

## LASER LITHOGRAPHY ON OXIDE FILM (I)

### 3D Titanium Object Micromachining

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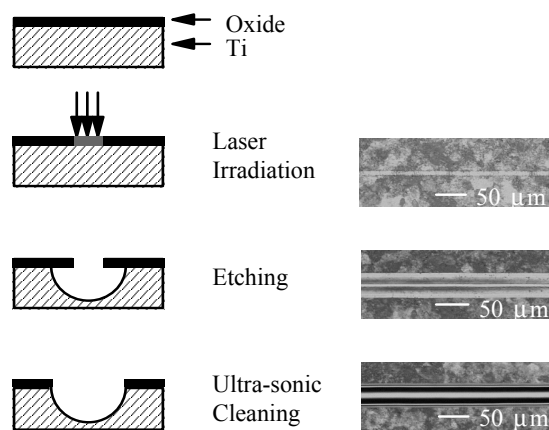
**INTRODUCTION:** Due to its good mechanical properties and chemical inertness, titanium is the material of choice for implantable devices in medicine and dentistry. For many of these applications the surface topography must be carefully controlled to achieve optimum cell adhesion and differentiation [1]. Electrochemical micromachining is a useful method for the fabrication of well defined surface structures in the micrometer range [2]. Normally, anodic dissolution is carried out through a suitably patterned photoresist, but the use of this technique is limited to planar surfaces. Certain applications, for example the production of biomedical implants, involve complex surface geometries to which a photoresist cannot be readily applied. Recently, it has been shown that a laser patterned anodic oxide film could assume the function of the photoresist [3]. In the present study this novel electrochemical micromachining method was applied to produce well defined microstructures on a titanium cylinder.

**EXPERIMENTAL:** The different steps of the process are presented on Fig. 1; results following each step are displayed on the right side. After anodic oxidation, the titanium sample is locally irradiated with a pulsed eximer laser. Next, Electrochemical dissolution takes place which results in isotropic etching. Ultrasonic cleaning is then sufficient to neatly break the free standing oxide bridge resulting from underetch.

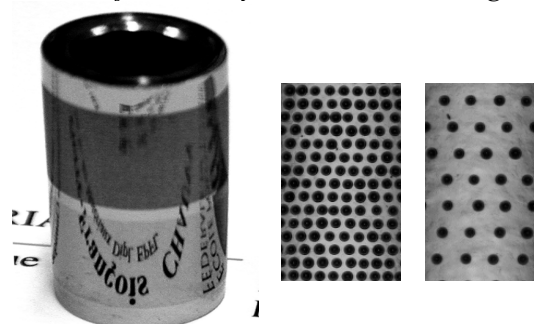
The final microstructure then reveals its shiny surface finish. **RESULTS:** A titanium hollow cylinder (diameter 1 cm, height 2 cm) was first electropolished and anodically oxidized, turning its colour to blue. It was then fixed on moving stages in front of the laser beam allowing lifting and rotating the sample during serial pulse writing. Displacement and laser parameters were set to pattern two areas of hole arrangement with two different spacings (50 and 100  $\mu\text{m}$ ). Laser writing was quite slow (27 min.) but this time could be drastically reduced using more elaborate optics [4]. Electro-dissolution was then carried out for 20 min., yielding well defined 40  $\mu\text{m}$  diameter hemispherical holes (Fig. 2).

**CONCLUSIONS:** Laser lithography on oxide film followed by electrochemical dissolution allowed us to micromachine well defined microstructures on an electropolished titanium

cylinder. This demonstrates the feasibility to use this technique to produce fine topographies on implant surfaces.



*Fig. 1 Processing steps for laser electrochemical micromachining of titanium. After anodic oxidation, serial pulsed laser writing allows for flexible and rapid patterning. Selective electrochemical dissolution of the irradiated features is followed by ultra-sonic cleaning.*



*Fig. 2 Photograph of a microstructured cylinder; Blow-up shows two areas with different densities (50 and 100  $\mu\text{m}$  spacing), holes are 40  $\mu\text{m}$  in diameter.*

#### REFERENCES:

- <sup>1</sup>B. D. Boyan, T. W. Hummert, D. D. Dean and Z. Schwartz, *Biomaterials*, **17**, 137 (1996).
- <sup>2</sup>C. Madore and D. Landolt, *J. Micromech. Microeng.*, **7**, 270 (1997).
- <sup>3</sup>P.-F. Chauvy and D. Landolt, *Electrochem. Solid-State Lett.*, **4** (5), C31 (2001).
- <sup>4</sup>B. Kasemo and J. Gold, *Adv. Dent. Res.*, **13**, 8 (1999).

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