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Mechanical behavior of diamond coated WC-Co submitted to high pressure and high temperature

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Abstract – Microcrystalline diamond films were grown on WC-Co substrates by microwave assisted chemical vapor deposition and processed at high pressure (7.7 GPa) and high temperature (1000°C). The mechanical behavior of the samples was investigated by hardness instrumented testing before and after the high-pressure/high-temperature (HPHT) processing. The results indicated the diamond films became less friable after the HPHT processing, probably due to the infiltration of Co from the substrate. This conclusion was corroborated by corrosion tests.

Diamond coated WC-Co cutting tools combine the outstanding mechanical properties of diamond and the toughness of the substrate. Moreover, the diamond coating may act as a corrosion barrier for the substrate. The goal of this work was to investigate the effect of HPHT on the diamond film hardness and corrosion resistance.

WC-Co (6% wt.) substrate was first cleaned using a solution of of 50% vol. HF – 50% vol. HNO_3 during 6 min, and then chemically etched, using a solution of 30% vol. H_2SO_4 – 70% vol. H_2O_2 during 20 s, to remove the cobalt content from a surface layer of about 10 µm. The diamond films were grown on the substrates in a microwave plasma assisted CVD using 300 sccm of H_2, 30 sccm of CH_4 and 3 sccm of O_2 at 70 Torr. The diamond film thickness was 2-5 µm.

The hardness instrumented tests (HIT) were performed in a Fischerscope HV100 equipment with a maximum applied load of 1 N. Corrosion tests were carried out in a glass cell with a stainless steel counter electrode and a saturated calomel electrode as a reference using a potentiostat AUTOLAB.

Figure 1 shows the load versus displacement during the loading and the unloading cycles of the hardness measurements. The relative plastic deformation for WC-Co was approximately 70%, while for the diamond coated WC-Co, it was reduced to ~20%, before and after the HPHT processing. This distinct behavior should be expected based on the different values of hardness and elastic modulus of WC-Co and diamond. The sudden forward displacements observed in the diamond coated WC-Co before HPHT processing are probably related to the formation of lateral cracks on the diamond film. The HPHT processing was able to eliminate the causes of these sudden displacements. A possible explanation is the HPHT improved the sintering of the diamond film and/or of the substrate reducing the generation and propagation of cracks during the hardness tests. The hardness measured for the pristine substrate was 17.8 ± 0.6 GPa and, for the diamond coated samples, it was 37 ± 3 GPa before and 50 ± 4 GPa after the HPHT processing.

The results of the corrosion tests indicated the deposition of the diamond film decreased the electrochemical activity of the samples to -228 mV compared to the value for the pristine substrate, -370 mV, but the HPHT processing partially recovered the original activity, -333 mV, probably inducing an infiltration of Co through the diamond film. This effect reduces the corrosion resistance of the diamond coating but, on the other hand, can improve the mechanical properties of the diamond coated cutting tool [1].

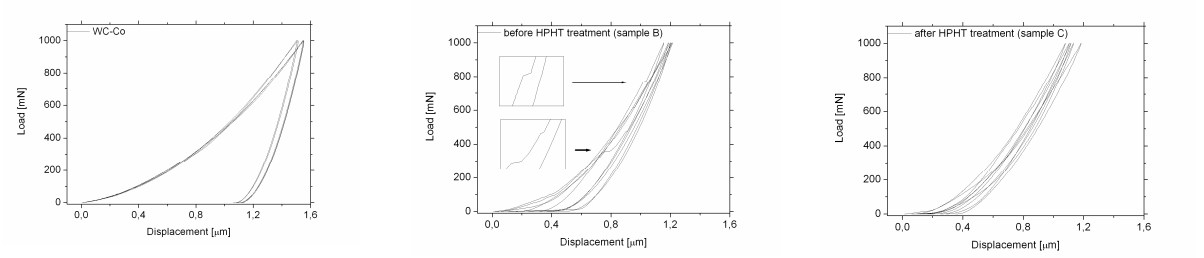

Figure 1: (a) WC-Co, (b) diamond coated WC-Co before and (c) after the HPHT processing.

References

[1]. R. V. Camerini, J. Z. Ferreira, A. S. Pereira, N.M. Balzaretti, J.A. Fernandes, R.B. Souza, E. Blando and R. Hübler
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