285 Synthesis of Ti-nanocrystalline alloys foams for biomedical applications

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The average age and life expectancy of human beings have continuously increased producing degenerative diseases, which leads to degradation of the mechanical properties of the bone. It has been estimated that 90% of the population (over 40 year old) suffered by these diseases. Some work have reported that the total number of joint replacements were rise to 174% and the total knee arthoplasties may grow to 673% in the USA by 2030 which is involves around 4 million of surgeries.

Artificial biomaterials were the solution for these problems and are expected to serve for longer time without failure. Therefore it is very important to develop the appropriate materials with high longevity, adequate mechanical properties and excellent biocompatibility. Pure Ti and Ti-based alloys have been more widely employed in biomedical applications rather than other metallic alloys because of its low E, low density, high specific strength, good biocompatibility and corrosion resistance [1]. The first generation of Ti-based alloys have some disadvantages such as: relatively poor wear resistance, low hardness, relative higher stiffness than human bones. The stiffness mismatch between the implant materials and human bones, causes bone resorption and eventual loosening of the implants. Also some alloying elements, like Al, V, Ni and Co that present in Ti-based alloys leads to toxic effects when they are released into the human body. Some diseases that can be produced from these elements are dermatitis, alzheimer, neuropathy and ostemomalacia. So the second generation of Ti-based alloys were produced with non-toxic elements for human body, like as Nb, Mo, Zr, Ta, Mn, but still these alloys presents the problems with mechanical, elastic modulus and corrosion properties [2].

The third generation of biomaterials are nanocrystalline and amorphpus materials. Nanomaterials are very interesting because they exhibit an unusual combination of properties such as strength, good ductility, high fracture toughness, and good corrosion resistance. These new and unsuspected chemical and physical properties are not found in coarse-grained materials. The bone forming cells generally attach themselves to the surface whose roughness is of nanometer range. The nano roughness arises because of the fact that our bones consist of inorganic minerals of grain size varying from 20 to 80 nm long and 2 to 3 nm in diameter. Ti-based alloys with bimodal microstructures produce a high ductility and strength. Apart from tissue compatibility, the mechanical properties also vary with grain size. Further, nanocrystalline coatings on biomaterials with grains of nanosize will lead to novel and enhanced mechanical properties.

References

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