An industrial application of 100 keV ion beam accelerator: Studies on N ion implanted stainless steel with respect to wear resistance to mild abrasion

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Abstract

We have built a 100 keV and 20 mA ion beam accelerator to apply for prolonged lifetime of metal parts subjected to mild abrasive environment. Studies were conducted on stainless steel which is often used for cutting blades. 70keV N ions of > 5x $10^{16}/cm^2$ were implanted into the surface polished stainless steel (SS420) with average surface roughness (Ra) of 0.04 μm. Then, wear resistance of N ion implanted specimen at the mild abrasive condition was investigated. When the beam incidence was 45° with respect to the specimen surfaces, the concentration of nitrogen in the near surface of the specimen was about 5 at% and detected up to at least 300 nm from the surface as measured with Auger electron spectroscopy. X-ray photoelectron spectroscopy analysis showed that the implanted N formed mostly Cr_2N without post irradiation annealing. Hardness profiles of the specimens were obtained with nano-indentation technique as a function of distance from the surface before and after ion implantations. The peak hardness of 14 Gpa formed at approx. 50 nm depth from the N ion implanted surface was about at least 2 times higher than non-irradiated specimen. Along with the hardness measurement, ball-on-disc wear resistance test was conducted. With 500 gf alumina ball, the wear track to the onset point of abrupt increase in the frictional coefficient was about 5 m for the N implanted specimen, while wear took place for the pristine as soon as the test started. On the other hand, when 1000 gf ball was used for the wear test, the difference in the wear track between the pristine and N implanted specimen was smaller than 500 gf ball, implying that the ion implantation is not suited to severe abrasive condition. After the ion beam irradiation, the surface roughness was reduced to Ra=0.02 μm. We found the ion implantation prolonged the lifetime of the metal parts subjected to mild abrasive environment like hair clipper blades.