Pyramid Array Substrates for Biomedical Studies

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In order to understand the influence of micro- and nano-structured material surfaces on adjacent biosystems, a broad investigation of cellular reactions and material surfaces is needed. The quality of the initial phase of cell-material interaction, consisting of cell attachment and adhesion followed by cell spreading and migration, is fundamental for growth and survival of the cells[1]. An external biophysical stimulus, such as surface topography or surface chemistry, affects the composition of the extracellular matrix, cytoskeletal organization, the expression of adhesion receptors, and intracellular associated adaptor proteins. Thus a suitably modified surface topography may e.g. improve the acceptance and long-term success of an implant. For this purpose it is mandatory to understand the fundamental principles of cellular responses to the influence of specific biomaterials.

The pyramidal arrays presented here offer very sharp edges and tips, which appeared to be the main adhesion spots in our earlier cell-surface-interaction studies[2]. Being made from silicon nitride with a thin cover layer of titanium they offer mechanical stiffness, inertness to all chemicals used in the cell experiments and a high degree of biocompatibility. The samples were patterned by UV-nanoimprint. Pattern transfer into the etch mask consisting of 100 nm silicon oxide was performed by short exposure to oxygen plasma to remove the residual layer and an anisotropic reactive ion etch step using CHF_3 and N_2. Pits were formed by anisotropically etching in KOH. After removing the remaining SiO_2-mask a 100 nm thin layer of silicon nitride was deposited by plasma enhanced chemical vapor deposition on the silicon substrate (c.f. fig 1). For simple use in biomedical studies, these pyramidal structures were transferred to a Pyrex substrate by anodic bonding. The Pyrex substrates were put on top of the silicon nitride and placed onto a grounded hotplate. The stack was contacted by an electrode from the top. A voltage of about 1 kV was applied to bond the samples at a temperature of 340 °C. After removal of the silicon by etching in KOH the pyramids are finally sputter-coated with a thin layer of titanium. Even though silicon nitride is not a commonly used material for anodic bonding, the bond proved to be sufficiently strong for the production process and for the biomedical studies (c.f. fig. 2).

Process details along with results from surface characterization will be presented for various pyramid sizes down to 200 nm period.

[1] K. Anselme, P. Linez, M. Bigerelle, D. Le Maguer, A. Le Maguer, P. Hardouin, H.F. Hildebrand, A. Iost, J.M. Leroy, Biomaterials **21**, 1567-1577 (2000).
[2] C. Matschegewski, S. Staehlke, R. Loeffler, R. Lange, F. Chai, D.P. Kern, U. Beck, J.B. Nebe, Biomaterials **31**, 5729-5740 (2010).

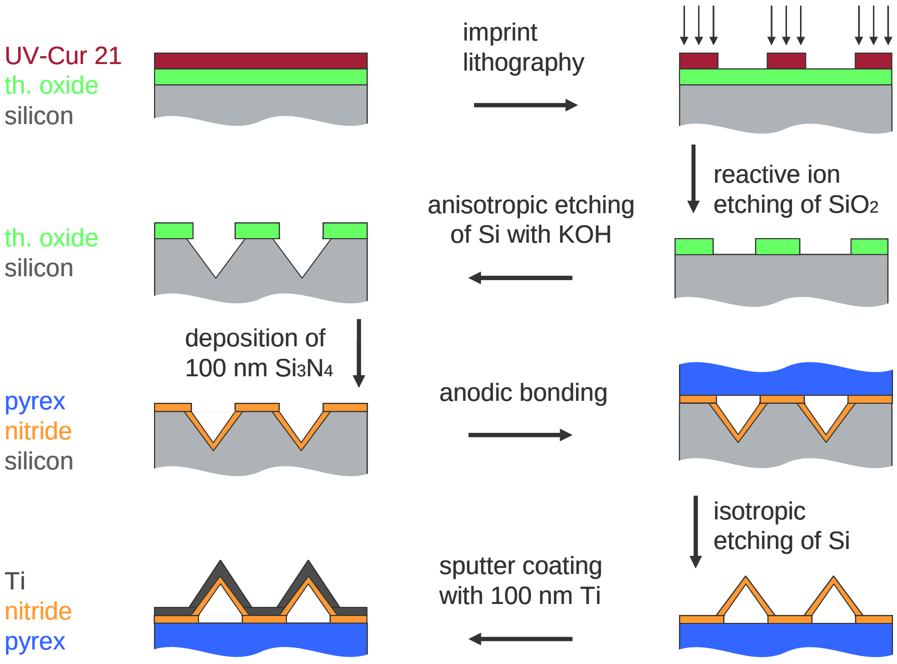

Figure 1. Schematic illustration of the fabrication process.

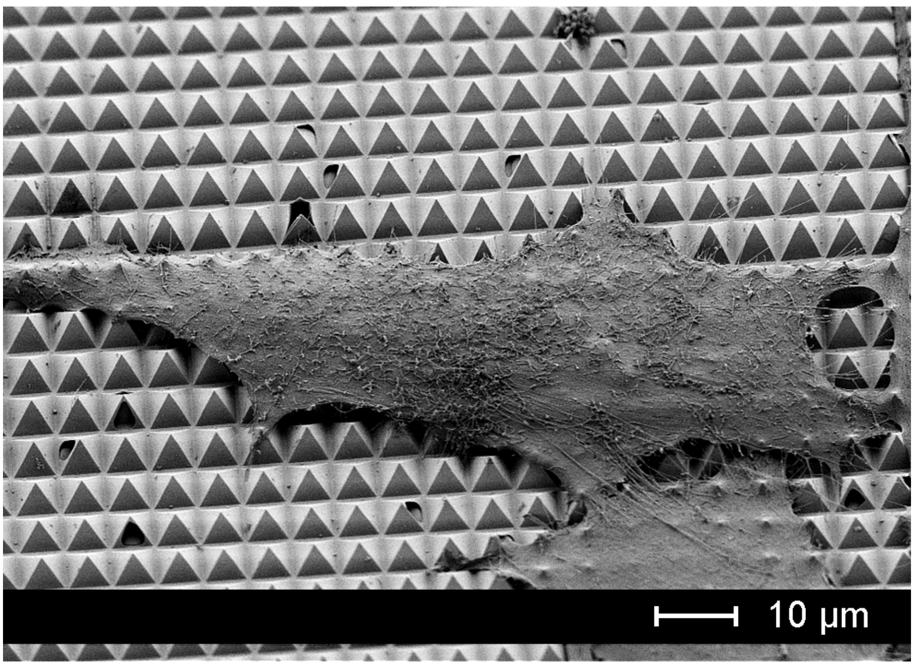

Figure 2. Human osteoblast cells on array of pyramids with a height of 5 µm.