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PLASMA TREATMENT OF STAINLESS STEEL SURFACES

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ABSTRACT
Described technology of stainless steel surfaces treatment is based upon the plasma nitridation of the component in micropulse plasma when nitridation atmosphere with a significant amount of methane is used. The process is performed so that a layer of iron and othet chemical element carbonitride may be formed on the surface of nitrided components. The formed layer is characterized by very good mechanical properties, e.g. an excellent abrasion resistence, a low friction coefficient and. high layer hardness.

Keywords: plasma nitridation of stainless steel, chemical composition, structure, properties

1. EXPERIMENTAL
Steel X12CrNi 18 8 (1.4300) was used for experiment. Chemical composition according to DIN standard, measured by GDOES method and verified for selected chemical elements by EDXS method is presented in Table 1. Plasma nitridation process was carried out on the PN 60/60 equipment according to parameters in Table 2. For experiment three samples were used, sample 3.0 was non-treated.

Table 1. Chemical composition of used stainless steel X12CrNi 18 8

Method	Chemical composition (weight %)								
	C	Mn	Si	Cr	Ni	P	S	Al	
DIN standard	≤ 0.12	≤ 2.00	≤ 1.00	17-19	8-10	≤ 0.045	≤ 0.030	-	-
GDOES/Bulk	0.045	1.78	0.45	18.6	8.60	0.027	0.002	-	-
EDXS	-	-	0.58	18.9	8.45	-	-	0.39	-
Parameters of GDOES/Bulk analysis: U = 1002 V, I = 34.9 mA, p_{Ar} = 450 Pa Parameters of EDXS analysis:U=30 kV, M=250 x, I=134 pA, WD=21.20 mm, Slide Position=41 mm, detector Pioneer									

Chemical composition of substrate alloy was measured by GDOES/Bulk method on the SA 2000 spectrometer and by EDXS method on the Noran Six apparatus, depth profiles was evaluated by GDOES/QDP and EDXS methods. Calibration of nitrogen: JK41-1N and NSC4A standards. Microstructure and surface morphology was evaluated by electron and light microscopy on the Vega TS 5135 electron microscope and Olympus digital camera on the Neophot 32 light microscope, respectively. Surface structure was tested by 3D topography method on the TALYSURF CLI 1000 with confocal gauge CLA before and after treatment. Mechanical properties, such as layer thickness and microhardness were measured by indentation method on the Leco M400 microhardness tester. From microhardness behaviour the layer depth in accordance with DIN 50 190 standard as Nht parameter was determined. Other properties (adhesion, corrosion resistance) were evaluated, too. Relations among chemical composition, structure and diffusion layer properties were briefly discussed.

Table 2. Parameters of plasma nitridation process

Parameter	Plasma cleaning	Plasma nitridation/ sample 3.4	Plasma nitridation/ sample 3.2
Temperature (^oC)	520	450	550
Time/Duration (min, h)	30 min	8 h	8 h
Flow H_2 ($l.min^{-1}$)	20	8	8
Flow N_2 ($l.min^{-1}$)	2	32	32
Flow CH_4 ($l.h^{-1}$)	0	1.5	1.5
Voltage (V)	800	530	530
Pulse length (μs)	100	100	100
Pressure (Pa)	80	280	280

2. RESULTS AND DISCUSSION

Depth profiles (Figure 1 and Figure 2) of carbon and nitrogen are in good agreement with the proposed plasma treatment regimes. Carbon and nitrogen contents decrease along the layer depth (from surface to substrate). As for carbon concentration there is local maximum ten micrometers from the surface. Existence of this maximum was verified by microstructure evaluation, too. A very sharp interface between substrate material and plasma nitrided layer was found out (Figure 3, Figure 4). Thickness/depth of plama nitrided layer was evaluated by way of microhardness behaviour measurement in compliance with DIN 50 190 standard. Attained Nht value is Nht 270 HV 0.05 = 0.08 mm (Figure 4). This result is in conformity with spectrometric and metalographic measuring and evaluation. The highest value of measured microhardness was observed for plasma nitrided layer of sample 3.2 and reached 1578 HV 0.05. Qualitative and quantitative results of 3D surface topography measurements are in Figures 5, 6 and 7. The most important parameters of surface structure are presented at the same time.

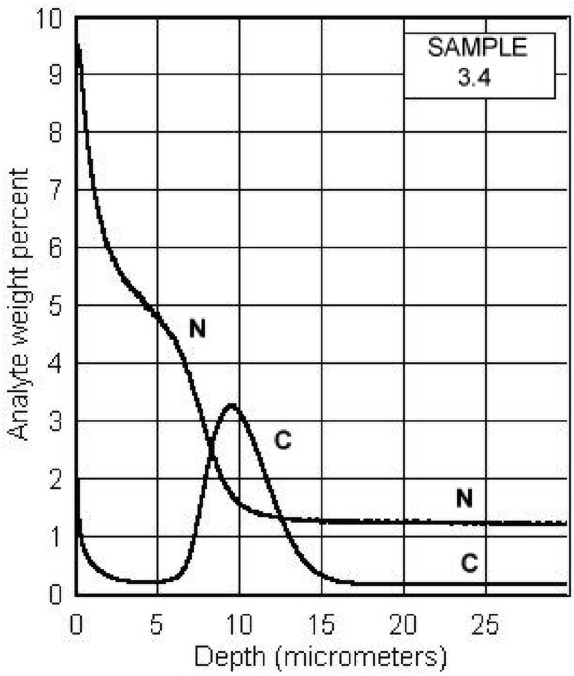


Figure 1. Chemical composition, sample 3.4

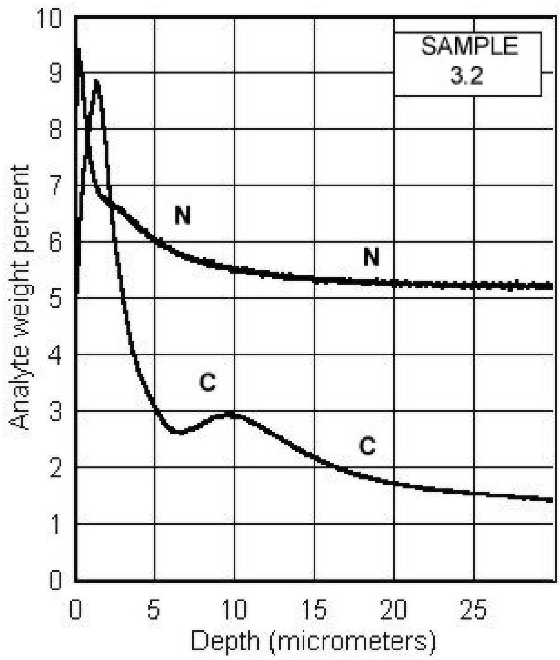
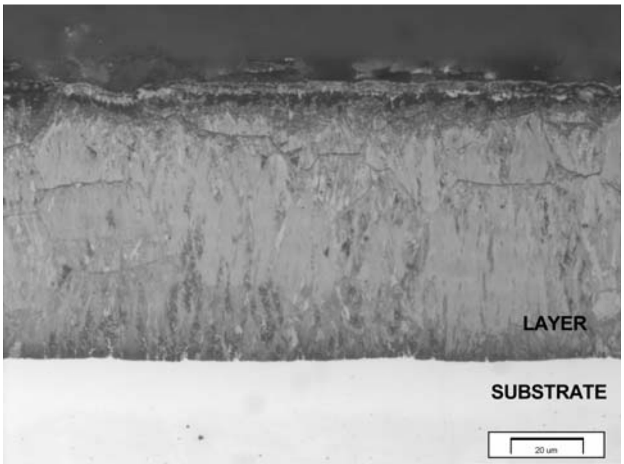


Figure 2. Chemical composition, sample 3.2



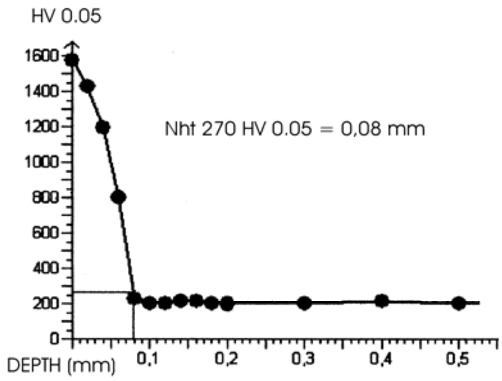
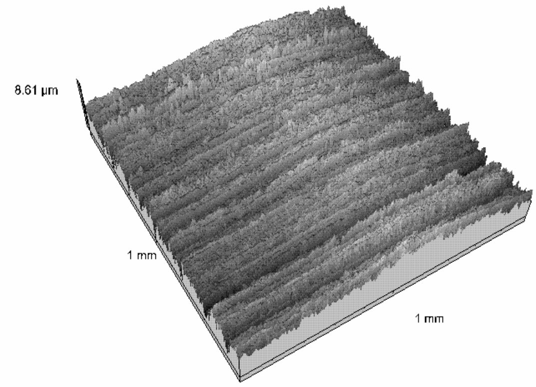
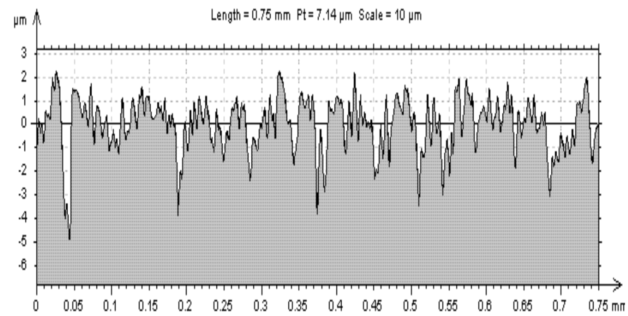


Figure 3 Microstructure of sample 3.2, Vilella Bain

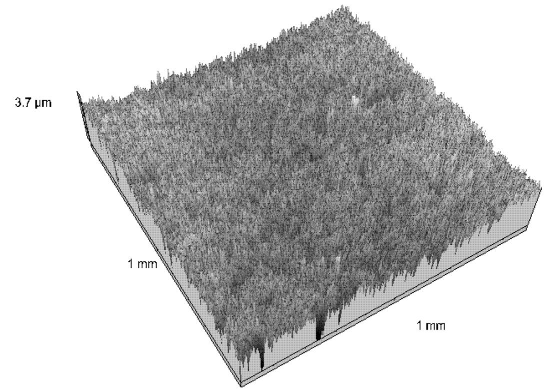
Figure 4. Microhardness behaviour of sample 3.2, determination of layer depth

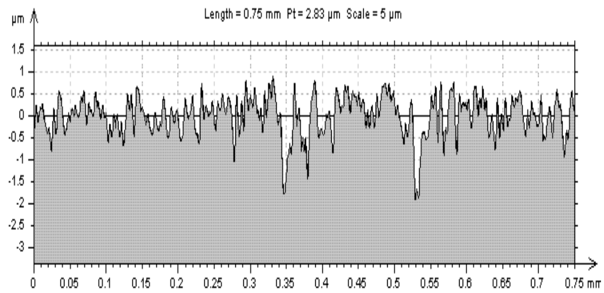




Pa = 0,873 µm; Pq = 1,14 µm; Pt = 7,14 µm
Ra = 0,799 µm; Rq = 1,03 µm; Rt = 5,94 µm
Wa = 0,0742 µm; Wq = 0,086 µm; Wt = 0,296 µm

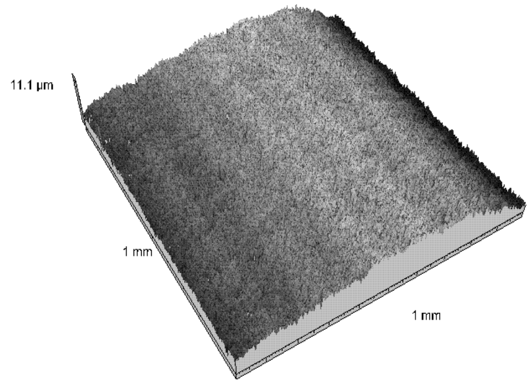
Figure 5. 3D surface topography, sample 3.0, non-treated surface

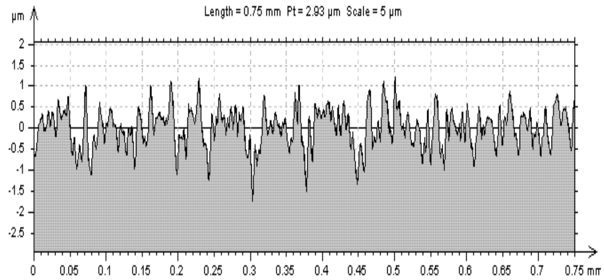




Pa = 0,345 µm; Pq = 0,452 µm; Pt = 2,83 µm
Ra = 0,358 µm; Rq = 0,47 µm; Rt = 2,73 µm
Wa = 0,043 µm; Wq = 0,0512 µm; Wt = 0,168 µm

Figure 6. 3D surface topography, sample 3.2, plasma nitridation 550 ^{o}C / 8 h





Pa = 0,373 µm; Pq = 0,469 µm; Pt = 2,93 µm
Ra = 0,375 µm; Rq = 0,477 µm; Rt = 2,75 µm
Wa = 0,0265 µm; Wq = 0,0298 µm; Wt = 0,114 µm

Figure 7. 3D surface topography, sample 3.4, plasma nitridation 450 ^oC / 8 h

3. CONCLUSIONS

Plasma nitride layer on the steel X12CrNi 18 8 surface at two different temperatures was created. The focus was on the relations among chemical composition, structure and properties of created layers. From GDOES measurements, it follows that a variable composition depth profile can be fabricated. The highest value of microhardness 1578 HV 0.05 was observed for plasma nitrided layer made at 550^{o}C / 8 h.

4. REFERENCES

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5. ACKNOWLEDGEMENTS

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