DEPOSITION Ti-Sn ON AISI 316L SUBSTRATE WITH SURFACE MECHANICAL ALLOYING TREATMENT (SMAT) FOR BIOMATERIAL APPLICATION IN SIMULATED BODY FLUID

DEPOSISI Ti-Sn PADA AISI 316L DENGAN METODE SURFACE MECHANICAL ALLOYING TREATMENT UNTUK APLIKASI BIOMATERIAL PADA LARUTAN SIMULATED BODY FLUID

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Abstract

The properties of biomaterials such as biocompatibility, which is non-allergic and non-toxic to be the main requirements that must be owned by the biomaterials because of the presence of direct contact between the biomaterial with body parts. Therefore the study of biomaterials is constantly carried to repair the biocompatibility. In this research, the improvement of the properties the compatibility of the metal alloy AISI 316L with superimposed ideal bio-inert Ti-Sn with the method of Surface Mechanical Alloying Treatment. Manufacture of the alloy with bio-inert Ti-Sn using a variation of the composition of Sn of 10% and Sn 20% done using Mechanosynthesis process. The results of the process are sintered with the variation of temperature of 800ºC and 900ºC for 2 hours and then were characterized by an optical microscope. Corrosion testing of the alloy was carried out with Polarization Tafel System Three Electrode method for 10 minutes. The results of characterization with an optical microscope shows there is a layer of bio-inert Ti-Sn the results of the process of SMAT of AISI 316L. The results of corrosion testing on alloy AISI 316L Ti-Sn in a solution of SBF showed that the content of Ti-10%Sn with a temperature of 800ºC the obtained corrosion rate 4.785 MPY and at 900ºC amounted to 4.155 MPY as well as on the content of Ti-20%Sn with a temperature of 800ºC the obtained corrosion rate 3.525 MPY and at 900ºC amounted to 3.234 MPY.

Keywords: Biocompatible; Biomaterial; AISI 316L; Ti-Sn; Corrosion Rate; Allergic Reaction; Deposition.

Abstrak

Sifat biomaterial seperti biocompatible, yaitu non-allergic dan non-toxic menjadi syarat utama yang harus dimiliki oleh biomaterial karena adanya kontak langsung antara biomaterial dengan bagian tubuh. Oleh karena itu penelitian biomaterial terus-menerus dilakukan dengan tujuan untuk perbaikan biokompatibilasnya. Pada penelitian ini dilakukan perbaikan sifat kompatibilitas paduan logam AISI 316L dengan melapiskan paduan bio inert Ti-Sn dengan metoda Surface Mechanical Alloying Treatment. Pembuatan paduan bio inert Ti-Sn dengan variasi komposisi Sn 10% dan Sn 20% dilakukan dengan menggunakan proses mekano sintesis. Hasil proses deposisi paduan bio inert T-Sn dengan metoda SMAT disintering dengan variasi temperatur 800℃ dan 900℃ selama 2 jam. Hasil deposisi paduan bio inert T-Sn pada AISI 316L dikarakterisasi dengan mikroskop optik. Pengujian korosi paduan bio inert Ti-Sn hasil deposisi pada AISI 316L Ti-Sn dilakukan dengan metoda Polarisasi Tafel System Tiga Electrode selama 10 Menit. Dari hasil karakteriasi dengan mikroskop optik menunjukkan bahwa terdapat lapisan bio inert Ti-Sn hasil proses SMAT pada AISI 316L. Hasil pengujian korosi pada paduan AISI 316L Ti-Sn dalam larutan SBF menunjukkan bahwa pada kandungan Ti-10%Sn dengan temperatur 800℃ didapat laju korosi 4,785 MPY dan pada 900℃ sebesar 4,155 MPY serta pada kandungan Ti-20%Sn dengan temperature 800℃ didapat laju korosi 3,525 MPY dan pada 900℃ sebesar 3,234 MPY.

Kata Kunci: Biocompatible; Biomaterial; AISI 316L; Bio inert; Ti-Sn; Laju korosi; Allergic Reaction; Deposition.

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INTRODUCTION

The survey conducted on Bindu Post Baby Mother, PHC Serpong 1 in 2014 gives the result that 100 participants Pos Bindu experiencing tooth loss with an average loss of eleven teeth per person. Therefore, people look for other alternatives to replace lost teeth. Currently, one of the alternative treatments that can be done is with dental implants[1)].

Dental implants were a surgical component that interacts with the jaw or skull bone to support dental prostheses such as jaw, bridges, dentures, prosthesis face or act as an anchor for orthodontic. The imported implants are mostly made from AISI 316L because AISI 316L has pretty good corrosion resistance. In some cases, bone implants using AISI 316L cause an infection in the body tissues due to the material's corrosion within a few years following an implant process. AISI 316L often causes problems after the installation of implants made of engineering material with Ti-6Al-7NB [2)].

Ti-Sn alloy has the properties of non-toxic and allergenic. Then, tin (Sn) is an alloying element that is safe to be made with a Ti alloy. In addition, Sn also could strengthen the alloy Ti (Dos Santos., 2017) so that the Ti-Sn alloy can produce some favourable mechanical properties that can be used as a metal for dental casting [3)].

Surface Mechanical Attrition Treatment (SMAT) is a new modification of the MA to induce grain in the surface layer of sample [4)]. The basic principle of SMAT is the formation of plastic deformation in the surface layer on the impact of a collision on the milling process. During the SMAT, the top layer of the nanocrystalline grain boundary is formed by a large orientation, cessation of dislocation [4)].

MATERIALS AND METHODS

Materials

The materials used for this research are an alloy of Ti –Sn and those retrieved from PSTNT BATAN Bandung. The alloy has cylinder-shaped with a diameter of 1.4 cm t and 1.5 cm thick. The chemical composition of the alloy AISI 316L is shown in table 1 below, and the Chemical composition of the alloy Ti-Sn is shown in table 2.

Table 1.
Chemical composition AISI 316L

TOTAL COMPOSITION	
COMPOSITION	**%**
Fe	Balance
C	0.03
Mn	2.00
Si	0.75
Cr	18.36
Ni	12.00
Mo	2.00

Table 2.
Chemical composition Ti-Sn

TOTAL COMPOSITION	
COMPOSITION	**%**
SPECIMEN 1	
Ti	Balance
Sn	1
SPECIMEN 2	
Ti	Balance
Sn	2

Methods

The SMAT process uses a Planetary Ball Mill for 2 hours and a Heat Treatment process for 2 hours with a temperature variation of 800°C and 900°C.

Figure 1.
(A). Planetary Ball Mill, (B). Tube Furnace

To observe the SMAT's layer, the sample was prepared with SiC paper on the specimen's side and using Olympus BX60M optical microscope with a magnification of 5X.

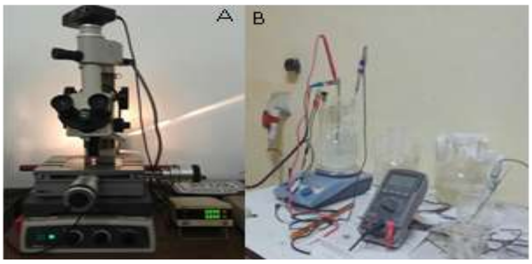

Figure 2.
(A). Nikon Measurescope mm-22, (B). Corrosion Testing

The thickness of the deposition layer measured by Nikon measure scope mm-22. The corrosion rate of samples tested by a potentiostat with a counter electrode Pt and a reference electrode calomel in a carbonated beverage solution.

Rockwell hardness test is used for testing because it is simple, fast, no need microscope to measure a trace and have no damage. It comes with 120˚ diamond cone, minor load (10 kg) and major load (150 kg) performed emphasis on three different points in each sample[6)].

RESULT

As the results of the heat treatment process, on temperature 800˚C the surface morphology tends to be rough because of the remains powder. On higher temperature 900˚C, the results are smoother because higher temperature reduced the porosity of the powder.

The results of determining the SMAT layer shown in figure 3 and figure 4 that there is a SMAT layer attached to the AISI 316L. The SMAT layer itself is influenced by the length of time the heat treatment because if it is getting hotter, then the SMAT itself is easier to stick to the AISI 316L layer.

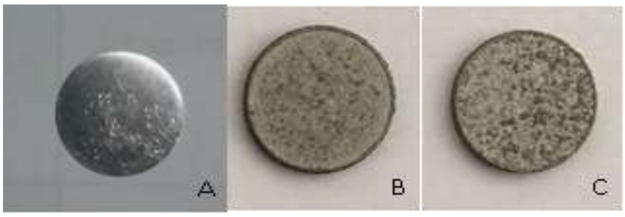

Figure 3.
(a) Surface morphology before SMAT, (b) Surface morphology Ti-10%Sn, and (c) Ti-20%Sn after SMAT

In figure 3 shows the metal surface AISI 316L process prior to SMAT, visible differences in the surface morphology of 10%Sn 20%Sn. At 20%Sn looks more black than 10%Sn.

Figure 4.
(a) SMAT Layer Ti-10% Sn Temperature Variation 800 ºC, (b) Layer SMAT Ti-20% Sn Temperature Variation 800 ºC, (c) SMAT Layer Ti-10% Sn Temperature Variation 900 ºC, and (d) SMAT Coating Ti-10% Sn Temperature Variation 900℃

After the process of sintering in figure 4, seen in 10%Sn over a smooth surface than 20% of Sn. It is influenced by the percentage of Sn in the process of SMAT.

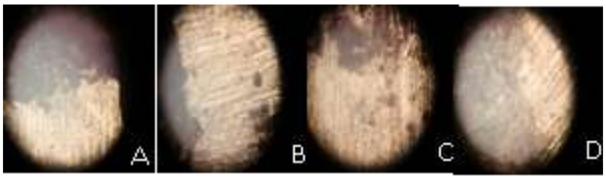

Figure 5.
Macrostructure of SMAT (a) coated with Ti-10% Sn and sintered on the temperature of 800 ºC, (b) coated with Ti-20% Sn and sintered on the temperature of 800 ºC, (c) coated with Ti-10% Sn and sintered on the temperature of 900 ºC, and (d) coated with Ti-20% Sn and sintered on the temperature of 900 ºC

On macrostructure to appear if the high time of sintering and the percentage of Sn will cause the magnitude of the layer of Ti-Sn.

Table 3.
The thickness of the deposition layer coated by Ti-Sn with various Sn content and sintered temperature

NO	COMPOSITION	THICKNESS (μm)
1	Ti-10%Sn 800ºC	23.6
2	Ti-10%Sn 900ºC	23
3	Ti-20%Sn 800ºC	27.6
4	Ti-20%Sn 900ºC	28.6

Corrosion testing itself uses a potentiostat with a Pt electrode counter and a reference electrode calomel in a Simulated Body Fluid fluid environment. The results of the corrosion rate of each sample with Sn content 10% and 20% with different sintering temperature is shown in Table 4.

From the corrosion testing results, it can be analyzed that the SMAT itself can affect the corrosion rate of AISI 316L and almost resembles Ti-6Al-4V in testing in the same solution. The SMAT used is Ti-Sn, which is non-toxic and not allergic based on[7] and therefore used for AISI 316L, which can cause allergies if used for a long period. This SMAT process can increase the time to use the implant to avoid allergies due to the presence of a Ti-Sn layer on the surface of AISI 316L.

Table 4.
Corrosion test results using a potentiostat

NO	COMPOSITION	SINTERING (°C)	CORROSION (Mpy)
1	Ti-10%Sn	800	4.785
2	Ti-20%Sn	900	3.525
3	Ti-10%Sn	800	4.155
4	Ti-20%Sn	900	3.234

The SBF liquid used has the following chemical composition.

Table 5.
Chemical composition of SBF fluids

ELEMENT	COMPOSITION
Na^+	154 mEq/L
Cl^-	154 mEq/L

Testing the pH aims to determine the pH value and obtain a pH of 5.82 Isotonic Solution, which has acidic properties and can cause corrosion to metals.

Figure 5.
Testing pH using a pH meter

Hardness test showed for the sample with 10% Sn with sintered temperature 800℃ and 900℃ is 37.33 HRC and 29.33 HRC, while in the 20% of Sn with sintered temperature 800℃ and 900℃ is 32.33 HRC and 23 HRC. In the Rockwell hardness testing process, an emphasis is placed on three different points in each sample[8]. It has taken the average price of violence from the three points in each sample. The value of the hardness obtained is converted into a maximum tensile stress value to determine its maximum strength[9].

Table 6.
The hardness of samples of AISI 316L deposited by Ti-Sn alloy and sintered on 800℃ and 900℃.

Testing	Result Hardness (HRC)			
	10%Sn -800°C	20%Sn -800°C	10%Sn -900°C	20%Sn -900°C
1	37	33	30	24
2	37	32	29	20
3	38	33	29	25
Σ	37,33	32,33	29,33	23

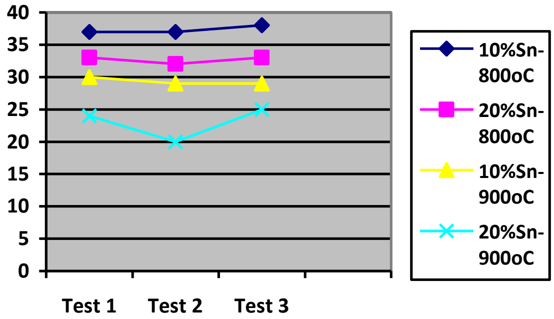

Figure 6.
Hardness vs Sn Content and Sintered Temperature

CONCLUSIONS

Based on the data obtained, the results of AISI 316L SMAT with Ti-Sn have good corrosion resistance. This is indicated by the corrosion rate of 1-5 mpy. in this study, the corrosion rate of low 3.234 mpy at Ti-20%Sn temperature sintering 900°C.

AISI 316L Ti-10% Sn 800℃ has higher strength than other alloys. However, the corrosion rate is still relatively high compared to other alloys, and while AISI 316L Ti-20% Sn has a relatively low corrosion rate than others, but the chilling is relatively low. The antibacterial, non-allergenic, and anti-toxic properties that Ti-Sn alloys may need to be further explored using other suitable testing methods. With the combination of density and high hardness, the thickness of the implant can be made thinner. High hardness means high wear resistance. The alloy life becomes longer. Corrosion resistance in SBF liquid, antibacterial, and non-allergen makes the AISI 316L Ti-20% Sn 800°C alloy can be chosen as a substitute for AISI 316L.

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