Ultra-fast laser surface processing of bio-implants for improved bio-compatibility

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Abstract

Bio-implants such as 45S5 bio-glass and Ti6Al4V-alloy have emerged as a potentially successful and preferred option for treatment and repair of bones as such materials facilitate growth of calcium rich Hydroxyapatite (HAP) on its surface in human plasma. However, a major drawback affecting use of these materials has been implant failure caused by contamination and bio-film formation on implant surfaces during implantation. Among number of strategies to improve bio-integration and to limit bacterial attachment, surface texturing of implants using ultra-short laser pulses is emerging as a promising option. This technique being a single step, chemical free process is an attractive approach as it also allows surface treatment localized both, in time and space.

In the work being reported, we have used a beam from a femtosecond Titanium: Sapphire laser delivering pulses of pulse width 45 *fs* and at repetition rate 3 kHz, at a wavelength of 800 nm focused on to the polished surface of the implant. Our in-vitro tests have demonstrated improved bio-integration efficiency of implants post laser treatment. Our results also establish that, laser surface modification of implants enables superior bacterial rejection without affecting its biocompatibility towards growth of human cells on it.

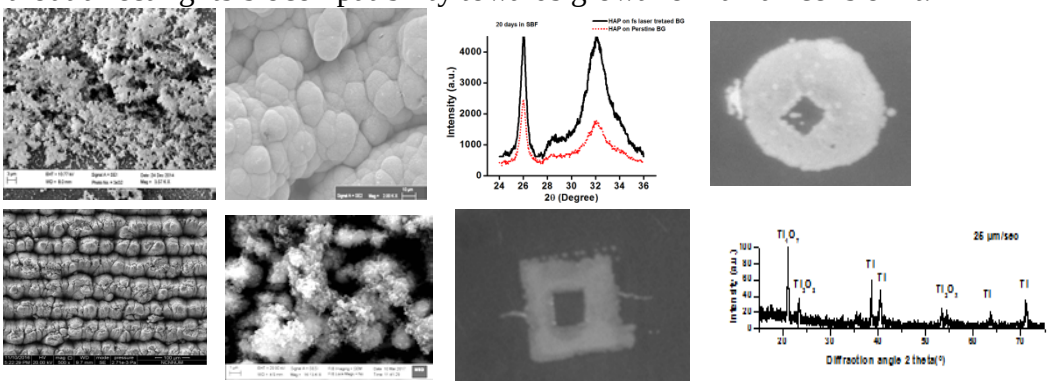


Figure: SEM image of (a) femtosecond laser treated BG (b) HAP grown on laser treated BG, (c) XRD for HAP, (d) photograph of nutrient agar plate showing replica imprint of laser treated BG after 2 hr incubation with Staphylacaccus aureus bacteria *(e) SEM image of laser treated Ti6Al4V-alloy , (f) SEM image of HAP on Ti6Al4V-alloy (g)photograph of nutrient agar plate showing replica imprint of titanium implant after 2 hr incubation with bacteria (h) XRD confirming megneli phase (Ti_4O_7) on laser treated Ti6Al4V-alloy.*

Scanning Electron Microscope images in Fig. 1a and 1b shows, generation of micro-porous structure and agglomeration of HAP on laser treated BG indicating efficient bio-integration post laser treatment. Higher intensity of X-ray diffraction (XRD) peak in Fig. 1c, confirmed faster growth of HAP on laser treated BG. Adhesion and growth of *Staphylacaccus aureus* bacteria on untreated BG and complete rejection on laser treated surface was clearly seen in replica imprint of nutrient agar plate, as shown in Fig. 1d. Unlike

BG, sharp conical structures were generated on Ti6Al4V (Fig. 1e) on laser treatment, which supported faster growth of HAP (Fig. 1f) and rejected *Staphylacaccus aureus* (Fig. 1g) completely. Presence of Ti_4O_7 megneli phase of titanium on laser treated surface was confirmed from XRD (Fig. 1f), which is known to kill bacteria.

Laser surface treatment thus can serve as a potential technique to improve both bio-integration and antibacterial properties of implants.

Keywords—*Laser surface processing, 45S5 bio-glass, Ti6Al4V-alloy, Antibacterial bio-implants*

Professional Biography

Dr. Sunita Kedia has completed her PhD at the age of 29 years from Indian Institute of Technology Bombay, India. Her thesis title is *Self-Assembled Photonic Crystals and Heterostructures for Light Control.* She did her postdoctoral studies from Physical Research laboratory Ahmedabad, India. Presently, she is a scientist in Bhabha Atomic Research Centre, India mainly working on laser surface processing of bio-implants using pulsed lasers, design and development of photonic crystal based micro-cavity lasers and pulsed laser deposition of boron carbide for neutron detection, thermo-electric conversion and high reflection coating. She has published more than 20 papers in reputed journals.



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