Creation of nano-structured oxide layers through anodization on laser-remelted Ti_6Al_4V surface for improvement of Its biofunctionalities

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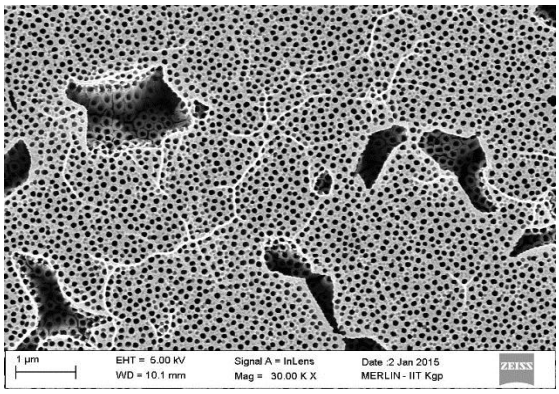
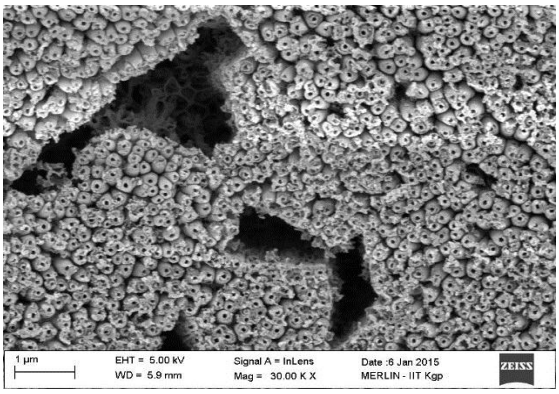
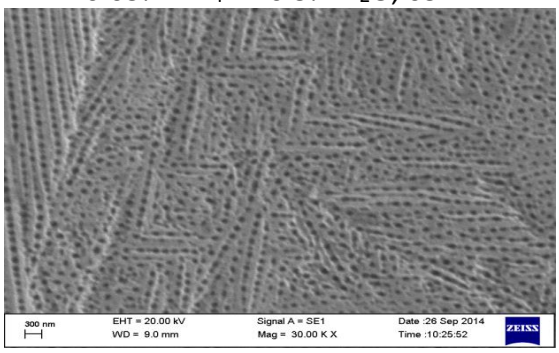
Abstract: Nano-structured surfaces are known to enhance the cell-surface interaction. Controlled anodic oxidation of laser-remelted Ti surfaces in F^- containing electrolytes produces different nano-morphologies on the surface, leading to higher cell growth and differentiation on the surface. Therefore, application of such nanoscale surface modification techniques on micro-featured implant surfaces results in hierarchical nano-to-micro features, which can further advance the biological performance of the implants. Thus, anodization of laser-processed Ti6Al4V surfaces was explored to identify the influence of associated process parameters on the resulting surface nano-morphologies. The corrosion resistance and osteogenic potential of the anodized surfaces were also studied. Fluoride containing non-aqueous electrolytes with varying concentrations of F^- ions and water were used to anodize laser-remelt surfaces. The resultant nano-topographies could be classified as nano-porous, nano-tubular or nano-grass like structures.



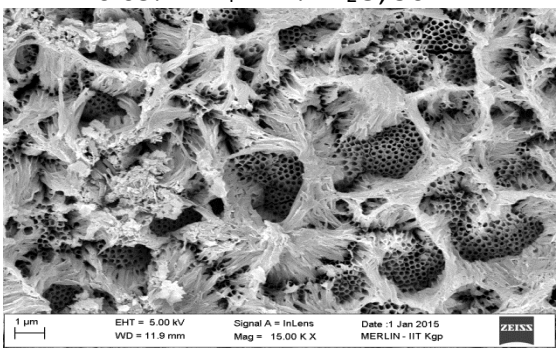
(a)Acid etched Ti6Al4V, Ethylene Glycol + 0.05% NH_4F + 0.5% H_2O, 65 V



(b)Acid etched Ti6Al4V, Ethylene Glycol + 0.05% NH_4F + 1% H_2O, 90 V



(c) Laser remelt Ti6Al4V, Ethylene Glycol + 0.05% NH_4F + 2% H_2O, 65 V



(d)Laser remelt Ti6Al4V, Ethylene Glycol + 0.2% NH_4F + 5% H_2O, 140 V

Figure: Surface morphologies after anodization under different experimental conditions.

5th International Conference on Nanotechnology for Better Living (NBL-2019), Jointly organized by National Institute of Technology (NIT) Srinagar and Indian Institute of Technology (IIT) Kharagpur; April 7 – 11, 2019 at SKUAST, Shalimar Srinagar, Jammu and Kashmir, India; Editor: Dr. M. A. Shah and Prof. P. Banerji, ISBN:978-81-939516-0-6; Published by Applied Science Innovations Pvt. Ltd., Pune, Maharashtra, India.

All the anodization parameters, namely, the applied potential, the concentrations of F^- ions and water content in the electrolyte, had roles to play in determining the type of nano-topographies as well as the dimensions of the porous/tubular structures. Nano-structures evolved on laser-remelted surfaces were homogeneous, but the presence of distinct α and β phases gave rise to inhomogeneously distributed nanostructures. Osteogenic differentiation of hAMSCs on the laser-remelted and anodized surfaces was higher than that on the acid-etched and anodized surfaces.

Controlled anodization of the laser-remelted surface was shown to induce osteogenic differentiation of stem cells, and thus, can accelerate the healing process. It is also possible to use the nano-tubular structures for controlled release of different drugs from the implant surface post-surgery.

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