FlagShip
Advanced NanoProbing

In the flagship Advanced NanoProbing we devise and develop novel scanning probe tools that allow the investigation and manipulation of the properties of materials on a nanometre scale. This includes the development of molecular functionalised probes for medical and biological applications and nano-optical probing. We are also engaged in the development of tools which allow the real time study and manipulation of systems under practical conditions such as high pressure and liquid. Scanning Probe Microscopy (SPM) is increasingly employed for industrial purposes. We make SPM tools and related nanotools accessible to small and medium enterprises.

Facts & Figures
- Number of projects: 15
- Partners: Radboud U, U Twente, TU Eindhoven, RU Leiden, AMOLF, Philips
- Members of the Users’ Committee: Shell Global Solutions Int. B.V., FEI Company, KU Leuven, UMC Nijmegen, Helianthos B.V., SmartTip B.V.

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Towards Nanoscale Thermal Scanning Probe Lithography

Many applications of nanoscience and technology require methods to reliably write and erase tiny structures on surfaces. Approaches on the basis of Atomic Force Microscopy (AFM) include shaving, grafting, molecular transport, and electric fields. Thermal Scanning Probe Lithography (TSPL) was introduced as a new lithographic tool for nanoscale thermal chemical lithography on polystyrene-block-poly(tert-butyl acrylate) (PS-b-PtBA) polymer thin films. TSPL utilises the highly localised resistive Joule heating at the cantilever end of self-heating silicon AFM cantilevers to locally thermally chemically modify small domains on PS-b-PtBA films. The thermally labile tert-butyl ester groups...
can be thermolysed at temperatures above 150 °C to yield carboxylic acid and anhydride functionalities (Figure 1) for subsequent covalent modification with amino containing molecules, such as fluoresceinamine or amino end-functionalised PEG.

We have successfully demonstrated the local thermal functionalisation via TSPL and subsequent wet chemical grafting reactions with fluoresceinamine or PEG on PS644-b-PtBA938 films for domains as small as ~370 by ~580 nm. Figure 2 shows the results for 2 different approaches used, which are (i) raster scanning with a heated probe (Ttip ~ 265 °C) in contact mode and (ii) indenting an array of 25 by 25 points (x-y separation 250 nm), respectively. The fluorescence microscopy images show the successful covalent grafting of fluoresceinamine to these thermally functionalised domains. Figure 3 shows corresponding AFM height images for the two approaches described in Figure 2. It appeared that most of the thermolysed material was moved to the sides perpendicular to the probe scanning direction during raster scanning in contact mode, presumably due to the high lateral forces. This explains why the fluorescence microscopy image in 2A shows bright lines of green emission from the covalent immobilised fluoresceinamine. In order to reduce the high lateral forces the indentation method was applied, which, as can be seen in Figure 3B-D, resulted in indentations of ~370 nm by 580 nm in size. The individual indents are too small to be resolved in fluorescence microscopy; however the clear green fluorescence emission from the combined resulting square indicates that the covalent modification with the fluorescent dye was very efficient.

The resolution limits of this new scanning probe lithography approach have not been established as yet, but temperature, duration of tip-samples contact and feedback settings, among other things are expected to contribute to attainable minimum feature size and separation. Future work will systematically explore the nanoscale thermal activation of polymer films as well as the characterisation of these thermal chemical modified polymer films surfaces at nanometre length scales.

Reference: