Structured titanium surfaces for biomedical applications

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It is well known that surface topography influences cell behavior like adhesion, migration, and growth [1]. 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. Since titanium is the most common implant material due to its high bio-compatibility and good corrosion resistance [2] it is appropriate to study well-defined titanium surfaces. For this purpose in an initial simple approach, photoresist patterns on a Si or glass substrate were coated by a thin Ti layer [3]. Much sturdier samples which are suitable for adhesion experiments can be obtained by Ti coated Si or SiO_2 structures. Here we present an approach to achieve regularly structured bulk titanium surfaces by reactive ion etching (RIE).

Atomic force microscopy shows that the commercial titanium foils to be used as substrates have a very rough surface. Therefore the samples were further processed by mechanical polishing (c.f. fig. 1). This way the surface roughness was reduced to a few ten nanometers, which is sufficient to examine etch processes with typical etch depths of several hundreds of nanometers. After polishing, the substrates were cleaned in an ultra sonic bath of acetone and isopropanol. The cleaned samples were sputter-coated with a 50 nm thick layer of aluminum, to be used as an etch-mask because of its chemical inertness in fluor-based etch processes [4]. The etch-mask was then patterned by e-beam lithography using NEB-22, a chemically amplified negative e-beam resist, followed by a wet chemical etch step in a mixture of phosphoric acid, sulphuric acid and water. It is known that the titanium substrate is not etched by this mixture [5]. The titanium substrate is then etched in an Oxford PlasmaLab 80 Plus using a mixture of sulphur hexafluoride, trifluoromethane and oxygen. We show that this process can not only be used to prepare silicon structures, for which it is well-established [6], but is also capable of anisotropically etching bulk titanium (c.f. fig. 2). We also present the use of an additional silicon dioxide layer beneath the aluminum film to provide improved lateral stability of the etch-mask during the RIE-process.

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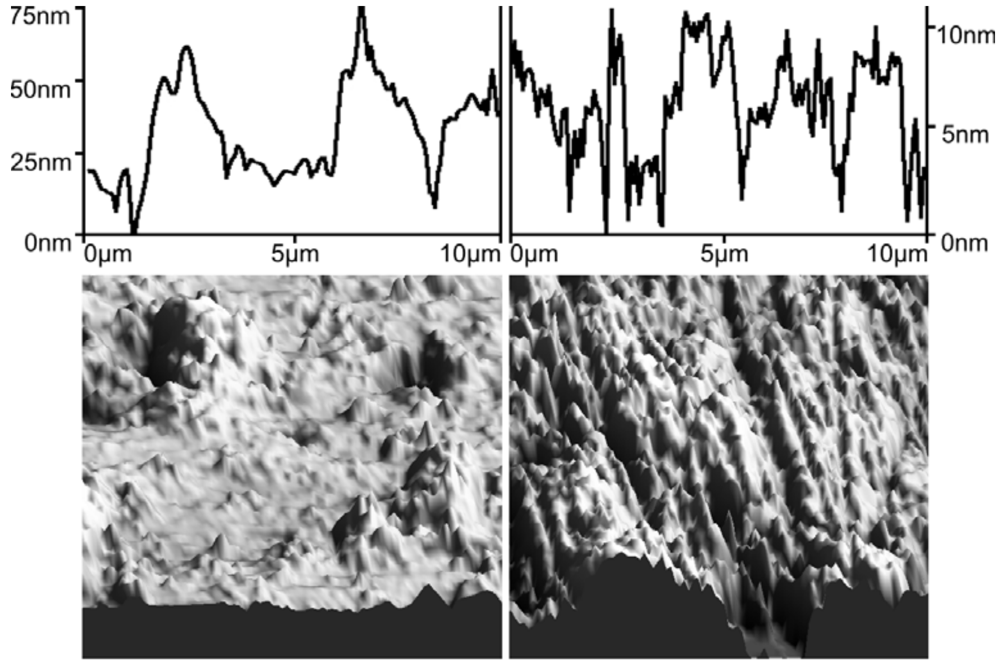

Figure 1: AFM picture of the surface of bulk titanium substrates before (left) and after (right) mechanical polishing.

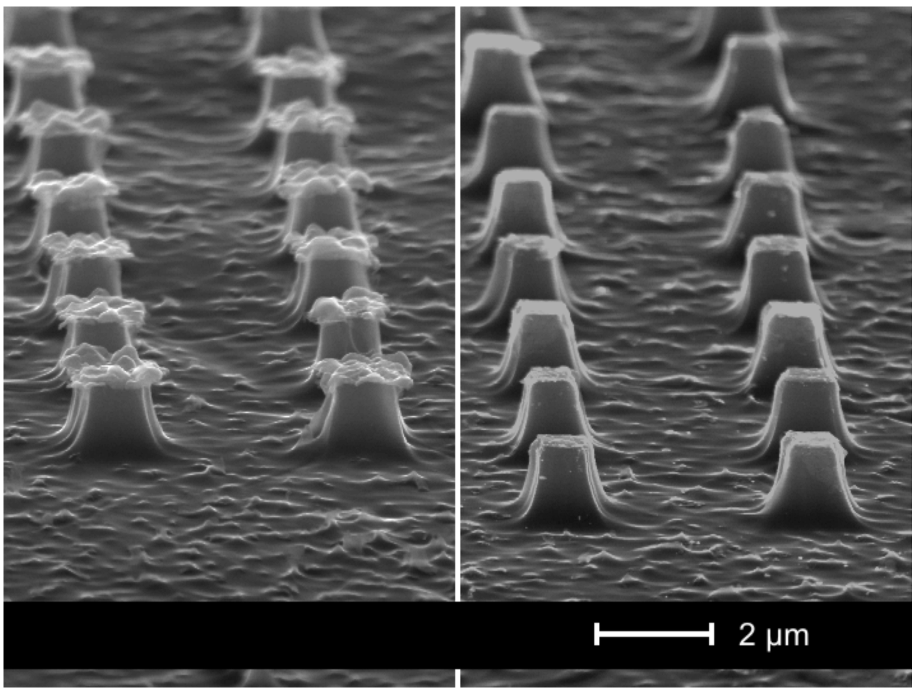

Figure 2: Titanium pillars, directly etched into a solid titanium substrate by an $SF_6/CHF_3/O_2$ reactive ion etch process. On the left the Al etch-mask is still in site on top of the pillars.