Video Article

Low Temperature Coating of Hydroxyapatite/Titanium Nanoparticles on Ti6Al4V Substrate with a Continuous Mode Nd:YAG Laser

New Author Gary[1]

[1]

Correspondence to: New Author Gary at Cheng

URL: http://www.jove.com/video/2353
DOI: doi:10.3791/2353

Keywords: Laser coating, hydroxyapatite, titanium nanoparticles, functional gradient coating, interfacial bonding strength, biocompatibility

Date Published: 6/15/2015

Citation: Gary, N.A. Low Temperature Coating of Hydroxyapatite/Titanium Nanoparticles on Ti6Al4V Substrate with a Continuous Mode Nd:YAG Laser. *J. Vis. Exp.* (), e2353, doi:10.3791/2353 (2015).

Abstract

Hydroxyapatite (HA) is a crystalline calcium phosphate with similar chemical composition to natural human bones; it is now used extensively in many medical applications. However, HA alone has limited application in load-bearing functions due to its unfavorable hardness, ductility, and toughness1. Combining HA with metal substrate improves mechanical strength2,3, biological fixation ability4,5, and osteoconductive property6 of implants. Microscale HA particles on metal implant were first coated on metal implants via plasma spray method7,8. Alternative techniques, including spin and dip coating9,10, deposition techniques11-17, thermal spray techniques2,18, and laser coating techniques3,4, were also proposed. Recent studies found significant advantages of nanosized HA (nanoHA) over large scale counterparts19-25. Various coating techniques, including anodic spark discharge26, chemical treatment27, electrochemical coating28, and sol-gel coating29 were developed to coat nanoHA. The main challenge for coating nanoHA remains weak coating/substrate bonding, non-uniformity of coating, mismatch of thermal and mechanical properties due to sharp interface, and limited thickness. Those drawbacks limit the implant in broader applications. There is an instant need to develop alternative methods to produce better coated implants. Low temperature laser coating of nanoHA/nanoTi (titanium nanoparticles) was developed in current investigation to address these needs. Laser beam heats the nanoTi based on the laser-particle interactions. Once its melting point is reached, nanoTi will be molten which creates a liquid network to entrap surrounding nanoHA. After solidification of nanoTi, nanoHA could then be bonded to the substrate. The methodology and experimental set-up are shown in Fig. 1. NanoTi were introduced here due to its lower melting point and stronger interaction with incident laser waves. With presence of nanoTi, lower temperature coating with lower laser power is realized since lower temperature is needed to melt nanoTi. To demonstrate this approach, we deposited nanoHA/nanoTi mixture on a Ti-6Al-4V substrate via dip-coating. Laser beam was applied to heat the dip-coated substrate. The laser power is selected such that nanoTi is melted and nanoHA will be bonded on the substrate. A multiphysics model coupled electromagnetic with heat transfer module is built to understand the mechanism of the laser coating process. It is found that the coating/substrate interfacial strength of the laser engineered coating is two times higher than that of the plasma sprayed coatings. Biphasic calcium phosphate (BCP) is introduced during the process, which is reported to have excellent biocompatibility. Indeed, we have shown that the resultant BCP/Ti nanocomposite coating supports the adhesion, spreading, and proliferation of osteoblast-like UMR-106 cells.

Disclosures

No conflicts of interest declared.