

Optically induced mass transport generated in near-fields

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Optically induced mass transport is a relatively new opto-mechanical effect which occurs in azobenzene containing films¹. The effect was e.g. observed as surface relief grating (SRG) which was created by exposure with a holographic pattern of circularly polarized light of 488nm wavelength.

Assuming viscoelastic flow of the polymer caused by a lateral force a change in polymer's elastic properties on light exposure could explain the massive displacement of polymer material. Though, the dimensions of the usually generated structures of surface relief gratings (SRG) are typically in the micrometer range. Now, for the first time in optical near-field investigations a nano-scale directed mass transport effect in those azobenzene containing films could be observed.

In our experiment we used near-field light, which was located in areas much smaller than the wavelength² and so we can optically generate nanometer large structures. The samples for the experiment are spin-coated films on glass (ca. 500 nm) consisting of side-chain azobenzene containing material, poly{(4-nitrophenyl)[4-[[2-(methacryloyloxy)-ethyl] ethylamino] phenyl] diazene} (pDR1M), which has a glass transition temperature of $T_g=129\text{ }^{\circ}\text{C}$ ³.

The applied optical near-fields were produced in two ways. First by the enhanced light around illuminated gold nanoparticles⁴ and second by light which tunnels through the nano meter aperture of a SNOM tip⁵. This special near-field light was directly used for influencing the surface profile of thin films which were optimized for mass transport effects.

In the first experiment nanoparticles were sparsely distributed on top of the film which was illuminated by suitable light ($\lambda = 480\text{ nm}$) with low intensity from a Xenon lamp. The gradient of this enhanced light around the nanoparticles caused a mass transport. This can be monitored by AFM.

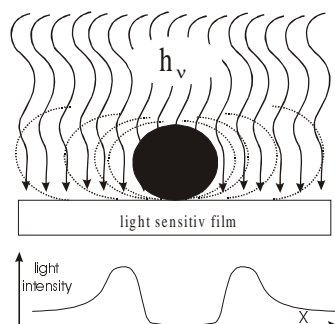


Fig1
Sketch of the experiment 1

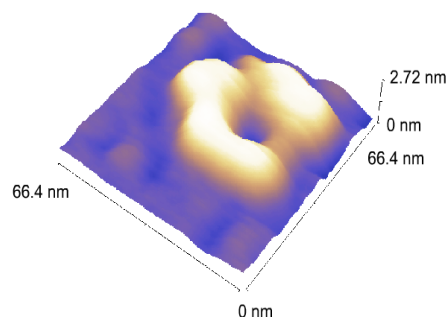
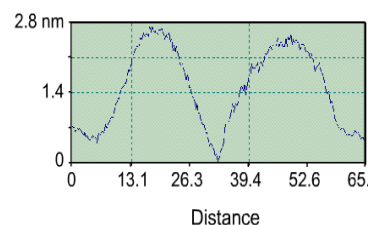


Fig 2
AFM image after illumination
(without particle)



Cross section

Figure 2 shows the topography of such an area where the particle was removed after the illumination of the film. The cross section of this structure shows that the optically produced dimensions of 2 nm x 30 nm are much smaller than the wavelength of the used light.

A second experiment (fig. 3) in this topic was related to the modification of a prior microscopically produced SRG (lateral period ca. 1 μm) by using light through a SNOM cantilever.

A laser of 523 nm was focused into the cantilever SNOM tip with an aperture of ca. 100 nm (Alpha-SNOM / WITec GmbH Germany). While scanning the SRG with the SNOM cantilever in contact mode near-field light through the aperture of the tip directly influences the surface causing an optical modification of the SRG. The micro graphs of 30 x 30 μm^2 in fig. 4 show the result after 30 min scanning an area of 10 x 10 μm^2 . If the laser was switched off while the SNOM tip was scanning the SRG no surface profile changes were detected so far.

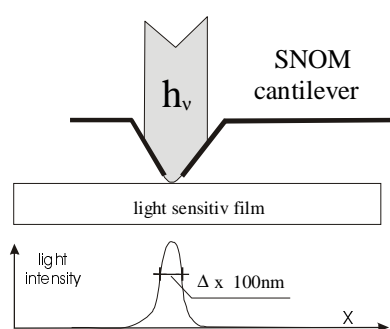


Fig. 3
Sketch of the experiment 2

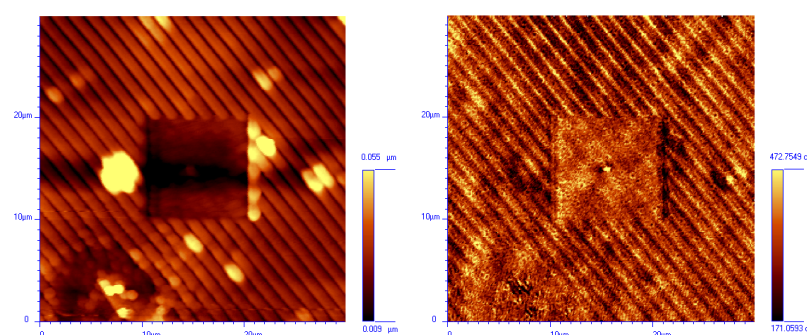


Fig. 4
Topography of the modified SRG after SNOM-scanning

SNOM image

Both experiments demonstrate the possibility to generate a light driven mass transport on nanometer level using an optical near-field. This might be helpful to provide further inside into the phenomena of such mass transport and the molecular origin of the massive polymer displacement. It also opens ways for applications of optics in nanotechnology.

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