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# Microstructure of Low Alloyed Steel 32CDV13 Nitrided by Plasma

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***Abstract*-** This paper presents microstructures of low alloyed steel 32CDV13 treated by plasma nitriding. The structure and phases composition of the diffusion zone and compound layer were studied by X-ray diffraction (XRD), optical microscopy and scanning electron microscopy (SEM). It was observed that increasing nitrogen, at middle temperature and at treatment time determined conducted to the formation of a compound layer and increases significantly the diffusion layer thickness.

***Keywords*-** *ion nitriding; steel 32CDV13; microstructure; x-ray difraction.*

## I. INTRODUCTION

Nitriding is a thermochemical process that is typically used to diffuse nitrogen into ferrous materials. This treatment plays an important role in modern manufacturing technologies [1]. It can improve surface hardness, fatigue strength, wear and corrosion resistance [2–5].

The basic mechanism of plasma nitriding treatment is a reaction between the plasma and the surface of the metal. In addition, depending on the steel compositions and process parameters, the plasma mass transfer has an effect on the formation and thickness of compound layer and diffusion zone [6].

Plasma nitriding owing to a number of advantages such as a lower process temperature, a shorter treatment time, minimal distortions and low energy use compared to conventional techniques has found wide application in industry [2,3].

The aim of the present work is to study the effect of gas mixture (N2-H2) on the microstructure of 32CDV13 low alloyed steel treated by ion nitriding process.

## II. EXPERIMENTAL

A series of experiments were carried out to investigate the plasma nitriding of low alloyed steel 32CDV13. The chemical composition of 32CDV13 is: 0.3% C; 0.31% Si; 0.5% Mn; 3.25% Cr; 0.44% Mo; 0.11% Ni; 0.1% V. This steel, commonly used for nitriding, presents good toughness. The substrate surface was prepared and polished with 1 μm diamond paste. Samples were nitrided in a vacuum furnace pumped down to low pressure ($10^{-3}$ mbar) to minimise the oxygen contamination. The temperature is measured using thermocouple. The nitriding parameters were fixed similar to previous works [2,7].

The samples morphology surfaces were observed by optical microscopy and scanning electron microscope (SEM). X-ray diffraction analyses with Co Kα radiations were performed to determine their structure.

## III. RESULTS AND DISCUSSION

### A. Microstructure and SEM observation

The compound layer thickness and diffusion zone of the plasma nitrided 32CDV13 low-alloy steel depending on the $N_2$ in the gas mixture are shown in figure 1. It can be observed that thickness of compound layer and diffusion zone increases with increase of $N_2$ at the gas mixture in plasma, at temperature 773 K and 4 h treatment time.

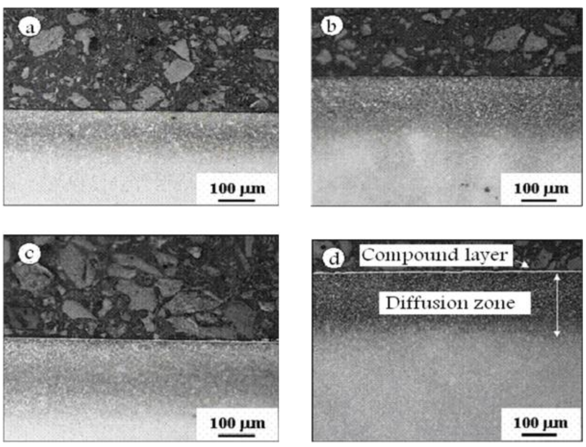


Figure 1. Optical micrographs plasma nitrided low alloyed steel 32CDV13 at 773 K and 4 h treatment time: (a) 20%$N_2$, (b) 60%$N_2$, (c) 80%$N_2$, (d) 100%$N_2$

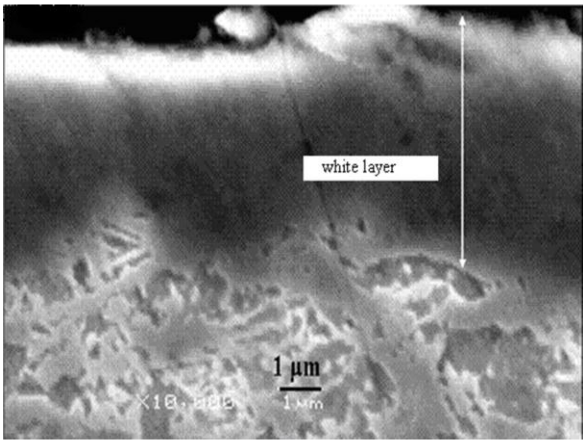


Figure 2. Micrographic SEM of sample nitrided during 4h in gas mixture ($20\% H_2$ - $80\% N_2$) at 773 K

The micrographic SEM of sample nitrided during 4h in gas mixture ($20\% H_2$ - $80\% N_2$) at 773 K (fig. 2) shows formation of compound layer (white layer) which increases during the processing to achieve a thickness around 5 µm.

EDS microanalysis showed that the nitrided layer contained a high amount of nitrogen on the surface and the nitrogen concentration decreased along with the increase of the distance from surface until the substrate value at a depth of about 100–150 µm (fig.3).

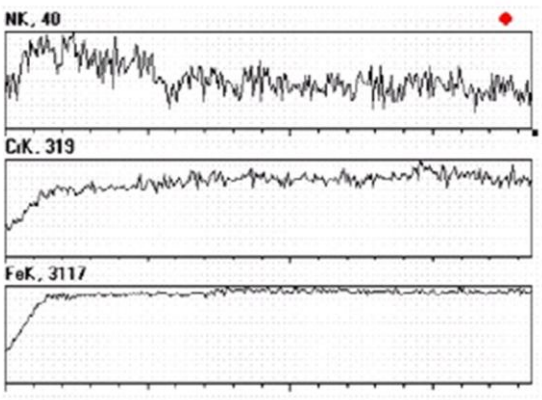


Figure 3. Concentration profile of elements N, Cr and Fe.

## B. *X-ray diffraction*

Treatment of nitriding by plasma at 773 K and 4 h of treated time produced different nitrided layers in terms of morphology, thickness and phase structure. XRD analysis was performed on treated samples (Fig. 4).

When the XRD patterns were examined, it has been seen that both γ'-$Fe_4N$ and ε-$Fe_{2–3}N$ phases have formed and the intensity of this phases in the compound layer is higher in the process, while the $N_2$ increases in gas mixture.

The XRD patterns shown in figure 4 indicate that treated samples consist of a mixed structure of γ'-$Fe_4N$ and ε -$Fe_{2–3}N$. However, the relative peak intensities of the two phases are different in samples with different conditions.

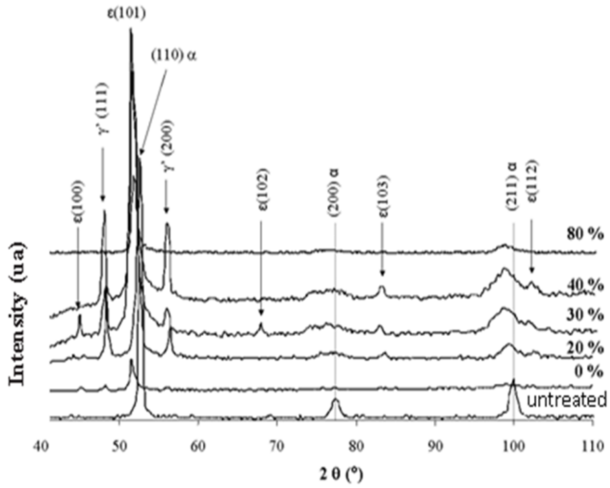


Figure 4. XRD patterns of samples treated at 773 K for 4 h of treatment at different nitrogen percentage.

## IV. Conclusion

The microstructure of low alloyed steel 32CDV13 nitrided by plasma was studied. The results obtained can be summarized as follows:

- Formation of compound layer and diffusion zone.
- The compound layer corresponds mainly to $Fe_{2–3}N$ and $Fe_4N$ iron nitrides.
- Increasing nitrogen in plasma at 773K during 4 hours of treatment increases significantly the compound layer and the diffusion zone.

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