International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 09, September-2015

Analysis of Mechanical Properties of Al_2O_3 Coated Dental Implants

D. Karunakaran, ' A. Jeyachandran
Assistant Professor,
Department of Mechanical Engineering,
Sri Manakula vinayagar Engineering College,
Puducherry-605107, INDIA.

Dr. V. S. K. Venkatachalapathy
Director cum principal,
Sri Manakula vinayagar Engineering College,
Puducherry-605107, INDIA

Abstract - Titanium is widely used as dental implants in medical applications because of its improved bio compatibility and mechanical properties such as high strength, high toughness, low density, good corrosion resistance etc., Aim of this research work is to modulate the biological response by modifying the implant surface characteristics. Aluminium oxide is a largely used ceramic material for coating. Aluminium oxide is coated on titanium implants using thermal spraying process to increase its mechanical properties. The implant was then characterized by scanning electron microscopy (SEM). The tribological wear behavior is investigated using pin-on-disc equipment for specific intervals of time by applying constant load and Micro hardness was found out. Analyses of the mechanical properties of Titanium implant material and Aluminium oxide coated titanium implant material was carried out.

Keywords: Titanium, Aluminium oxide, Detonation thermal spraying, SEM, Wear test, surface coating.

1. INTRODUCTION

Titanium has excellent characteristics which enables it to form interface of the implant\bone. Implants are manufactured using either pure titanium or a Ti-Al-V alloy. Many studies proved bio-compatibility of Ti and Ti alloy for fabrication of dental implants. The composition and properties of the implant's surface plays vital role in the biological response of artificial biomaterials. Thus, it is possible to change the biological response by modulating the implant surface characteristics.

Surface treatments can be effectively used to improve the interaction between the bone and the implant, such as by using bioactive ceramic to cover the titanium. Aluminium oxide (Al_2O_3) is a largely used ceramic type material which is used for coating. Surface coating of implants with aluminium oxide establishes a chemical link with the bone. The other option is the roughened surface of the implant, restriction of movement of the implant over the bone. The rough surface topography can be achieved by a coating process with aluminium oxide. Micro topography can be used to study the influence of formation of coating. The aim of this research is to characterize titanium surfaces coated with aluminium oxide (Al_2O_3) particles using thermal spraying process which increases mechanical properties.

2. EXPERIMENTAL PROCEDURE

Wear resistance of titanium is quiet poor. Wear resistance of Titanium can be improved methods like Nitride Coatings, Flame, Plasma Detonation Gun Coating, Electrolytic and Electroless Coatings. The difficulty involved in plating metals on titanium is because of the presence of a stable oxide film on its surface. So, Electrolytic and Electroless Plating Processes are less efficient methods. In the Detonation Thermal Spraying Process, it is possible to produce excellent wear resistance, high bond strength, less porosity and low cost. A wide range material from pure metals to ceramics can be coated on titanium. Aluminium oxide is the powder used for coating. Titanium implants are coated with Aluminium Oxide using Detonation thermal spraying process. The Detonation-Gun uses measured quantities of oxygen, acetylene and particles of a coating material, detonated by a timed spark in the firing chamber. The resultant high-speed gas stream heats up the coating particles to a plastic state and throws them from the gun barrel at supersonic velocity (up to 1200 m/s). This action joins the coating material to the surface of the work piece with a tenacious mechanical bond. Bond strengths in excess of 10,000 psi are obtained. Coating hardness can go up to 1350 VHN. Rapid –fire detonations, during automatically controlled passes across the work piece, build up to the coating to a specified thickness. Although temperatures around 3500 °C is reached inside the gun, the work piece remains below 100°C, this eliminates the possibility of microstructure changes in precision parts. Also, metallurgical properties in the substrate remain unchanged. This coating has got excellent bond strength, toughness, wear resistance and very less porosity.

3. RESULT AND DISCUSSION

3.1 Microstructural Characterization

The microstructure analysis was carried out by using SEM. Fig.1 shows microstructure of the fabricated Ti Alloy.

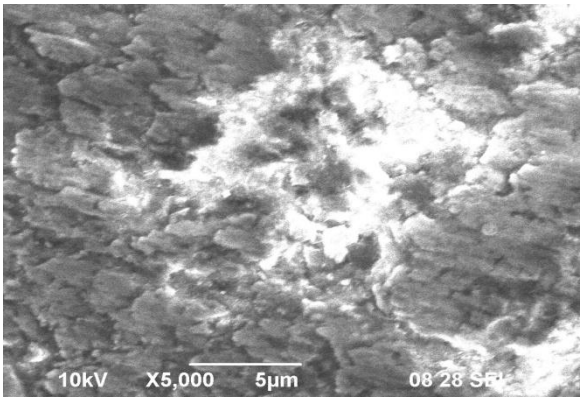

Fig.1.SEM image of Titanium material

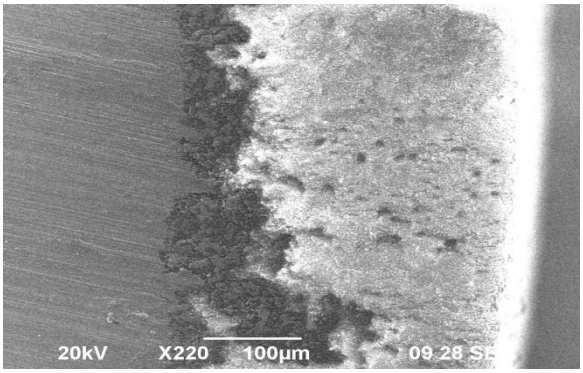

Fig. 2. SEM image of Al_2O_3 coated on titanium implant material

Figure 2. Clearly shows the Al_2O_3 particles are well bonded and distributed evenly with Titanium matrix.

3.2 Micro Hardness

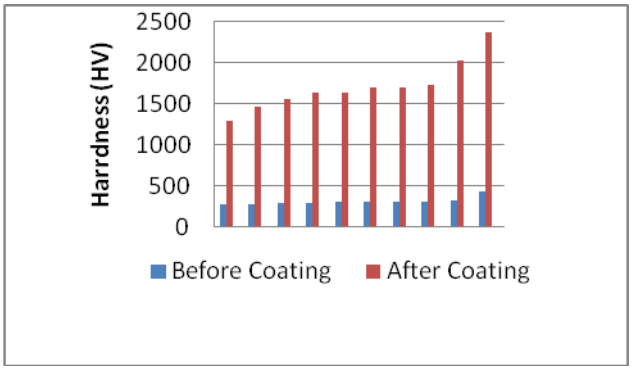

Fig. 3. Micro Hardness Values Of Coated And Non-Coated Titanium Implants Materials

The micro hardness test was carried out in Micro Vickers Hardness Tester. Fig.2.represents hardness measurement between Al_2O_3 coated titanium implant material and non-coated titanium implant material. Since Alumina possesses strong ionic inter atomic bonding giving rise to its desirable material characteristics, it can exist in several crystalline phases which all near to the most stable hexagonal alpha phase at elevated temperatures. Alpha phase alumina is the strongest and stiffest of the oxide ceramics. Its high hardness, excellent dielectric properties, refractoriness, good thermal properties makes it good for many applications.

3.3. Wear Analysis

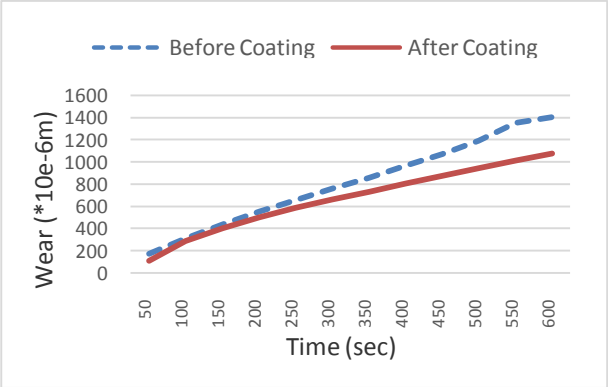

Fig.4. Linear wear Vs Time for Al_2O_3 coated titanium implants and non-coated titanium with constant load and constant velocity

Wear test was conducted employing a Pin-on-Disc Tribometer with preferred constant load (5kg) and velocity. Most requirements of the ASTM G99 standard on wear Testing were followed. However, substantial modifications were considered, mainly regarding the Pin shape. Cylindrical bar with dimension of 8mm × 30 mm were made of Aluminium oxide coated with titanium implants. Numerous materials can be diffused into the surface of titanium by relatively high temperature heat treatments to provide a hard surface layer on the material, but temperature at which the treatment is carried out can cause distortion problems. Aluminium oxide coating on titanium implants increases its wear resistance.

4. CONCLUSION

In the current study, 'Analysis of mechanical properties of dental implants', coating of Aluminium oxide on titanium dental implants increases its hardness and wear resistance. Alumina exhibits strong ionic inter atomic bonding gives rise to its desirable material characteristics. Alpha phase alumina is the stiffest and hardest of the oxide ceramics; due to this it provides high hardness. Because of better wear resistance properties of Aluminium oxide than Titanium, its wear resistance increased. We successfully compared the mechanical properties of Aluminium oxide coated titanium implants and non-coated titanium implants materials.

REFERENCES

[1] Artif. Organs, Wear studies of frequently used implant materials, Trends Biomater. Artif. Organs. Vol.17 (2) PP 135-140 (2004).
[2] Braz. Oral, Characterization of titanium surfaces for dental implants with inorganic contaminant, res. Vol.19 no.2 sao paul Apr./june 2005.
[3] Depprich R, Zipprich H, Ommerborn Metal. Osseointegration of zirconia implants compared with titanium: an in vivo study. Head Face Med. 2008; 4:30.
[4] Gravedona(CO) and Via Trento, Residual Aluminium oxide on the surface of titanium implants has no effect on osseonintegration, received 7 November 2002; accepted 8 April 2003.

[5] Gahlert M, Gudehus T, Eichhorn S, Steinhauser E,Kniha H, Erhardt W. Biomechanical and histomorphometric comparison between zirconia implants with varying surface textures and a titanium implant in the maxilla of miniature pigs. Clinical Oral Implants Res.2007; 18: 662–668.
[6] J P Pathak, S Mohan & V Singh, Wear behavior of Titanium alloy GTM-900 under dry sliding. Indian journal of Engineering & Materials Sciences. Vol. 9, October 2002 PP. 351-358.
[7] S.Lalik and J.Cebulski Corrosion resistance of titanium in water solution of hydrochloric acid, Archives of Materials Science and Engineering, Volume 28 Issue 6 June 2007 Pages 349-352.
[8] Steinemann SG. Titanium— The material of choice Periodontol 2000. 1998; 17:7–21
[9] Tschernitschek H, Borchers L, Geurtsen W, Non alloyed titanium as a bioinert metal-are view. Quintessence int.2005; 36:523-530.
[10] Yamauchi R, Morita A, Tsui T. Pacemaker dermatitis from titanium. Contact Dermatitis. 2000; 42:52-53.