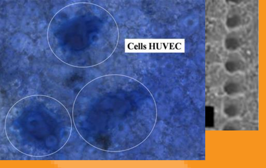

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Laser Surface Modification and Characterization of Titanium for endothelialization of Ventricular Assist Devices

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1. Introduction

Ventricular Assist Devices (VAD) are pumps that stabilize hemodynamics of patients in end stage of congestive heart failure until their recovery or cardiac transplantation [1-3]. Typically, titanium is the biomaterial chosen for machining processes of VADs because it provides stable biological integration without compromising implant biocompatibility. A promising scientific trend is to develop biofunctional materials that integrate with the surrounding endothelial cells that line the artery to afford a prohealing functional response [4, 5]. Biofunctional surfaces for VADs became possible through coatings and surface modification in order to improve the interface between biomaterial and assisted organ [6].

Our previous studies with Plasma Electrolytic Oxidation (PEO) technique formed a promising textured oxide layer with scaffolding characteristics and pore size proportional to endothelial cells of circulating blood [6, 7]. The textured layer created by PEO is capable of promoting endothelialization in vitro as shown with in vitro tests performed with Human Umbilical Vein Endothelial Cells (HUVEC) [7, 8].

The aim of the experiments is to promote a textured surface similar to that obtained by PEO process but using laser materials processing available in KNMF. Unlike micro arcs created in PEO [9, 10], the interaction of laser with metal surface can be controlled at micro and nano levels [11, 12]. Thus, we expect to alter morphology and topography, creating pores and scaffolds of size between 5 to 20 µm increasing adhesion of endothelial cells and reducing hemolysis inside VADs [8].

2. Materials and methods

Based on surfaces obtained with a 100W Q-switched YAG laser and 10 kHz pulse frequency and 0.6 µs pulse width [13], the experiments here proposed for texturing titanium can be conducted with YAG lasers available in KNMF. The idea is to reproduce topography of cell pits like previously obtained with PEO.

Titanium samples should be disks with 12mm in diameter and series of regular features with dimensions of the order of tens of micrometers as shown in Figure 1. Cell response to these features can be further determined with HUVEC cells [8].

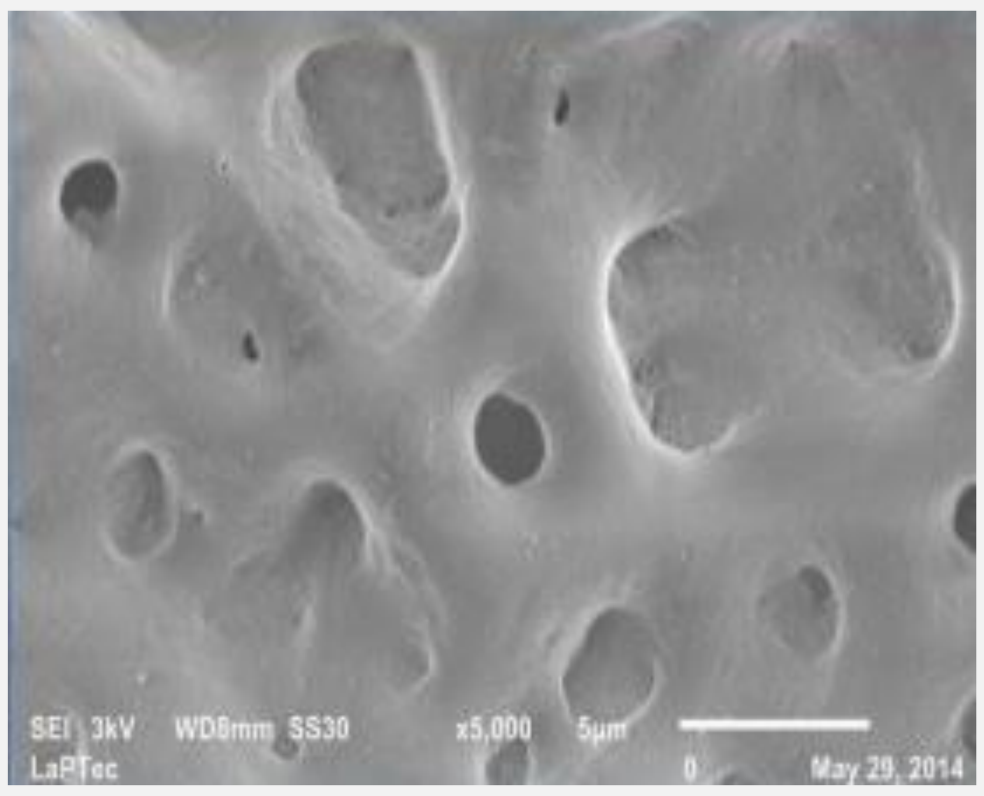

Figure 1: SEM micrographs of pores and scaffolds obtained with PEO, cells response after endothelialization.

Initial topography is a major influencing factor on substrate surface and future procedures for HUVEC cell culture [8].

Characterisation of the laser milled features will determine its feasibility with a lengthscale of a few microns (5 to 20 µm) superposed on the larger scale groove structures [13].

Samples characterization must be performed before and after material processing by lasers and different processing parameters or techniques.

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3. Results and conclusions

An advantage of laser based methods to modify texture of titanium surfaces is that they are non-contact, clean processes that are highly controllable and are well suited to automation and on-line monitoring [13]. The textured surface is similar to that obtained by PEO process, Figure 2 [8].

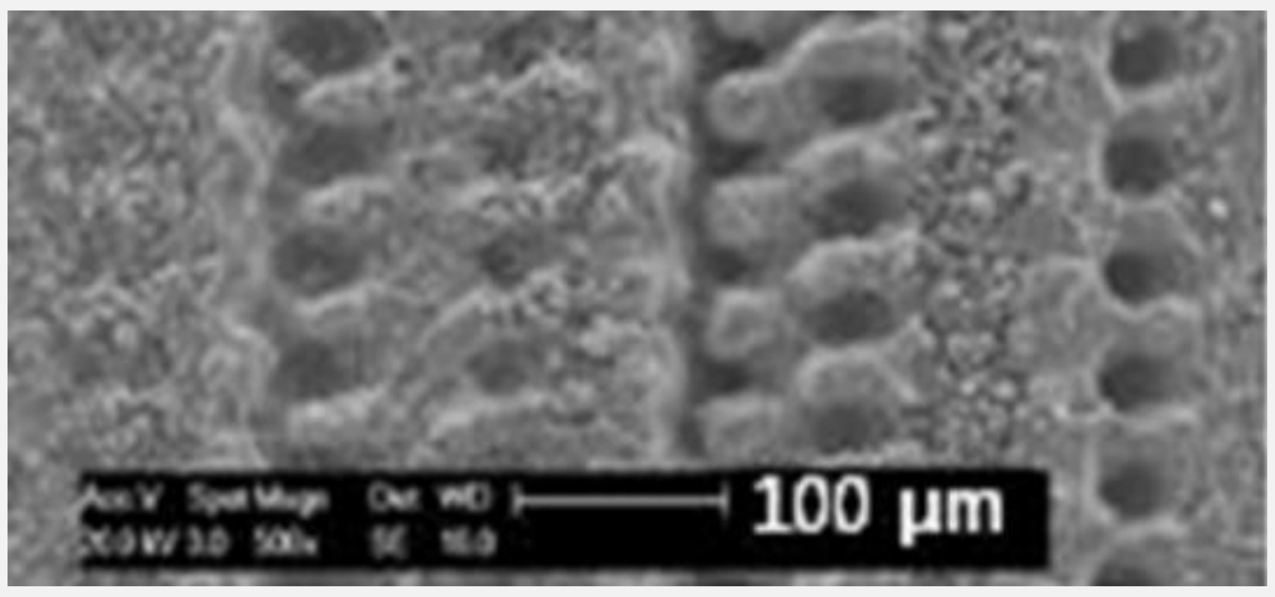

Figure 2: Groove and cell pits obtained with 100W laser 500mm/s.

Several different types of laser materials processing can serve to this task. Different parameters could be altered in order to obtain a better topography to a biofunctional surface like Figure 1 [5, 6, 13].

Up to the present time, our studies with PEO (Figure 3) has been relatively complex due to reagents and the difficulty of mathematical modeling of physical phenomena involved with formation of micro arcs. Laser processing require reagents and could be simpler than PEO [11-13].

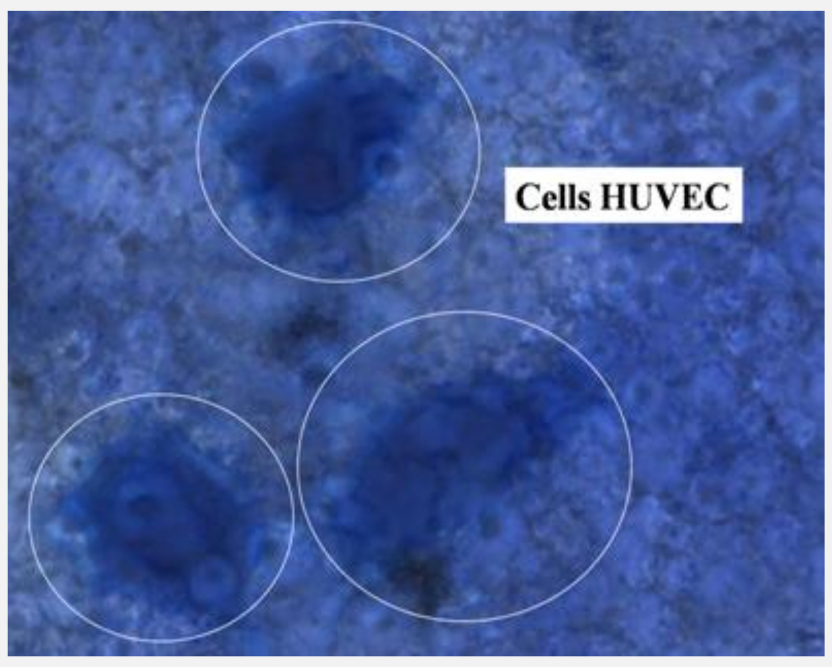

Figure 3: Cells response to endothelialization after PEO.

It is expected that a surface formed by pores and scaffolds of 5 to 20 µm would enhance biofunctionality increasing endothelial cell adhesion and reducing heparin dosage, also avoiding rupture of red blood cells caused by mechanical trauma (hemolysis) [8, 13].

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