Comparison of Commericially Pure Titanium Surface Hardness Improvement by Plasma Nitrocarburizing and Ion Implantation

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Abstract. Commericially pure (cp) titanium has a relative soft hardness property. In particular usage such as sliding, the improvement of the surface hardness will be required. In this study, surface hardness improvement of cp titanium by Plasma Nitrocarburizing and Ion Implantation are compared. Plasma Nitrocarburizing processes are conducted at different elevated temperatures with different duration processes, i.e. at 350 °C for 3, 4, and 5 hours, and at 450 °C for 2, 3, and 4 hours respectively, while Ion Implantation processes are conducted at room temperature and process durations are varied as 2.3 hours, 4.7 hours, and 9.3 hours. Nitrogen ions are used to implant the material. Hardness tests are then performed on each specimen by using Micro Vickers Hardness Tester. The surface hardness number (HV) for specimens of the Plasma Nitrocarburizing processes at temperature of 350 °C for process duration of 3 hours, 4 hours, and 5 hours are 74.16, 92.25 and 94.41, respectively while those at temperature of 450 °C for duration process of 2 hours, 3 hours, and 4 hours are 103.70, 121.31 and 126.17, respectively. The processes of Ion Implantation produce the surface hardness number (HV) of 88.97, 125.51, and 130.2, for duration processes of 2.3 hours, 4.7 hours, and 9.3 hours. The process of Ion Implantation produce higher surface hardness number than the Plasma Nitrocarburizing process at temperature 350 °C but the surface hardness number is lower when compared to the Plasma Nitrocarburizing at a temperature of 450 °C. For the duration processes 4 hours and more, the process of Ion Implantation produces the same surface hardness number with the Plasma Nitrocarburizing at temperature of 450 °C.

Introduction

Nowadays, titanium is widely used in industry and medical field [1, 4]. Since titanium first became commercially available about sixty years ago, the pure metal is developed rapidly. It is because titanium has outstanding properties in term of high strength to weight ratio, exceptional resistance to corrosion, and excellent biocompatibility [5-7]. In industry, about 80% of its usage is in the field of aerospace [8]. In medical field, titanium is widely used because of its excellent biocompatibility and less corrosion. Its applications involve surgical implement and implants, such as hip ball and socket in hip joint replacement that can last up to 20 years [9-12].

On the other hand, titanium is characterized by, especially in sliding situations, poor tribological properties. So, when titanium is used as a part of which will experience friction with other parts such as that is in hip joint replacement, the improvement of the surface hardness number will be required. However when the surface hardness number is increased by a certain treatment to the whole part, there is a possibility the material will become brittle, which is not expected. Any excessive loading applied to the material will damage it easily.

Increasing the hardness number at the surface without changing the ductility properties of materials on the inside of the material will increase the toughness properties of material without changing the ductility in the inner part. This process is referred to as surface hardening.