Microcontact Printing

Microcontact Printed Monolayers inspected with Imaging Ellipsometry and Scanning Probe Microscopy

Introduction

For the production of microstructures Microcontact Printing [1] is a simple an cheap alternative to the rather complicated and expensive Photolithography. By means of Microcontact Printing (fig.1) SAMs (*self-assembled monolayers*), e.g. a thiol can be printed on a suitable substrate, e.g. gold. The SAM protects the surface from being etched when in a next step the surface is etched to produce a lateral structure. The chemical function of a thiol depends on its functional groups, which can be modified. In that way the surface can be modified to bind particular classes of molecules. Microcontact Printing of SAMs can produce Microarrays carrying thousands of different sensor properties within one cm^2. Microarrays are applicable in Genomics and Proteomics in biotechnology. Imaging ellipsometry is cheap, fast, and marker-free detection method on Microarrays [2].

Samples

Microcontact Printed SAMs of two different thiols on gold (50 nm film on glass slide)

Instrumentation

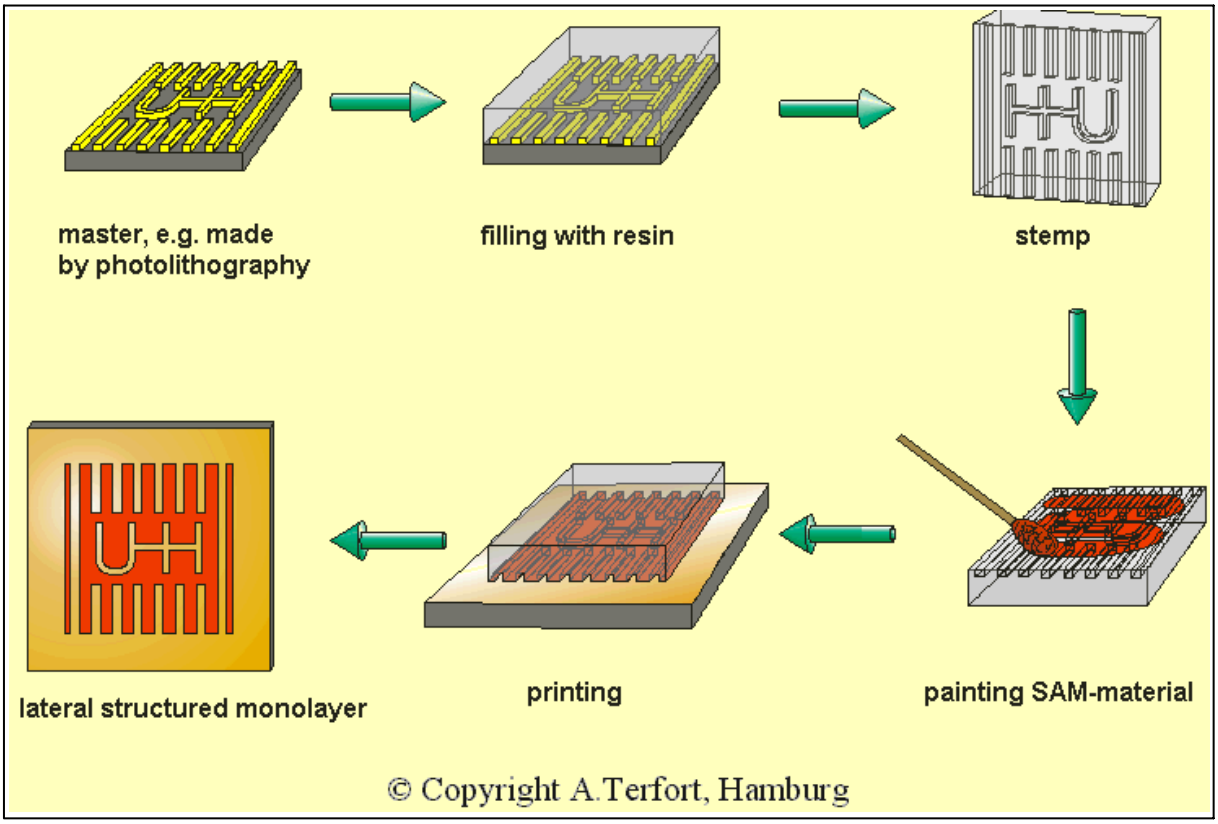
Imaging Ellipsometer EP^3-SW (532 nm) optional Scanning Probe Ellipsometric Microscope (SPEM) including scanning probe microscope (SPM)

Task

Quality control of the Microcontact Printed SAMs by means of thickness maps

Steps of evaluation

- Optimize the ellipsometric image contrast with the angles of analyzer and polarizer
- Search for points of interest in the ellipsometric contrast image in real time



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- Let the EP^3 record a map of Delta, from which the map of the thickness of thiol (fig.2) is calculated.
- Set the Region of Interest (white box, fig.2 A) where to zoom in with the scanning probe microscope (fig.2 B,C) (optional)

Measurements

The Imaging Ellipsometer has the advantage that it can identify thickness variations in structured SAMs with sub-monolayer vertical resolution (typ. 0.01 nm) in real time, while the sample can be moved by the operator with an automatic translation stage. By contrast scanning probe micrographs need many minutes for preparation, optimization, and recording. SPMs produce artefacts when scanning a large field of view (80 µm as in fig.2 B) due to sample curvature and nonlinear piezoelectric response. In fig.2 B the increasing signal towards the left and right edges is an artefact, which makes the search for structures with nm-step size very difficult with SPM. In order to identify nm-steps in the layer with SPM it is also necessary to eliminate vibrations e.g. by an anti-vibration stage, which is not needed for ellipsometry.

The SPM offers a sub-micron lateral resolution (fig.2 C), where the imaging ellipsometer is limited by the optical diffraction limit (around 1 µm). A calibrated SPM and the ellipsometer, both measure step sizes in layers very precisely. Only the ellipsometer can measure thickness absolutely without need for a step in the layer. To this end the ellipsometer measures a phase shift Delta, which is proportional to the monolayer thickness. The constant of proportionality can be calculated from the optical properties of the
sample (refractive indices of layer and substrate). The ellipsometer cannot measure the thickness absolutely when the difference of the refractive indices is smaller than 0.01, which can be the case at SAMs on ordinary glass. Absolute thickness measurement is always possible for SAMs on absorbing substrates, i.e. gold and silicon, when the refractive indices of the SAM and of the substrate are known. In order to calibrate the thickness scale of the map (fig.2 A) typical

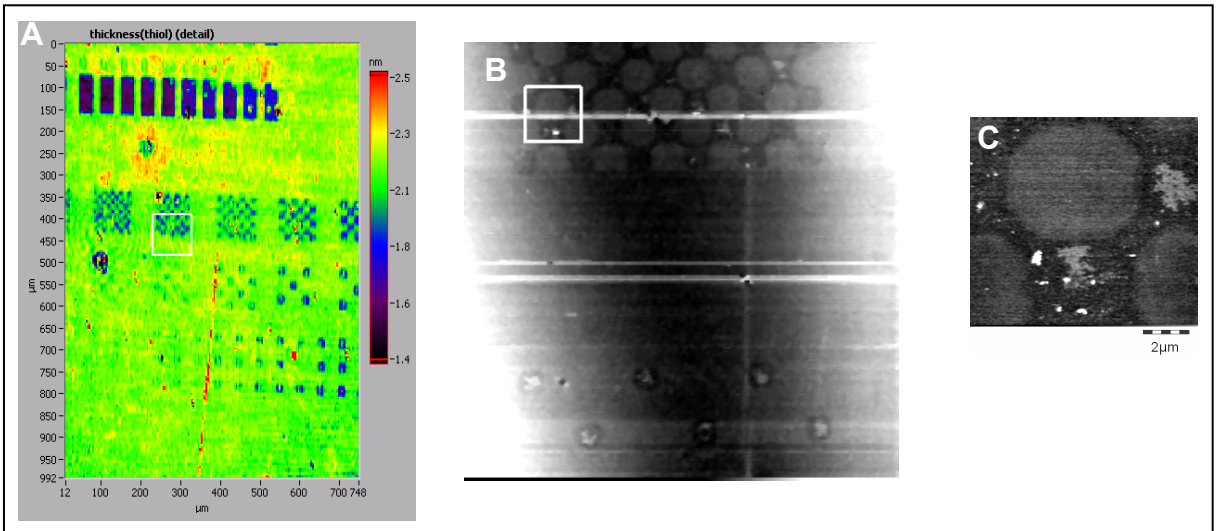

Fig. 2: Microcontact-Printed thiol on gold, thickness map (**A**, 5x objective, 1 min. recording time), scanning probe micrographs with 15 min. recording time (**B**, 80 µm x 80 µm, corresponding to the white box in **A**, and **C**, 10 µm x 10 µm, corresponding to white box in **B**)

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Results

Sub-monolayer-sized steps of 0.3 nm are observed between two different types of thiols (blue and green in fig.2 A) in Micro-contact Printed SAMs.

Conclusion

The Imaging Ellipsometer EP^3 identifies steps in monolayers much faster and with less effort than a SPM. Only the imaging ellipsometer can record a thickness map with a field of view between 0.1 and 2 mm depen-ding on the objective. To zoom into the ellipsometric image with sub-micron lateral resolution a SPM is well suitable. The scanning probe ellipsometric microscope (SPEM) unifies SPM and EP^3 in one instrument. The EP^3 and the SPEM are perfectly suitable to characterize structured SAMs.

Acknowledgement

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References

[1] J.L. Wilbur, A. Kumar, E. Kim, G.M. Whitesides, Microfabrication by Microcontact Printing of Self-Assembled Monolayers, Adv. Mater., Vol. 6, 600 (1994)

[2] Marker-free Detection on Microarrays by M.Vaupel et al., p. 181-207, in Microarray Technology and Its Applications, U.R. Müller and D.V. Nicolau (Eds.), Springer (2005), ISBN 3-540-22931-0

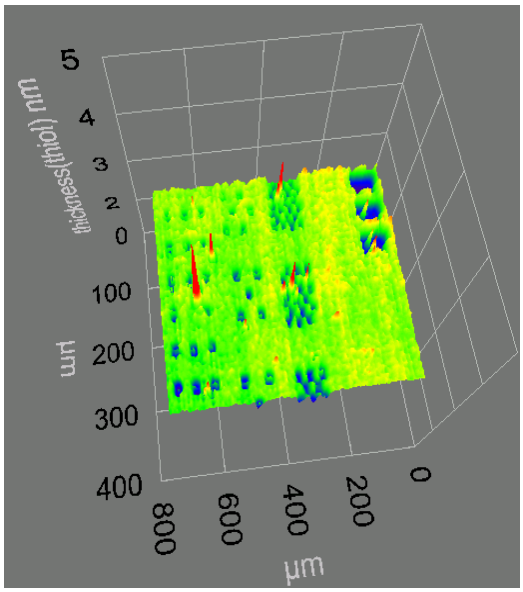

Fig. 3: Microcontact-Printed thiol on gold, thickness profile according to the thickness map (fig.2 **A**)

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