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Bioceramic Coatings with Nanostructural Surface Prepared by Plasma Spraying

Liu, XY 1,2, Wang GC1, Ding, CX1, Paul K. Chu2

1 Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai 200050, China
2 Dept. of Physics & Materials Science, City University of Hong Kong, Kowloon, Hong Kong

Introduction

Nanoscale materials are thought to interact with some proteins more effectively than conventional materials to mediate osteoblast functions due to their similar size and altered energetics. Balasundaram et al. [1] thought nanophase materials might be an exciting successful alternative orthopedic implant materials due to their ability to mimic the dimensions of constituent components of natural bone (like proteins and hydroxyapatite). Webster, et al. [2-4] revealed that nanophase ceramics could promote osseointegration that is critical to the clinical success of orthopedic/dental implants. Therefore, in this work, TiO2 and ZrO2 coatings with nanostructural surface were prepared using plasma spraying, and their bioactivities were also evaluated.

Experimental

Commercially available nanometer-sized TiO2 powders (P25, Degussa, Germany) and ZrO2 powders stabilized with 12.8mol% calcia were were deposited onto Ti-6Al-4V substrates by atmospheric plasma spraying (APS) under modified spraying parameters. The as-sprayed TiO2 coatings were post-treated by UV-illumination in air for 24 hours to enhance its bioactivity. After ultrasonically washed in acetone and rinsed in deionized water, the coatings were soaked in a simulated body fluid (SBF) for four weeks. The formation of apatite on the coatings was used as an indicator of its bioactivity.

Results and Conclusions

The high magnification surface views of the as-sprayed TiO2 and ZrO2 coatings displayed in Fig. 1 indicate that the surface of the TiO2 coating comprises particles about 50 nm in size (Fig. 1a), whereas the surface of the ZrO2 coating is made of particles with size of about 100 nm (Fig. 1b). However, in the interior of the coatings, most of the grains exhibit a columnar morphology with a diameter of about 100~200 nm. The difference in the crystal growth between the surface and interior of the coating depends mostly on the thermal history. During plasma spraying, the bulk of the coating tends to possess larger columnar grains due to the continuous heat provided by the plasma and subsequent melt, whereas the surface grains are subjected to less heating.

![Figure 1. Surface views of plasma sprayed TiO2 (a) and ZrO2 coatings with nanostructural surface.](image)

After immersion in SBF for four weeks, the surface of the UV-illuminated TiO2 coating and as–sprayed ZrO2 coating with nanostructural surface can induce the bone-like apatite to precipitate their surfaces. It is well known that plasma sprayed TiO2 and ZrO2 coatings with conventional surface can not do so. It can thus be inferred that the bioactivity of the plasma-sprayed TiO2 and ZrO2 coating depend on nanostructured surface composed of enough small particles.

References