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Effect of Carbon Nanotubes on the Behavior of the Nanocomposites TiNb/CNTs and its Weldability with TA6V by Spark Plasma Sinter for Orthopedic Application

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ABSTRACT

In the present work, nanocomposite Ti 50wt.% Nb with and withaout reinforcement of carbon nanotubes were successfully fabricated by ball milling of Ti, Nb and SWCNTs nanopowder mixture folloyed by field actived spark plasma sintering process (FASPS) for biomedical application, superconductivity and magnetism in the ITER Project. The use of brittle Ti powder, instead of ductile elemental powder, led to significant increment in the yield of mechanically alloyed powder. The powder consisted of homogeneously distributed nano-sized Ti/Nb particles together with micron-sized pure Nb particles. Sintering of the powders under low temperature and pressure conditions (1273 K, 1473 K and P=50 Mpa) resulted in the fine-grained heterogeneous microstructure consisting of α and β phases. On the other hand, sintering at higher temperatures (1473 K) resulted in a relatively coarse-grained chemically homogeneous microstructure with almost complet phase.

Coarse-grained homogeneous β TiNb alloy exhibited higher average hardness as compared to that of heterogeneous fine-grained microstructures. An attempt has been made to illustrate the correlation between the microstructural characteristics and mechanical properties of the sintered Ti50Nb compacts. To studies and to develop the influence of CNTs on the behavior of the nanocomposite TiNb/CNTs and the welding joint interface between TA6V and nanocomposite by sparck plasma sintering. At last, the continuation of the work has been discussed and prepared, planning dynamic flexion tests to measure the TiNb, TiNb/CNTs, TiNb/CNTs,/TA6V fatigue limit and developing a computer processing chain in order to customize prostheses respecting patients' morphology.

Introduction, Experimental and Results

Total Hip Arthroplasty (THA) is used to replace a damaged hip joint. Bone is a living tissue which remodel itself depending on its solicitations. If a bone does not withstand enough stresses, it will lose density be weakened and fracture. After a joint replacement, the differences of mechanical properties, and mostly the Young's modulus, between the prosthesis (110 GPa) and the bone (20 GPa) modifies the solicitations distribution. This phenomenon is called stress-shielding because it obstructs the constraints transmission from the implant to the bone. However, coating the prosthetic stem, by the process, with a superelastic titanium alloy, TiNb, might reduce the stress-shielding effect. This TiNb alloy [1,2]. Has a low Young's modulus (60 to 80 GPa) which can be lowered (about 35 GPa) thanks to a "flash sintering" The stresses distribution should be enhanced, the bone more stimulated resulting in a lower risk of fracture or implant loosening. The ultimate aim of this work is to demonstrate the process TiNb alloys, TiNb/CNTs [3] nanocomposites and TiNb/CNTs/TA6V after welding by FASPS has the required mechanical and chemical properties for this kind of biomedical applications.

First, nanoindentation tests were performed with a coupled analysis in a scanning electron microscope to show the gradient properties the interface between the bulk TA6V [3-5] and the TiNb, TiNb/CNTs, cladding. Scratch and wear tests were used to study the tribological properties of this Titanium alloy nanocomposite in comparison with welded with TA6V. Then, galvanic corrosion risk was also analyzed between the interface of TA6V and TiNb and TiNb/CNTs in physiological medium. At last, the continuation of the work has been discussed and prepared, planning dynamic flexion tests to measure the TiNb, TiNb/CNTs and TiNb/CNTs/TA6V fatigue limit and developing a computer processing chain in order to customize prostheses respecting patients' morphology. Titanium and its alloys have been widely used in key engineering applications covering a variety of areas, such as aerospace, marine, biomaterials, chemical industries, sports, etc., due to their unique combination of outstanding mechanical and chemical properties. In spite of all the meritorious properties of titanium-based alloys and reinforced by CNTs, the complexities associated with their thermo-mechanical processing and subsequent machining limit their widespread usage.

Therefore, it is necessary to develop an optimum fabrication/processing strategy to offer commercially viable and good quality Ti-based near-net shaped products. A field actived spark plasma sintering process (FASPS). based processing approach could be a suitable way of achieving these ble relayive density and mechanical properties. However, the preparation and handling of Ti-based powders has several issues associated with it.

Nevertheless, in recent years, several new processes have been developed to prepare high quality elemental Ti and Ti-alloys at a relatively lower cost [6]. These processes combined with other secondary powder metallurgy-based operations spark plasma sinter offer several advantages over other conventional fabrication processes, enhancing the feasibility of commercial viability of Titanium, its alloys and nanocomposites.

Conclusion

The effect carbon nanotubes addiions and sintering temperature on the microstructure and mechanical properties of the sintered binary Ti 50 wt. % Nb alloy compacts have been evaluated, and the results related to this aspect are presented and discussed. The possibility to develop the weldability of TiNb/CNTs nanocomposites [3] with TA6V alloys to form TiNb/CNTs/TA6V by sparck plasma sintering is in achived. TiNb/CNTs nanocomposites has required mechanical and chemical properties for this kind of biomedical applications. First, nanoindentation tests were performed with a coupled analysis in a scanning electron microscope to show the gradient properties the interface between the TA6V bulk substrate and the TiNb/CNTs adding. Scratch and wear tests were used to study the tribological properties of this Titanium alloy in comparison with TA6V. Then, galvanic corrosion risk was also analyzed between TA6V/TiNb and TiNb/CNTs in physiological medium. At last, the continuation of the work has been discussed and prepared, planning dynamic flexion tests to measure the TiNb and TiNbCNTs/TA6V fatigue limit and developing a computer processing chain in order to customize prostheses respecting patients' morphology.

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