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Decrease of friction coefficient by generation of self-organising nanostructures using femtosecond laser

Investigation on microstructuring different probe materials made by the Laserinstitut at University of Applied Sciences using femtosecond laser station FS-150-10 (presented in LASER MAGAZIN 1/2005) shows on depending of selected process and structuring parameters the generation of self-organising nanostructures – known as ripple (Fig. 1).

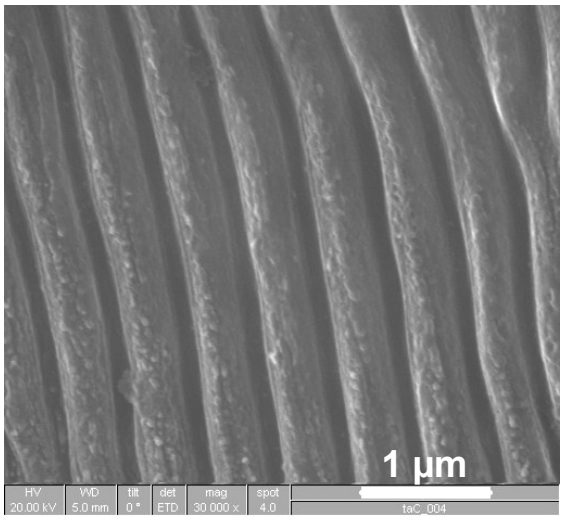

Fig. 1: Scanning electron microscope image of generated ripple-structures on an 1,5 µm thick ta-C-layer.

The ripple-structures have a period between 500 nm and 700 nm and a maximum depth of 400 nm. For our tests steel probes coated with a 1,5 µm thick ta-C-layer were comprehensive structured. As results of tribometer tests on these probes (testing method: ball on disk) a considerable decrease of friction coefficient for no lubricant testing conditions could be observed. The testing curves in comparison to probe with unstructured surface are shown in Fig. 2.
For 1 N load a friction coefficient less than 0,01 was detected, but loads of 5 N and above destroys the ripple fast.
In comparative studies grating structures with a period of 2 µm were produced with Excimerlaser in a mask projection process. These structures also shows a decrease of friction – till 5 N load friction coefficients less than 0,05 could be reached.

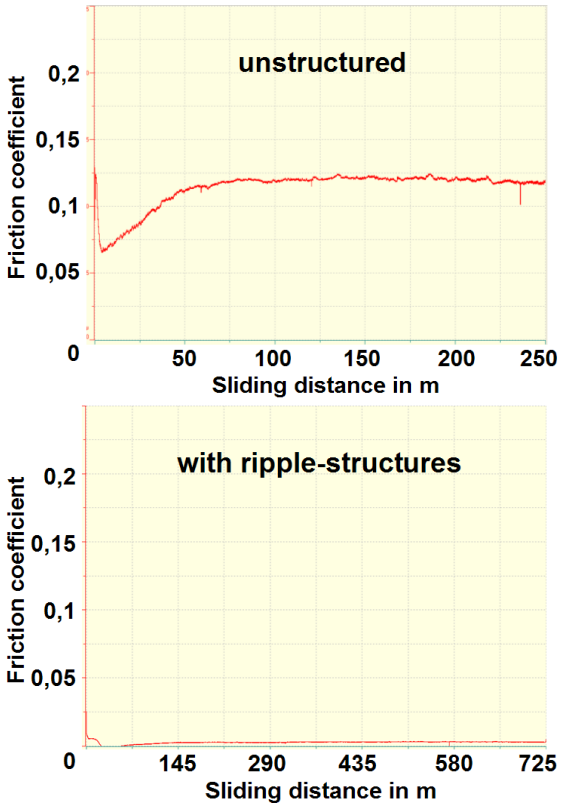

Fig. 2: Results of tribometer tests for determination of friction coefficicient on a ta-C-coated steel probe (testing method: ball on disk; ball: 100Cr6, Ø 6 mm; load: 1N; top: unstructured ta-C-layer; down: ta-C-layer with ripple-structures).

Excimerlaser microstructuring of polystyrene for biotechnical applications

Using an Excimerlaser microstructuring system (laser wavelength 248 nm) grating structures (bar wide and groove wide 100 µm, depth of structure 50 µm) were produced in polystyrene on an area of 10 mm x 10 mm (Fig. 3). At University of Applied Sciences these structures are used for biological studies.

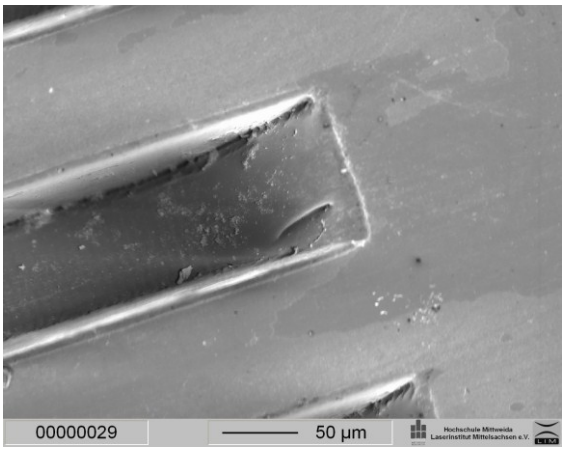

Fig. 3: SEM image, microstructures in polystyrene, bar wide and groove wide 100 µm, depth of structure 50 µm.

In the project „Growth characteristics of adherent cell lines on laser modified surfaces“ (WAZELO) the selective engraftment of mouse fibroblasts is reviewed. Result of these analysis is a 125 % higher cell density for polystyrene probes structured by Excimerlaser with groove wide 50 µm, bar wide 8 µm and depth of structure 50 µm (Fig. 4) in comparison to unstructured reference polystyrene probes.

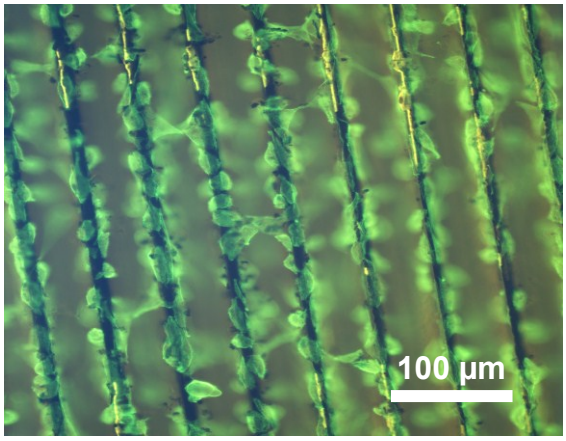

Fig. 4: Mouse fibroblasts of cell line L929 on the surface of microstructured polystyrene (bar wide 8 µm, groove wide 50 µm; focus on top of the bars with strongly adherent cells. image: Dipl.- Biol. Annette Hübner, Zeiss Axiovert 200M fluorescence / laser scanning microscope, 200x, staining with Alexa Fluor 488).

Excimerlaser microstructuring of ta-C-layers

By adoption new developed masks for the mask projection microstructuring system (wavelength 248 nm) defined microstructures with sub micron dimensions, shown in Fig. 5, can be produced in ta-C-layers. In further investigations these structures should be used to diversify the tribological characteristics of the processed surface.

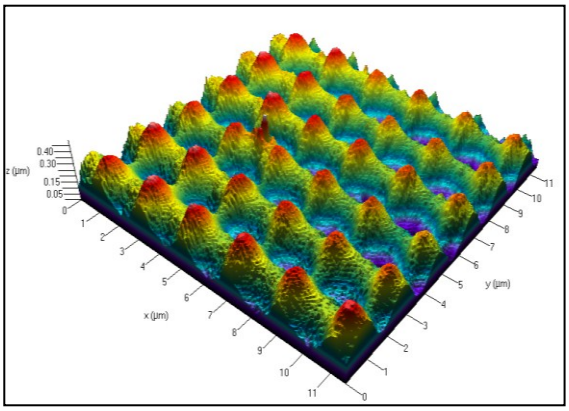

Fig. 5: Laser scanning microscope image, microstructures in a 1,5 µm thick ta-C-layer, average distance of burling 2 µm, depth of structure ca. 300 nm.

Generation of micro drillings in wide band gap materials using VUV- laser

For adoption by optical dark field microscopy circular drillings with a diameter of 16 µm were produced in fused silica substrates (material: Corning HPFS 7980) using a VUV-laser with a wavelength of 157 nm (Fig. 6). The drilling depth of more than 50 µm causes an adequate contrast for microscopy.

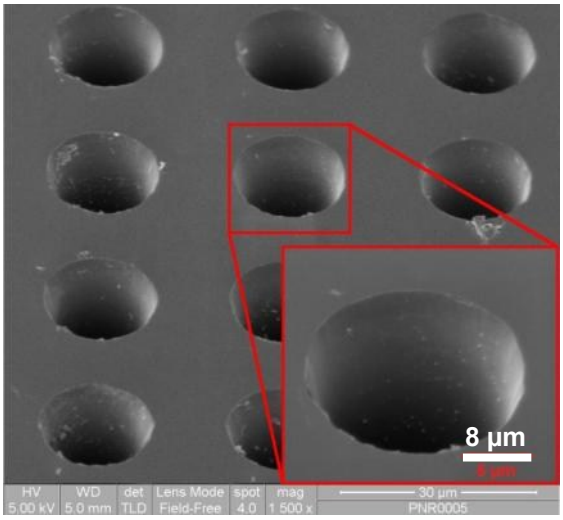

Fig. 6: Array of drillings in fused silica with a distance of 30 µm, a drilling diameter of 16 µm und an average depth of 50 µm.

With the high photon energy of 7,9 eV the laser system (presented in LASER MAGAZIN November 2005) is also useable for structuring materials like CaF_2, MgF_2 und Sapphire with good edge quality and low roughness for the ground of the structure. This could be verified in a large number of investigations.

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