THE RELATION BETWEEN TiN COATINGS AND THE SURFACE OF HSS STEEL AFTER PLASMA NITRIDING

Jiri STANISLAV
UNITERM Liberec, Ruprechticka 85, 46001 Liberec, CSFR

Abstract

The relation between TiN coatings and the surface of HSS samples after nitrogen saturation by ionnitriding technology has been evaluated. The samples with nitriding layer, that were grinded into shape of the long wedge were used. Different nitrogen saturation along the substrate surface was ensured in this way. Consequently, they were deposited TiN coatings by reactive magnetron sputtering. Chemical analysis and X-ray difraction methods for determination of macroscopic and microscopic residual stress were used on grinded ionnitriding layers and TiN coatings respectively. The relation between the nitrogen saturated surface and TiN coatings was evaluated mainly by adhesion measurements.

1. Introduction

There is a treatment of tool materials by an ionnitriding process with a consequent deposition of TiN coating.It is one of the ways to increase the durability of the tool edge. This technology can bring significant improvement in some cases. However, this one is less reproducible in practice, i.e., the results are not stable.

2. Experimental procedure and results

The specimen from HSS steel with size 97x60x3.5 mm was heat-treated to 65 HRC, and consequently ionnitrided with these technology parameters: temperature 510°C, interval of saturation 11 hours, working atmosphere $N_2/H_2=1/3$. Then the nitrided layer was ground into a wedge along all specimen length. A TiN coating with 3.2 μm thickness was deposited on this treatment specimen.

Fig.1 shows the analysis of phase composition along the wedge length. Gradually there are nitrogen concentrations present as Fe_2N, Fe_3N and Fe_4N and then an α'-Fe(N) solid solution supersaturated by nitrogen.

Fig.2 shows the analysis d(110) interplane distance and B(110) expanding of difraction lines along the wedge length in the area of an α'-Fe(N) supersaturated solid solution. Increased values of d(110) and B(110) indicate that both microscopic and macroscopic stresses increase with increasing nitrogen concentration in α'-Fe(N). Magnetron-deposited TiN coatings have usually been loaded by considerable macrostress. Their values are influenced by different thermal expansion coefficients of both the coating and specimen, argon deposits in the coating and by bias. Macroscopic stress in the TiN coating was analyzed along all the wedge length. Nearly constant values of

stress of about 6260 MPa (see Fig.3), were measured there. The other TiN physical properties (microstress, subgrain size D_{OKR} and texture) have been nearly constant along the wedge length too.

Fig.4 shows values of TiN coating adhesion along the wedge length measured by the CSEM equipment. The coating adhesion have been the highest in areas with low nitrogen concetration in α'-Fe(N) and have decreased gradually with increasing nitrogen concentration. The lowest adhesion was detected firmly under the surface layer of Fe nitrides . As much as 5 mass% of nitrogen was measured by chemical analysis there. The adhesion had increased again on the original surface of the sample.

The perfect possibility of nitrogen partial pressure control (in the range p_{N2}=2-5 Pa and with a residual atmosphere lower then 1 Pa) is necessery to achieve the stated level of nitrogen concentration with ionnitriding technology. The majority of equipment for plasma nitriding technology is not able to guarantee these parameters. This is the reason for bad reproducibility in practice both with plasma nitriding technology for cutting tools and their combination with TiN coatings.

3. Conclusion

On the basis of measured results it is possible to say that the nitrogen presence on the substrate surface does not influence properties of TiN coatings. The nitrogen concentration in the specimen however substantially affect the TiN adhesion and further, properties of the substrate. It is possible to estimate, from a comparision of the X-ray values and chemical analyses, the optimal properties of TiN coatings connection to the substrate have been in an area of approximately 0.5-1.0 mass% of nitrogen concentration, where the α'-Fe(N) lattice parametr has been lower then 0.2880 nm.

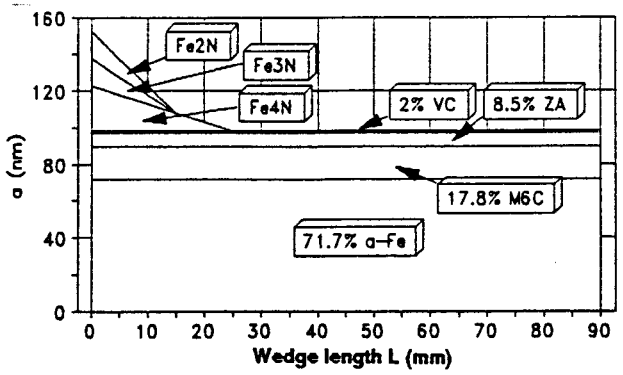

Fig.1 The phase analysis of the nitriding layer along the wedge length.

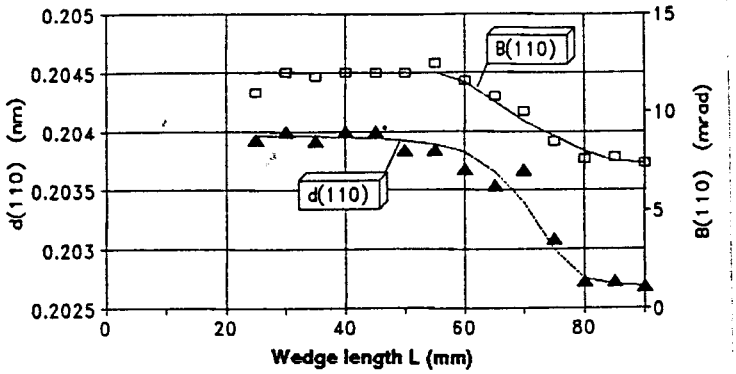

Fig.2 The α-Fe(110) interplane distance and the B(110) expanding of difraction lines along the wedge length.

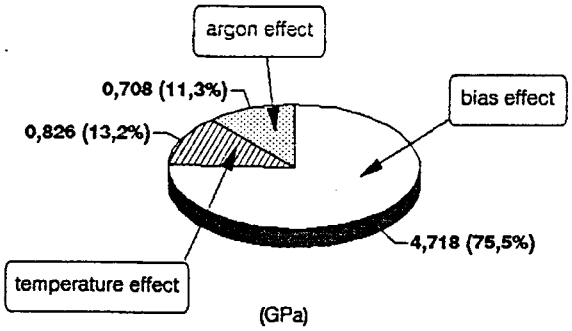

Fig.3 The average value of macrostress in TiN along the wedge length

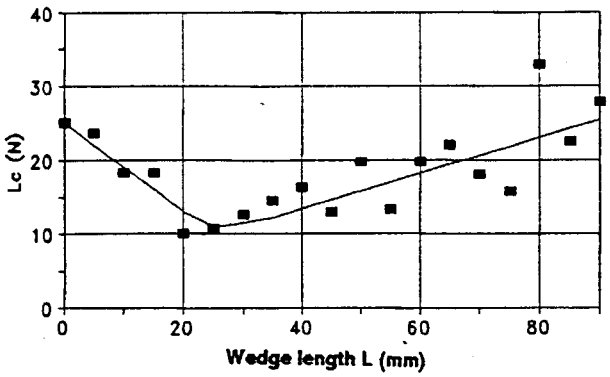

Fig.4 The measurement of the TiN coating adhesion to the nitriding specimen.