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Dario Loaldi[1], Danilo Quagliotti[1], Matteo Calaon[1], Ilja Czolkos[2], Alicia Johansson[2], Theodor Nielsen[2], Jørgen Garnæs[3] and Guido Tosello[1]

[1] Department of Mechanical Engineering, Technical University of Denmark (DTU), Kgs. Lyngby, Denmark
[2] NIL Technology ApS, Denmark
[3]Danish Fundamental Metrology A/S, Hørsholm, Denmark

AFM - High aspect ratio nanostructures - Measurements artefacts - NanoMetrology - Nano Imprint Lithography

Research Outline

- Characterization of high aspect ratio nano structures for diffractive optical purposes.
- Measure a rectangular grating with a pitch of 700 nm, a trench size of 350 nm, a nominal height of 1130 nm, representing an aspect ratio of 3 using an Atomic Force Microscopy (AFM) on a silicon wafer produced via Deep Ultra Violet (DUV) lithography.
- Evaluate the performance of AFM in tapping mode using dedicated sharp silicon tips.
- Estimate tip convolution requirements for the reconstruction of the effective surface topography.
- Characterization of measurements artefacts and propose a deconvolution procedure.

Silicon master Characterization

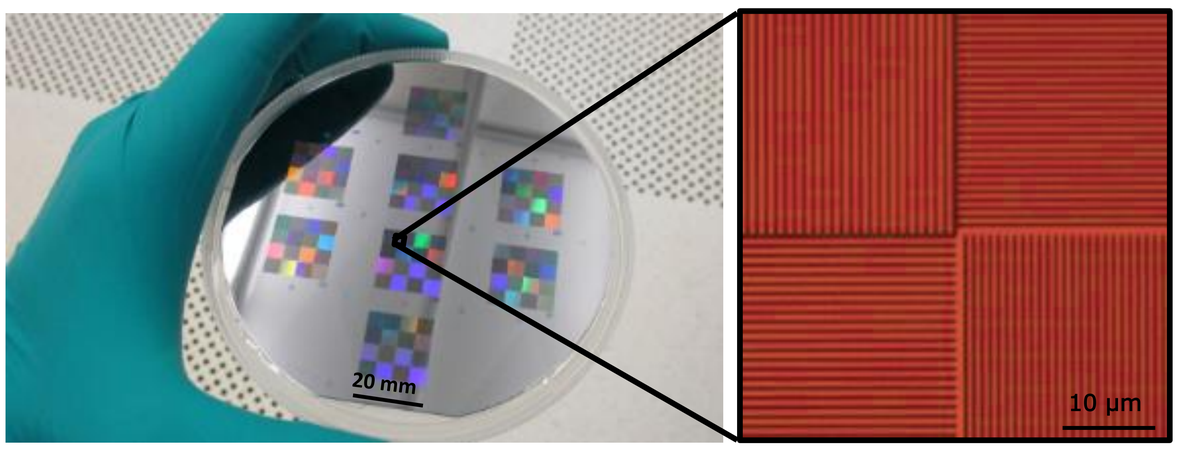
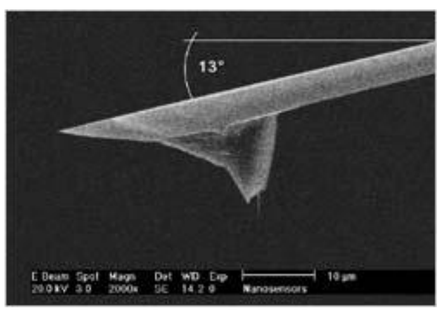


Fig. 1: Silicon master fabricated in clean room by Deep Ultra Violet (DUV) lithography embedding rectangular gratings of nominal height 1130 nm and pitch varying from 700 nm – 1400 nm

Atomic Force Microscope (AFM)



Cone shape tip with an incremental radius nominally up to 120 nm in the first 2.00 µm of tip height. (Nanosensors © Gmbh, AR5-NCHR)

Fig. 2: Bruker AFM Dimension Icon (left) used for the experimentation in tapping mode in clean room, equipped with a dedicated high aspect ratio tip (right). The piezo is operated at 80 mV, which corresponds to cantilever free amplitude of 3.4 nm. The amplitude set-point is set to 2.1 nm, which provides an overall damping ratio of approximately 62 %.

Measurements results

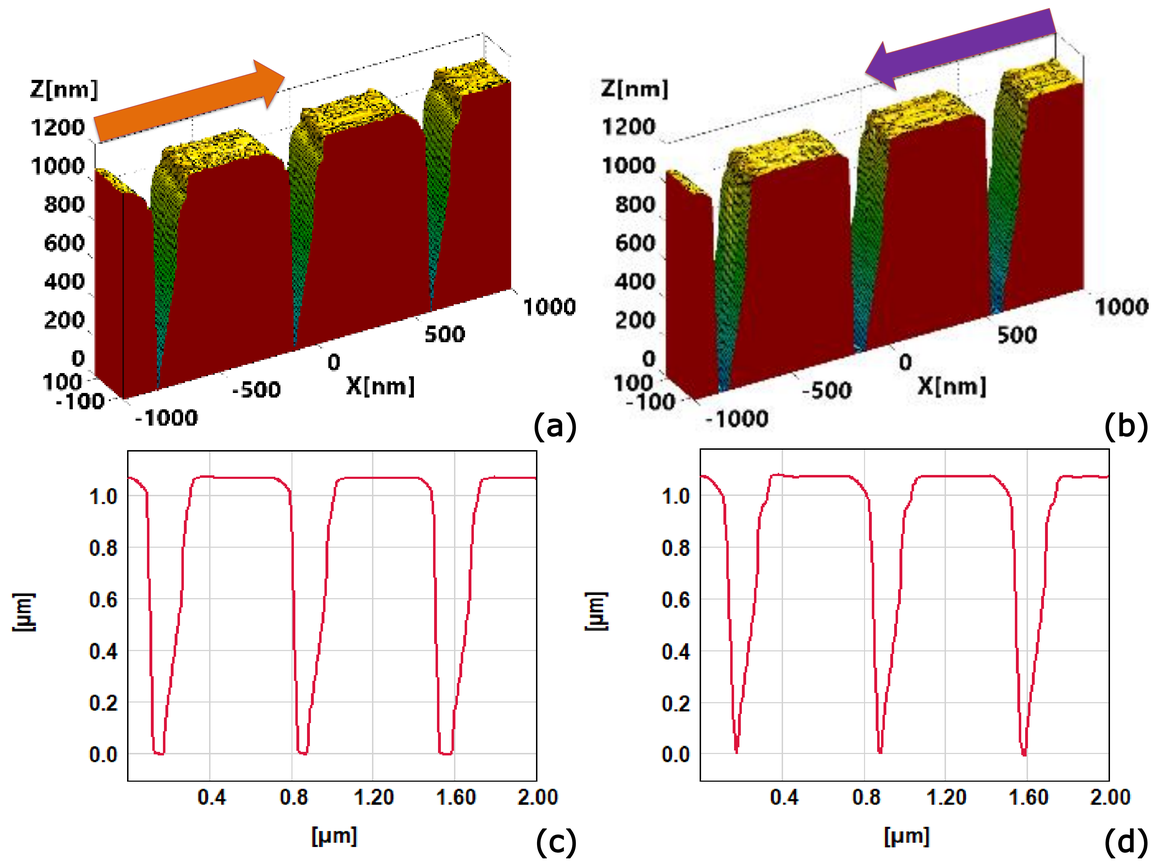


Fig 3. 3D view of the traced (a) and retraced (b) and respective average X profiles (c), (d), of the AFM acquisition sampled in the longitudinal scanning direction.

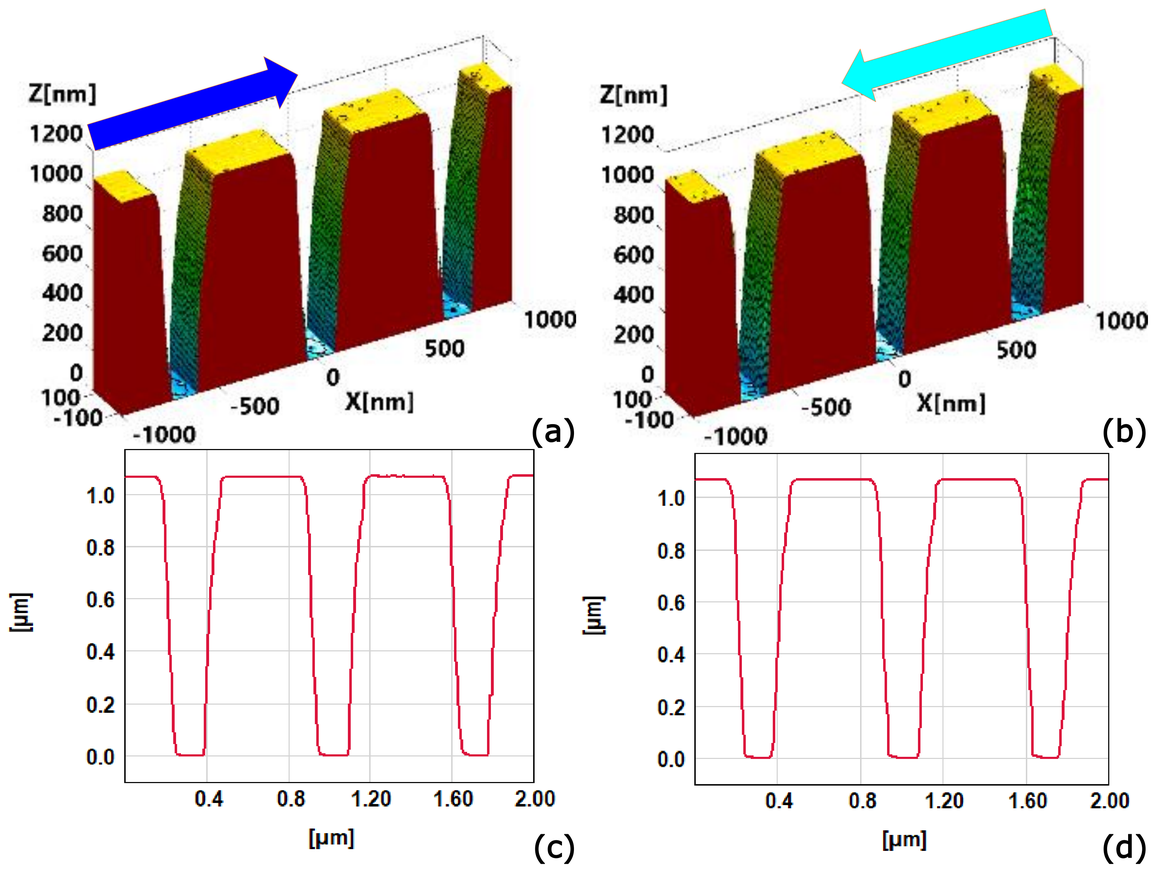


Fig 4. 3D view of the traced (a) and retraced (b) and respective average X profiles (c), (d), of the AFM acquisition sampled in the longitudinal scanning direction.

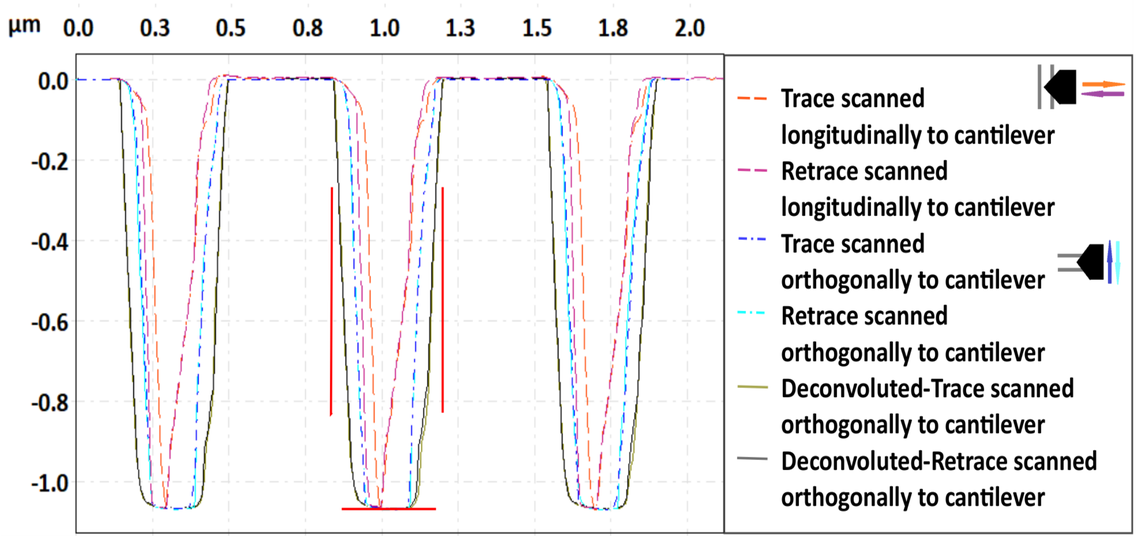


Figure 4 Deconvolution profile obtained with random reconstruction algorithms overlapped with the average X profiles from Fig. 3 and 4. for different scanning directions and orientations

Conclusion

Measurements of high aspect ratio (3+) sub-micrometric rectangular gratings can be achieved using AFM microscopes with some limitations. Even though scanning velocity is kept low (0.01 µm/s), measurements are performed in tapping high resolution with dedicated sharp tips; the metrology task challenges the utilization of the microscope. An acceptable result can be achieved by performing tip deconvolution. However, the method is not traceable according to the standards.

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