small areas of several micrometers [1]. For this purpose, it becomes more and more important to overcome these limitations and to fabricate and analyse structures over long ranges. In this contribution, the focus lies on the investigations on the new Nano Fabrication Machine 100 (NFM-100), which has a positioning range of Ø100 mm and poses an important platform for basic research in the field of tip- and laser-based nanomeasuring and nanofabrication. To investigate new tip-based measuring systems in combination with the NFM-100 in large working areas, an Atomic Force Microscope (AFM) is installed.

2. Design of the Nano Fabrication Machine 100 and the Mounted AFM System

Based on the experiences with the Nanomeasuring Machine 1 (NMM-1) and the Nanopositioning and Nanomeasuring Machine (NPMM-200), the NFM-100 was developed at the Technische Universität Ilmenau, Institute for Process Measurement and Sensor Technology and IMMS gGmbH. In collaboration with SIOS Meßtechnik GmbH, IMMS gGmbH and nanoanalytik GmbH, the combination of the NFM-100 and its tip-based measuring system was realized. For high accuracy positioning in the x- and y-directions, this machine uses a planar driving system. The slider is moved by three linear actuators, which consist of flat coils and a magnet array each [2]. These actuators are arranged in a single plane and have an angle of 120° between each other. The position of the slider can be determined by three fibre-coupled laser interferometers.

Additionally, an atomic force microscope is installed, which uses self-sensing and self-actuated microcantilevers. These microcantilevers use a wheatstone bridge of four piezoresistors to detect the deflection and a thermomechanical actuator, which uses the bimorph effect for oscillation [3].

3. AFM Scan Results over Long Range

To show the performance of the mounted AFM-System and the NFM-100, a step grating is used. The grating has a pitch size of 3 µm and depth of approximately 560 nm. During the measurement, the microcantilever is in a fixed position in the x- and y-directions, while the z-position is controlled by the piezo-scanning unit. The movement in the x- and y-directions is realized by the NFM-100. As an example, a line scan with a length of 3 mm was performed with a velocity of 1 µm/s (see Figure 1). In principle, it is possible to analyse samples over an area up to Ø100 mm. A detail of the result of this measured line scan can be found in Figure 1.

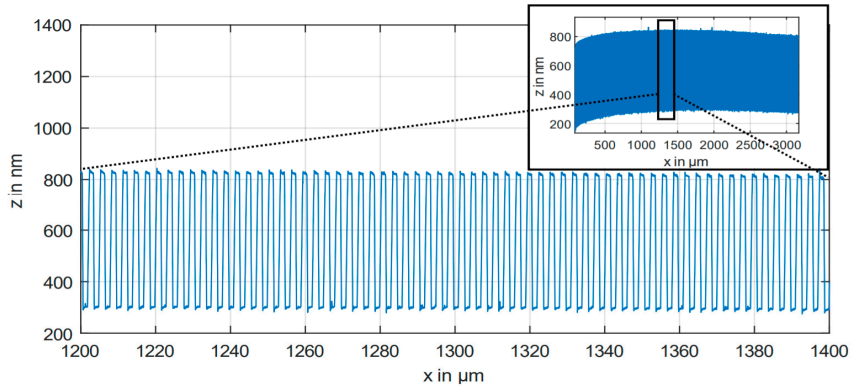

Figure 1. Line scan of 3 mm with a count of 1000 pitches and section (200 µm in length) of the line scan of a calibration sample with the NFM-100 and its mounted AFM system over a range of 3 mm.

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Conflicts of Interest: The authors declare no conflicts of interest.

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