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ADP014992

TITLE: N+ Ion Implantation Effects on Microhardness Properties of
Stainless Steel 52100

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This paper is part of the following report:

TITLE: International Conference on Phenomena in Ionized Gases [26th]
Held in Greifswald, Germany on 15-20 July 2003. Proceedings, Volume 4

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N⁺ ion implantation effects on microhardness properties of stainless steel 52100

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1. Introduction

Ion implantation has been used to modify the mechanical properties of a wide range of metals and alloys using plasma techniques for ion sources and plasma surface treatment [1-2]. It is well known for producing a modification in the structure of the superficial layers of metals by formation of new crystalline phases, meta stable or amorphous, and thus to improve the surface properties [3]. By ion implantation we are able to change the chemical composition, phase and structure of near – surface layers, i.e. the very parameters of a material which predetermine, to a great extent, its mechanical, optical, electrophysical, corrosive properties.

It has been establish that nitrogen implantation into metals can alter their surface properties such as friction, wear, corrosion, etc [4].

Nitrogen is the most common ion used for metallurgical application when the ions penetrate the surface of the workpiece, some of them peg microcracks, some fill lattice spaces in crystalline structures, and some react chemically to form compounds, giving new lattice properties [5].

When treated surfaces wear, the atoms trapped interstitially in the metal structures become dislodged and may diffuse deeper into the surface. As this process continues, the atoms continue to close up micro cracks. This discourage crack propagation in the work piece and lead to better abrasion resistance. It can also prevent the ingress of oxygen and other potentially corrosive compounds.

In this paper, the results of our experiments, are given concerning the influence of High-dose in surface hardening.

2. Experimental and Results

First, samples, as stainless steel disks containing 1.52 wt% Cr. as the major alloying elements, with a thickness of 4 mm, were mechanically polished and cleaned by acetone and methanol, using ultrasonic device.

Disks were implanted with dosed ranging from 1×10^{16} to 3×10^{19} N⁺/cm² at an energy of 90 keV. In every cases, the substrates temperature was kept at 224°C.

Beam current and accelerator voltage during the experiment were 5 mA and 105 kV, respectively. Vacuum before implantation process was 4.8×10^{-4} pa and during implantation it was better than 1.6×10^{-3} pa.

Comparison of unimplanted sample microhardness, with implanted one, shows increasing about 41.6% at dose of 1×10^{19} N⁺/cm². Figure 1, presents the Vickers hardness(HV), profile, versus Nitrogen irradiation dose at the energy of 90 keV.

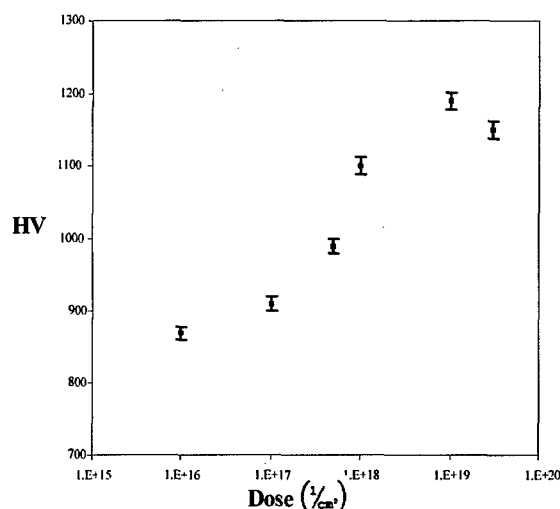


Fig. 1. Micro hardness measurement profile versus dose variations

As this profile shows, the microhardness increase with accumulation of dose up to $1 \times 10^{19} \text{ N}^+/\text{cm}^2$, and then decrease at dose of $3 \times 10^{19} \text{ N}^+/\text{cm}^2$. It may be because of saturation of the implanted layer by nitrogen. A great role in the surface hardening is obviously played by different crystalline phases of iron nitrides produced as a result of nitrogen ion implantation into stainless steel targets [6-7]. Hardness measurements and wear reduction of 52100 steel by implantation of oxygen, aluminum and carbon dioxide have been reported [8].

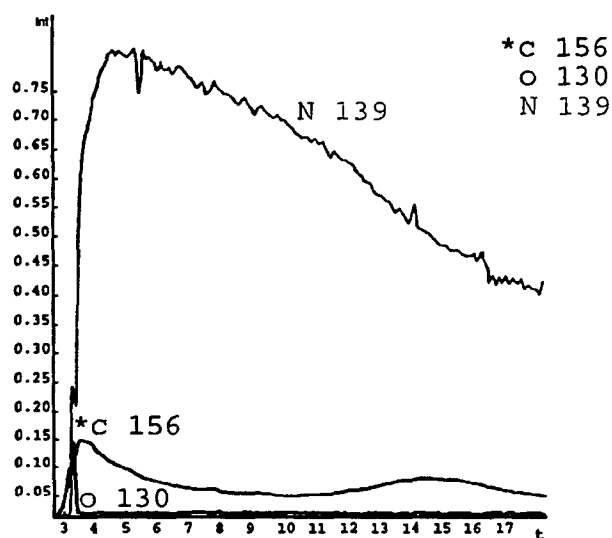


Fig. 2. Elemental Analysis for stainless steel sample implanted by $1 \times 10^{19} \text{ N}^+/\text{cm}^2$.

Figure 2, shows nitrogen distribution in the surface of a sample at dose of $1 \times 10^{19} \text{ N}^+/\text{cm}^2$. using GDS instrument which confirm theoretical distribution of nitrogen implantation into stainless steel.

Also the elemental analysis of Oxygen, and Carbon on the surface have been carried out using GDS instrument (fig2.)

3. Conclusion

Hardness increasing could be because of dislocation fixing by nitrogen deposition (as figure 2 shows) in steel crystalline. Also high chromium existence in 52100 steel, can cause formation of chromium nitride phases, and this may be another reason of hardness increasing.

4. References

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