COMPARISON OF FIVE COATED CUTTING TOOLS USING SEM AND EDS

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The differences between coated cutting tools from five different suppliers used in the same application (turning) were assessed with respect to their properties, composition and microstructure.

Although the tools are used for identical applications, large differences were found in their properties, composition and microstructure, both for the substrates and for the coatings. Table 1 and 2 summarize the properties of the substrates while Table 3 details the thickness and composition of the multilayered coatings.

Table 1: 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 2: EDS analysis of the substrates

Tool No.	*Elements present*	*Co content [wt.%]*
1	W, Co, Ti	6.2
2	W, Co, Ti, Fe	7.3 (+ Fe)
3	W, Co, Ti	8.5
4	W, Co, Ti	7.3
5	W, Co, Zr	8.2

It is known from x-ray diffraction that W and Ti are present in the form of WC and (Ti,W)C. Since our beryllium windowed EDS system did not allow the determination of carbon, it was not possible to determine the carbon content of each carbide.

The coatings were analyzed in a LEO 1525 FESEM and the composition of each layer was determined using an ultrathin windowed detector.

Table 3: EDS analysis of the coatings

Tool No.	*Coating*		*Empirical formulae*
	Layers	*Thickness [μm]*	
1	TiC	5.3	TiC
	Ti(CN)	7.4	$Ti_{0.4}C_{0.25}N_{0.35}$
2	Ti(CN)	1.4	$Ti_{0.4}C_{0.2}N_{0.4}$
	Ti(CN)	10.2	$Ti_{0.4}C_{0.4}N_{0.2}$
	Al_2O_3	2.5	Al_2O_3
	Ti(CN)	0.6	$Ti_{0.3}C_{0.2}N_{0.5}$
3	Ti(CN)	0.4	$Ti_{0.5}C_{0.25}N_{0.25}$
	Ti(CN)	7.7	$Ti_{0.5}C_{0.3}N_{0.2}$
	Al_2O_3	4.9	Al_2O_3
	Ti(CN)	1.4	$Ti_{0.3}C_{0.3}N_{0.4}$
4	Ti(CN)	9.0	$Ti_{0.5}C_{0.35}N_{0.15}$
	Al_2O_3	2.1	Al_2O_3
	Ti(CN)	0.9	$Ti_{0.2}C_{0.5}N_{0.3}$ or $Ti_{0.4}C_{0.4}N_{0.2}$
5	Ti(CN)	5.6	$Ti_{0.4}C_{0.4}N_{0.2}$
	TiC	2.0	$Ti_{0.4}C_{0.6}$
	Ti(CN)	0.9	$Ti_{0.2}C_{0.4}N_{0.4}$
	Al_2O_3	1.1	Al_2O_3
	Ti(CN)	3.9	$Ti_{0.2}C_{0.5}N_{0.3}$

The results in Table 3 were obtained from cross sections of the coatings, starting in each case with the first deposited layer on the substrate. It should be noted that the diameter of the analysed volume was greater than 1 μm. Thus, the composition of some of the coating layers (expressed in terms of empirical formulae) must be taken as approximations.

Although the five cutting tools are all used in the same application, the samples show significant differences in the properties, as well as in characteristics of the substrate and coating. The relative resistance to wear of the five tools is known. Thus these results provide manufacturers with useful information on the optimum composition and microstructure.

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