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A systematic metallurgical comparison among CVD coated WC-Co cutting tool inserts from five different suppliers

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CHARACTERISATION OF HARDMETAL CUTTING TOOLS

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1. Introduction

This paper presents results from an investigation of five coated cutting tools produced by five different companies, all the tools being used for the same application, turning.

The properties studied were average Vickers hardness using a load of 30 kg, and crack resistance. The microstructure and composition of the substrate and coating layers were determined using a JSM-840 SEM with a Be window EDS x-ray detector and a LEO 1525 FESEM with an ultra thin windowed EDS x-ray detector. The grain size of the carbides was measured from SEM micrographs using an image analyzer.

2. Substrates

Table 1 details the results of the properties of the five different substrates.

Table 1: Material properties of the substrates

Tool No.	HV30	Crack resistance [μm/kg]	Average grain size [μm]
1	1591	2.36±0.48	0.91
2	1563	2.10±1.33	0.91
3	1488	1.56±0.52	1.38
4	1463	2.06±0.43	1.33
5	1350	0.98±0.31	1.47

Table 1 (continued):

Tool No.	Elements present	Co [wt.%]
1	W, Co, Ti	6.3
2	W, Co, Ti, Fe	7.2 (+ Fe)
3	W, Co, Ti	9.1
4	W, Co, Ti	7.2
5	W, Co, Zr	8.1

A typical microstructure (secondary electron mode) of the substrate is shown in Fig. 1. Three phases can be distinguished: the darker grains are (Ti,W)C, the light grey ones are WC and the white regions are Co.

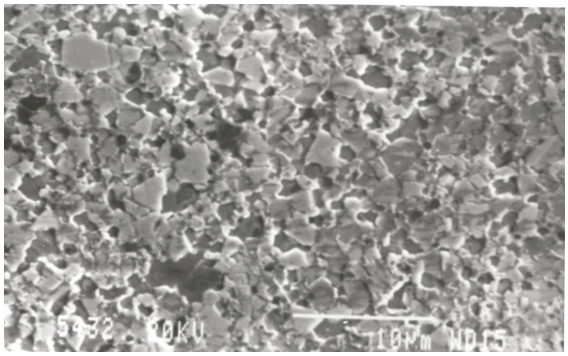

Fig. 1: Microstructure of substrate No. 1

From the EDS data, (Ti/W) and (Co/W) ratios were calculated, see Fig. 2.

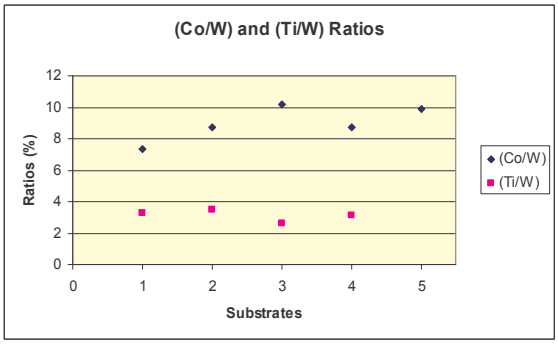

Fig. 2: (Ti/W) and (Co/W) ratios

3. Coatings

Table 2 lists the hardness of the "substrate/coating" system.

Table 2: Hardness of the "substrate/coating" systems

Tool	Hardness HV30
1	1672
2	2056
3	1509
4	1679
5	1410

Comparing the hardness of the substrates with that of the "substrate/coating" system, it can be seen that the coatings enhance the hardness of the tools to varying degrees.

Figure 3 shows, as an example, the cross section of a coating (sample 3), where the labels indicate the following:

1: substrate
2: Ti(CN)
3: Ti(CN)
4: Al_2O_3
5: Ti(CN)
6: mounting resin

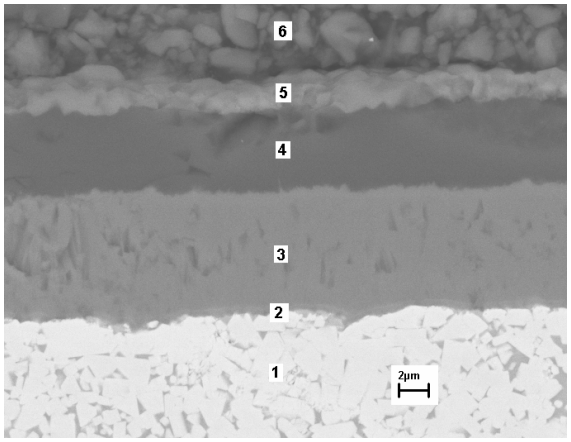

Fig. 3: Coating layers of sample 3

Using EDS analysis, the composition of the various layers was determined as well as their thicknesses. From the quantitative analysis, the empirical formulae of each coating layer was calculated, see Table 3:

Table 3: Empirical formulae and thickness of the coating layers

Sample 1:

Coating layer	Overall thickness [µm]	Empirical formulae
TiC	12.5	TiC
Ti(CN)		$Ti_{0.4}C_{0.25}N_{0.35}$

Table 3 (continued):

Sample 2:

Coating layer	Overall thickness [µm]	Empirical formulae
Ti(CN)	14.7	$Ti_{0.4}C_{0.2}N_{0.4}$
Ti(CN)		$Ti_{0.4}C_{0.4}N_{0.2}$
Al_2O_3		Al_2O_3
Ti(CN)		$Ti_{0.3}C_{0.2}N_{0.5}$

Sample 3:

Coating layer	Overall thickness [µm]	Empirical formulae
Ti(CN)	14.4	$Ti_{0.5}C_{0.25}N_{0.25}$
Ti(CN)		$Ti_{0.5}C_{0.3}N_{0.2}$
Al_2O_3		Al_2O_3
Ti(CN)		$Ti_{0.3}C_{0.3}N_{0.4}$

Sample 4:

Coating layer	Overall thickness [µm]	Empirical formulae
Ti(CN)	12.0	$Ti_{0.5}C_{0.35}N_{0.15}$
Al_2O_3		Al_2O_3
Ti(CN)		$Ti_{0.2}C_{0.5}N_{0.3}$ or $Ti_{0.4}C_{0.4}N_{0.2}$

Sample 5:

Coating layer	Overall thickness [µm]	Empirical formulae
Ti(CN)	13.5	$Ti_{0.4}C_{0.4}N_{0.2}$
TiC		$Ti_{0.4}C_{0.6}$
Ti(CN)		$Ti_{0.2}C_{0.4}N_{04}$
Al_2O_3		Al_2O_3
Ti(CN)		$Ti_{0.2}C_{0.5}N_{0.3}$

4. Conclusion

The five cutting tools have different properties and characteristics although they are used for the same application. Since the relative wear resistance is known, these results provide information on the optimum properties and microstructure for this type of tool.

Acknowledgement

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