STRUCTURE AND PROPERTIES OF NITROGEN ION IMPLANTED 304 STAINLESS STEEL

by

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Dedicated to my
Husband and Son

CERTIFICATE

This is to certify that the thesis **"STRUCTURE AND PROPERTIES OF NITROGEN ION IMPLANTED 304 STAINLESS STEEL"** being submitted by **Mrs. Sadhna Shrivastava** to the Indian Institute of Technology, Delhi for the award of Degree of Doctor of Philosophy, is a record of bonafide research work carried out by her under our guidance and supervision. To our knowledge, it has reached the standard of fulfilling requirements of the degree. The matter embodied in this thesis has not been submitted for the award of any degree or diploma of any other university or institute.

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ABSTRACT

The present research work elucidates the effect of nitrogen ion implantation on the structure and mechanical properties of 304 stainless steel. Glancing angle X-ray diffraction (GAXD) studies revealed conversion of the fcc phase to a bcc phase on severe cold working (by facing on a lathe or compression).

Implantation induced effects in faced (martensitic) and unfaced (austenitic) specimens were investigated at doses of 5×10^{16} $N_2^+ cm^{-2}$ and 1×10^{17} $N_2^+ cm^{-2}$. X-ray diffraction showed the formation of ϵ-iron nitride at 1×10^{17} $N_2^+ cm^{-2}$. Significantly more and richer nitride formed in the faced specimen. On annealing to 285°C the nitride in the faced specimen reduces to the composition of the nitride in the unfaced specimen. The unfaced specimen is unaffected at this temperature. Further annealing causes the nitrides in both kinds of specimens to dissolve and nitrogen appears in solid solution. At the lower dose, indirect evidence was found for the formation of iron nitrides in the faced specimen. On annealing the nitrogen appears in solid solution in this case also. The martensitic specimens exhibited increase in hardness considerably. This is due to large nitride production and due to the presence of interstitial nitrogen.

Several mechanically polished discs were implanted with 3.5×10^{17} $N_2^+ cm^{-2}$ at different target temperatures (by changing the beam powers). Some specimens were compressed prior to implantation. The specimens implanted at high

temperatures ($370^\circ C$ or higher) showed increased hardness and nitrogen in solid solution. The increased hardness also persists to large depths. The Auger depth profiles in these cases are deeper due to thermal broadening. High temperatures also lead to the formation of CrN and Cr_2N. In general the implanted discs showed a wear resistance. Wear parameter for the pin was reduced by one order of magnitude.

The compressed disc developes an enhanced oxide layer during implantation. This layer increases the retention of nitrogen and higher hardness is achieved, which is accompanied by a wear resistance. The compressed coupon formed Cr_2N, Ni_3N and Fe_2N and ϵ-iron nitride with low nitrogen concentration.

Implantation induced changes depend on the kind of phases initially present. The target temperature also influences the structure and properties of stainless steel.

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