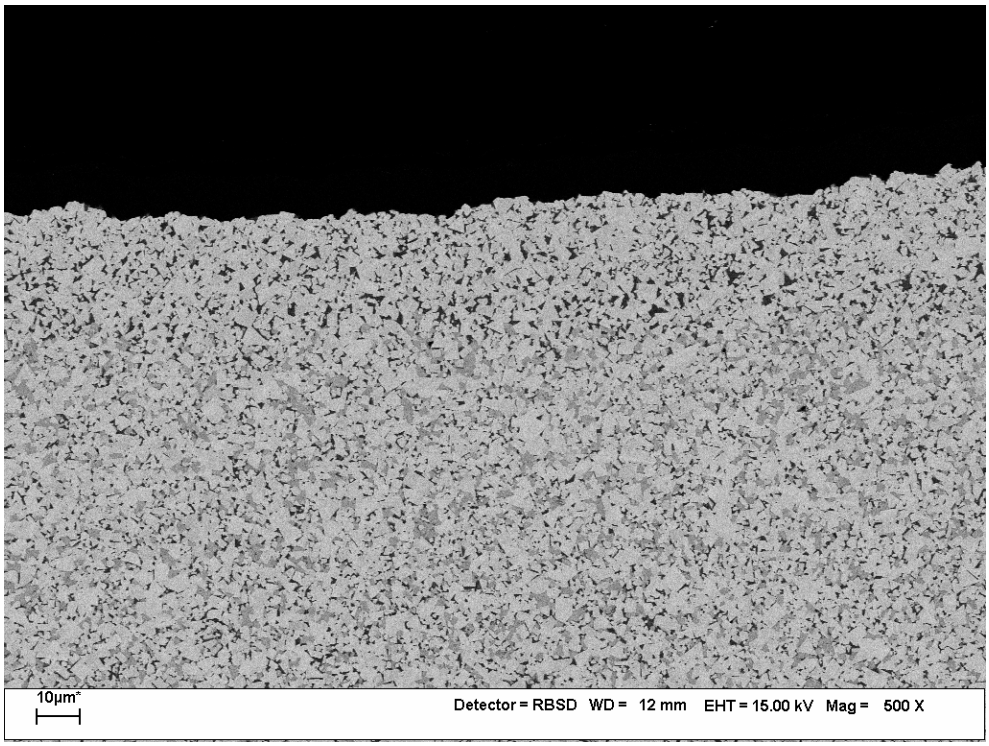

Fig. 4.32: Backscattered electron micrograph of insert from supplier 5. Below is a cross section of the substrate (which is graded), above is the coating (which appears black). Note the substrate/coating interface. The white phase is WC, the grey phase (W,Zr)C and the black phase is Co.

4.2.5 Qualitative Analysis

Qualitative analysis was performed first by EDS to identify all elements in the cutting tool substrates and then, XRD analysis was executed to find the phases present.

4.2.5.1 EDS Analysis

Specimens of the cutting tool inserts from suppliers 1, 2, 3, 4 and 5 were metallographically prepared and their microstructures analyzed in the SEM. From each cutting tool substrate, backscattered images were taken to see the number of phases present. They can be distinguished by their different shading as phases with a high average atomic number appear light, while phases with a low average atomic number appear dark. Figures 4.33 to 4.37 show a backscattered micrograph from each of the cutting tool substrates, all at the same magnification.

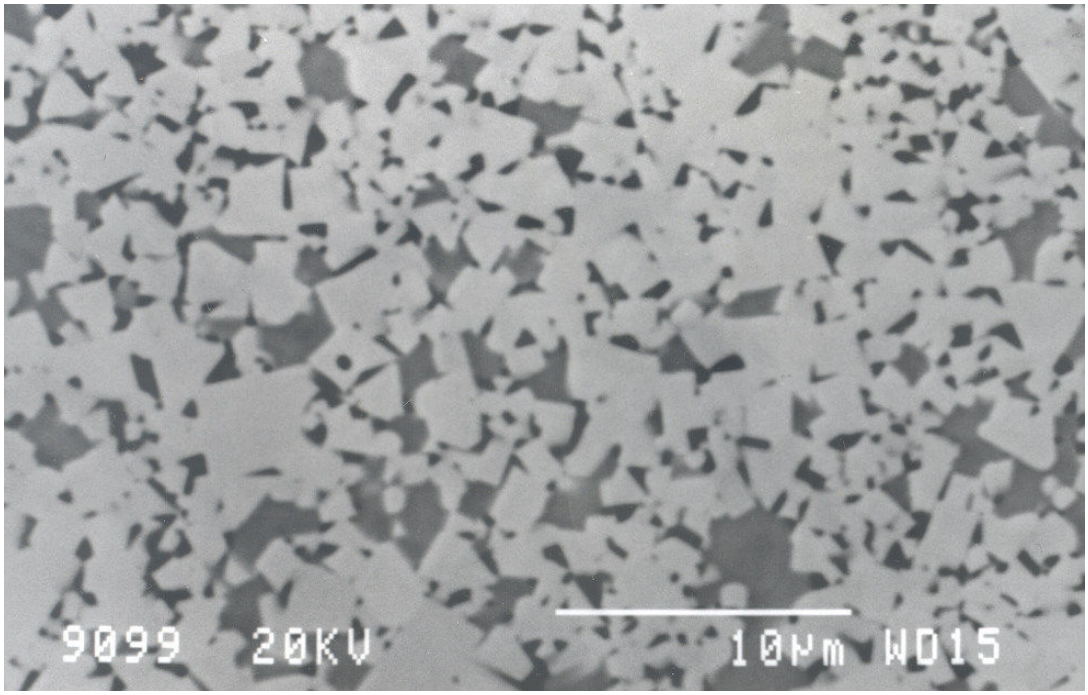

Fig. 4.33: Backscattered image of substrate from supplier 1. The lightest phase is WC, the intermediate phase (W,Ti)C and the darkest phase Co.

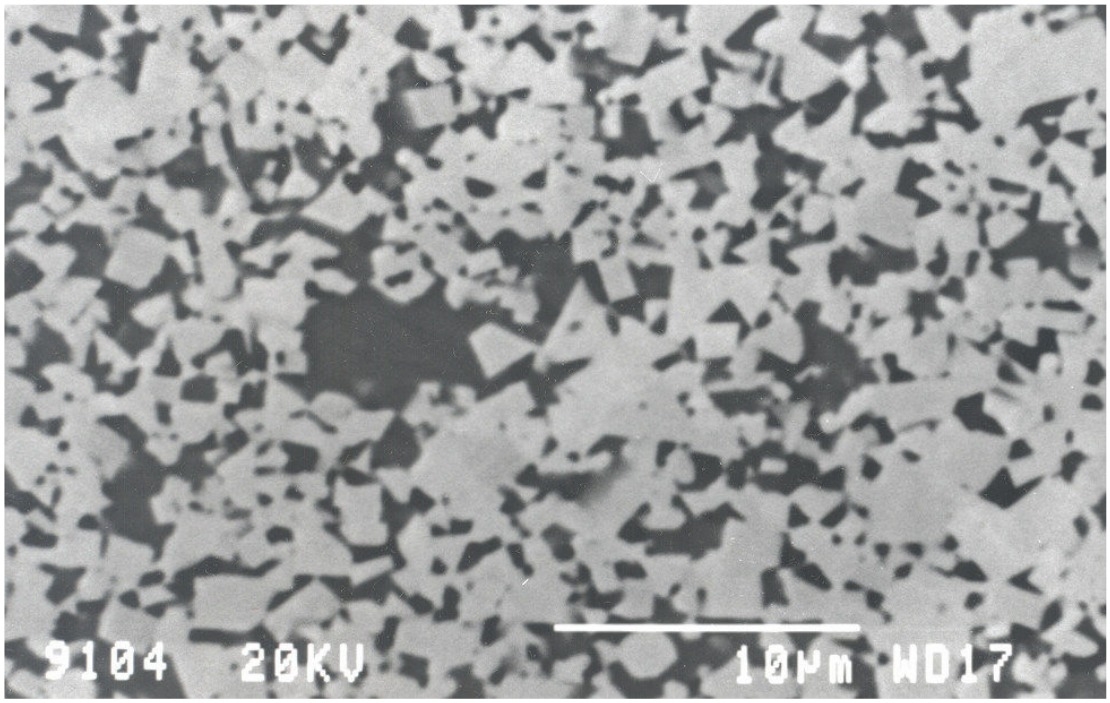

Fig. 4.34: Backscattered image of substrate from supplier 2. The lightest phase is WC, the intermediate phase (W,Ti)C and the darkest phase Co.

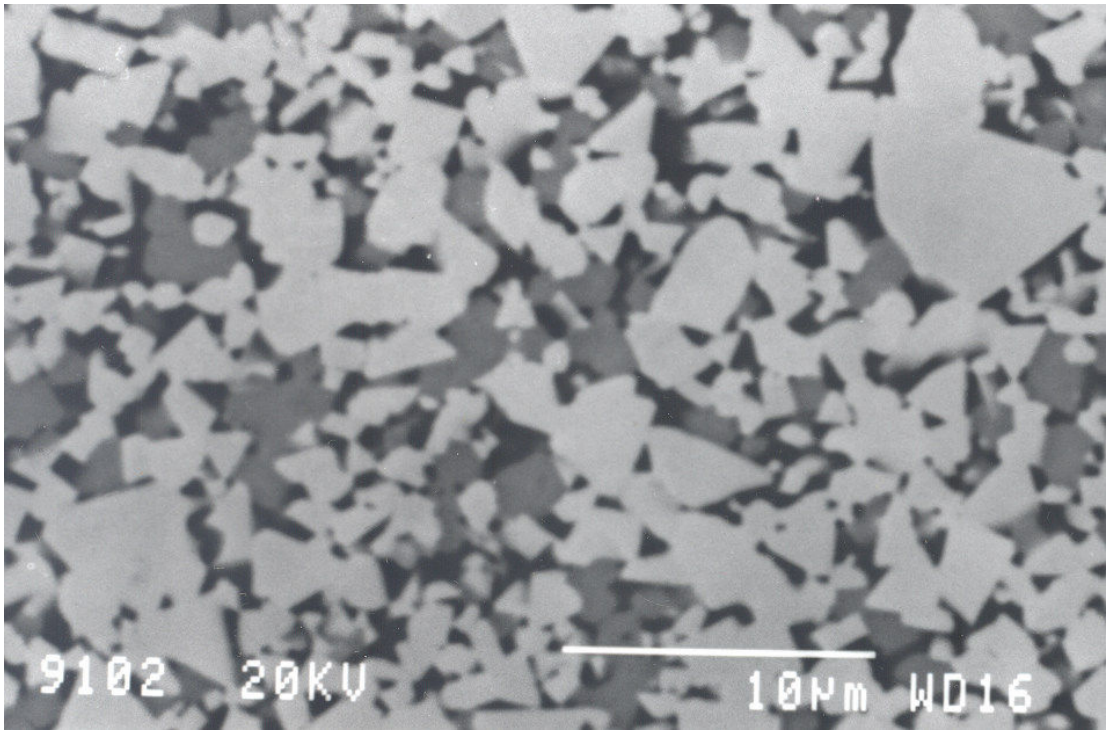

Fig. 4.35: Backscattered image of substrate from supplier 3. The lightest phase is WC, the intermediate phase (W,Ti)C and the darkest phase Co.

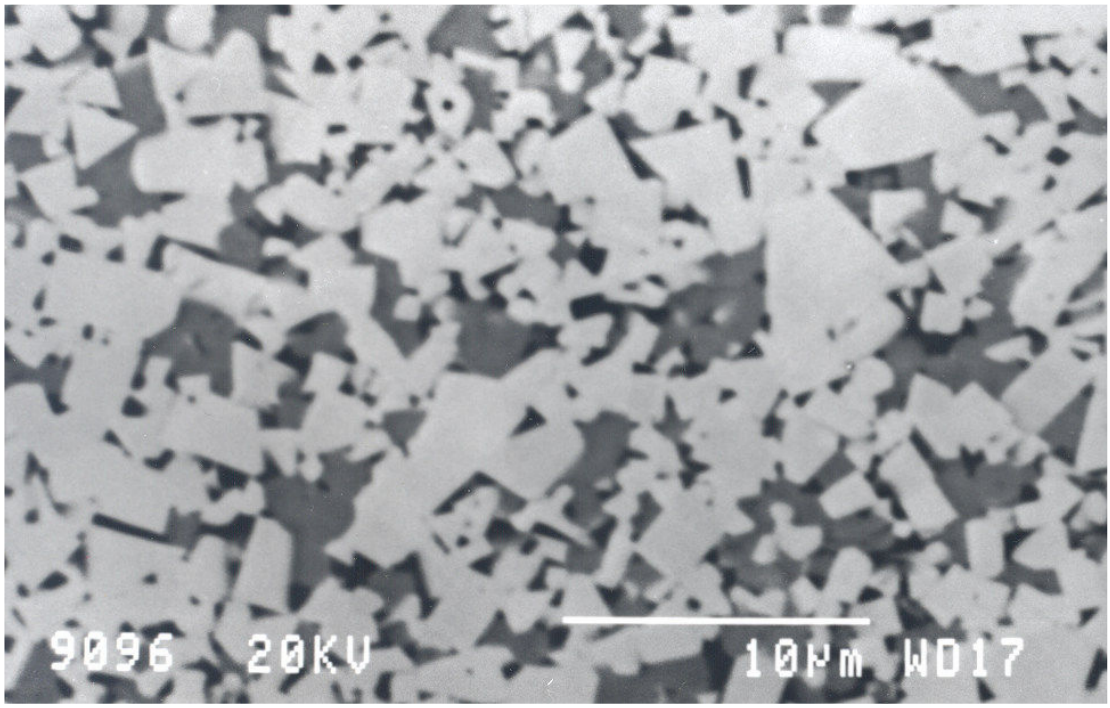

Fig. 4.36: Backscattered image of substrate from supplier 4. The lightest phase is WC, the intermediate phase (W,Ti)C and the darkest phase Co.

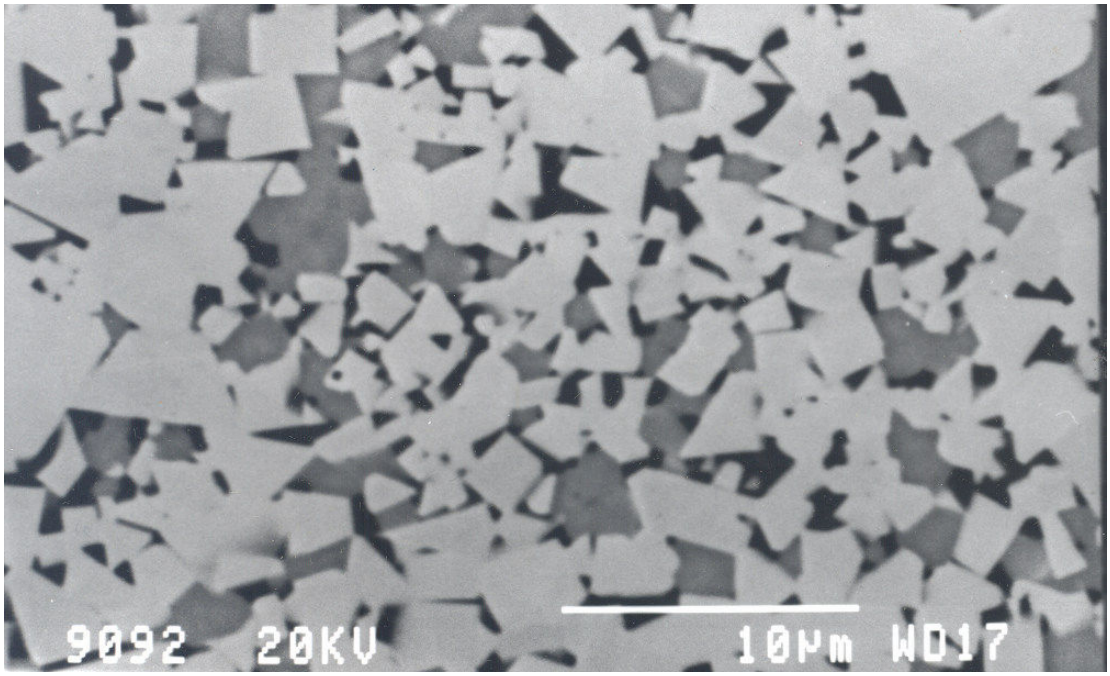

Fig. 4.37: Backscattered image of substrate from supplier 5. The lightest phase is WC, the intermediate phase (W,Zr)C and the darkest phase Co.

All the microstructures of the substrates from suppliers 1 to 5 showed three different phases which were distinguished by three different shades of grey. Elemental evaluation of theses phases was done by EDS X-ray analysis.

A general spectrum of each substrate was taken at a magnification of x500. That magnification was low enough to give a true average of the composition of the sample. The voltage was 20 kV and the acquisition time 100 sec. After acquiring one spectrum, the elements present were determined by identifying the peaks (see Figs. 4.38 to 4.42).

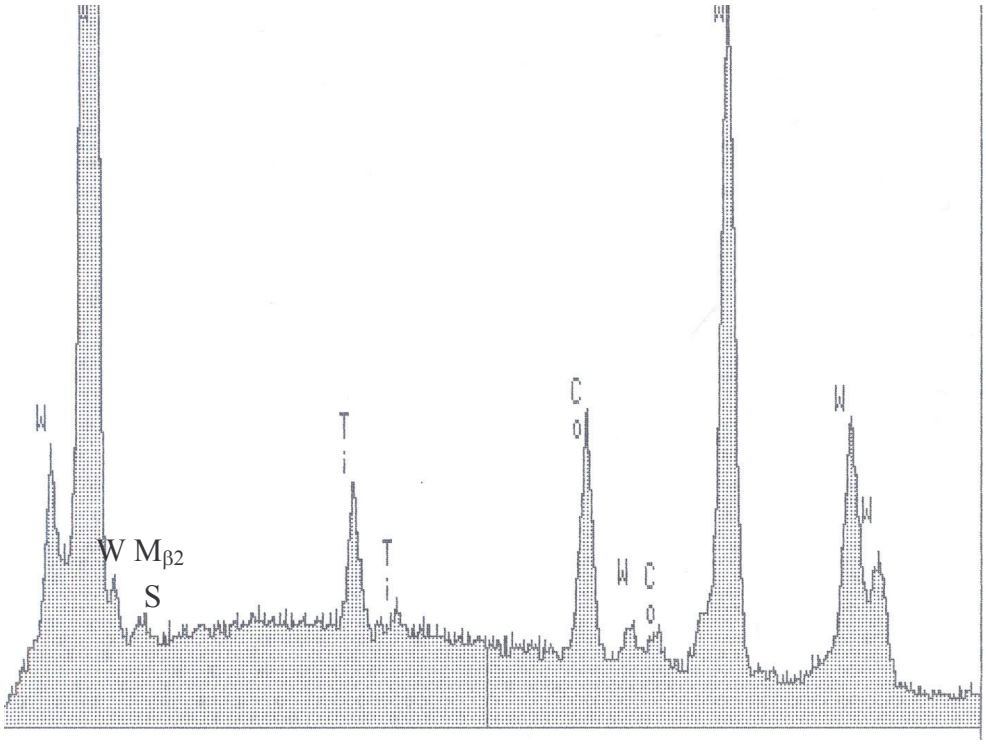

Fig. 4.38: EDS analysis of substrate from supplier 1

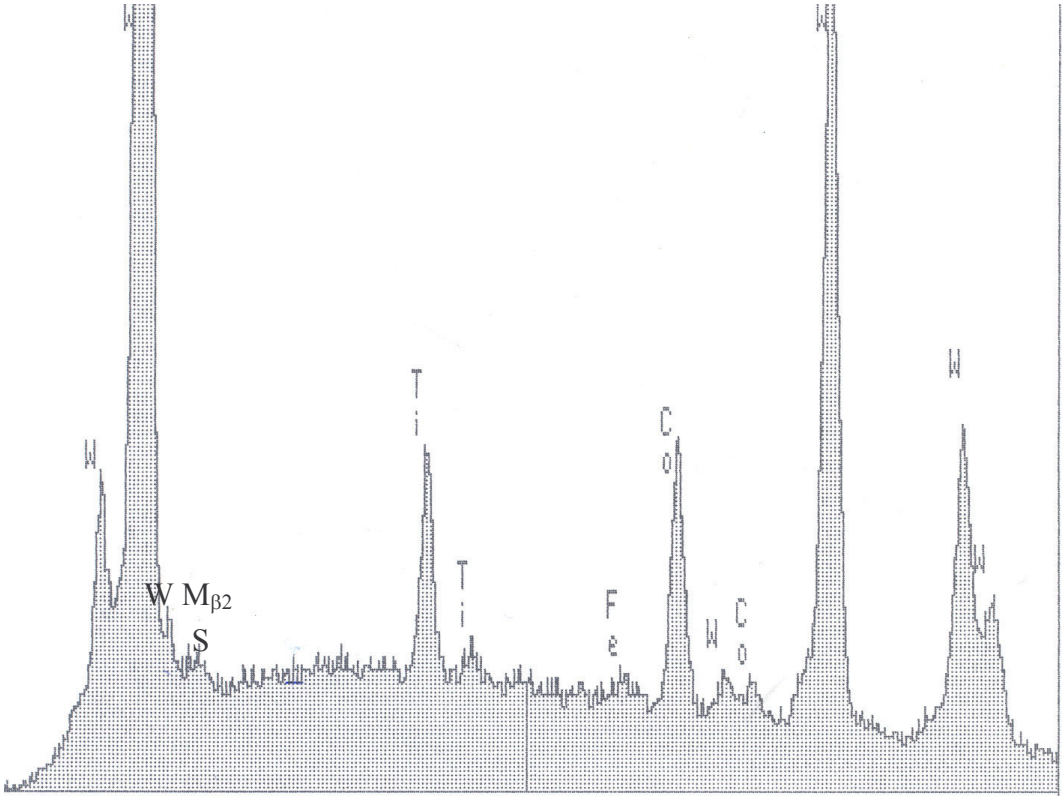

Fig. 4.39: EDS analysis of substrate from supplier 2

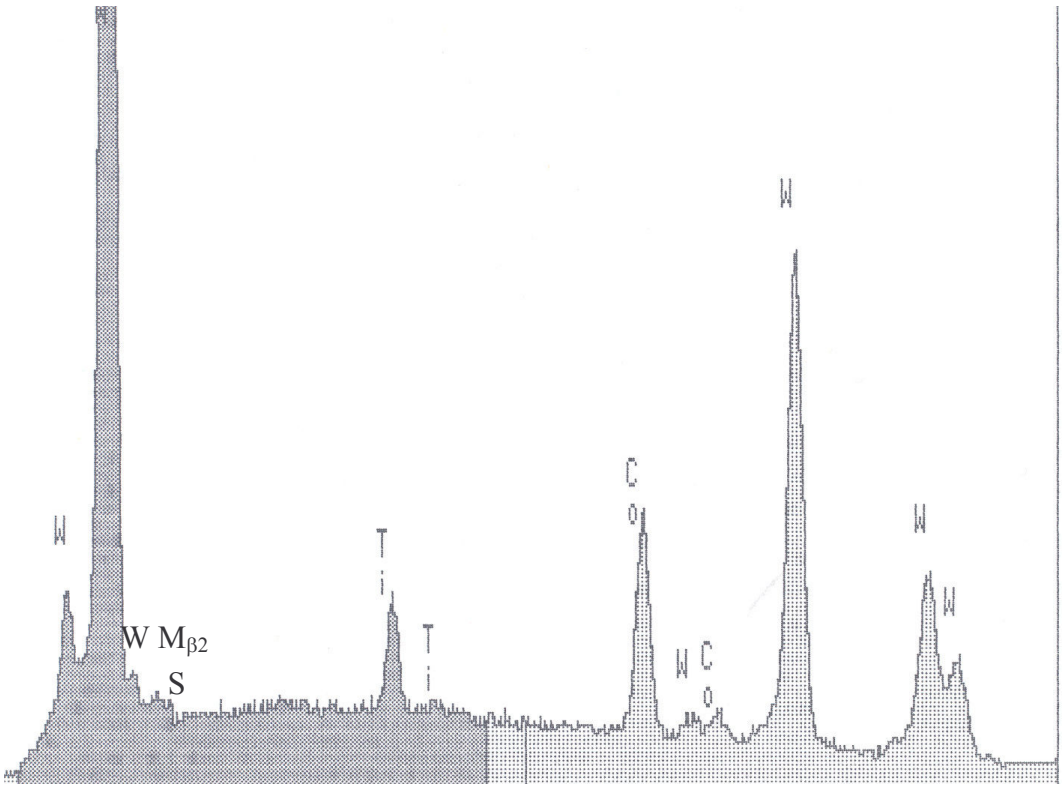

Fig. 4.40: EDS analysis of substrate from supplier 3

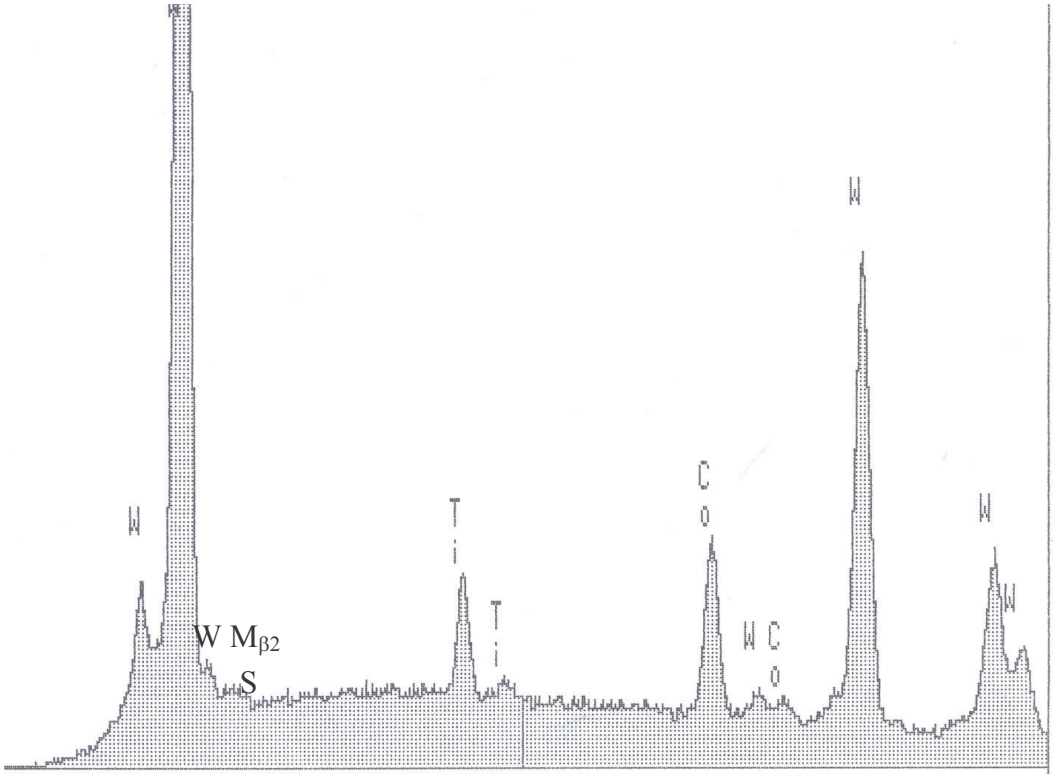

Fig. 4.41: EDS analysis of substrate from supplier 4

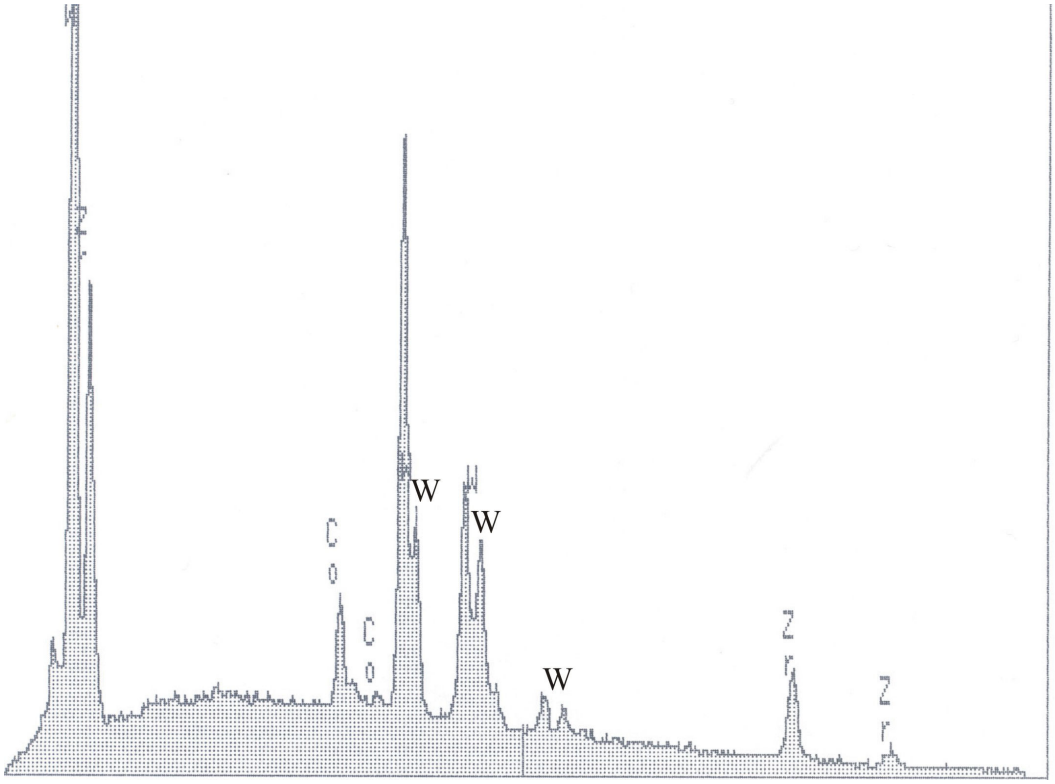

Fig. 4.42: EDS analysis of substrate from supplier 5

Symbols indicate, next to the peaks, the detected elements. Four of the cutting tool substrates had similar elemental compositions, mainly W, Co and Ti, as can be seen in Table 4.7. C cannot be detected with the used system, a JSM-840 SEM with a Be window EDS X-ray detector.

Table 4.7: EDS analysis of substrates using a general spectrum at x500

Substrate	**Qualitative analysis**
Supplier 1	W, Co, Ti
Supplier 2	W, Co, Fe, Ti
Supplier 3	W, Co, Ti
Supplier 4	W, Co, Ti
Supplier 5	W, Co, Zr

From Table 4.7 it can be seen, that the substrate from supplier 2 had additionally to W, Co and Ti a small amount of Fe, which is probably unintentional contamination, and that supplier 5's substrate contained Zr instead of Ti.

Examining the spectra of the substrates revealed, that all spectra except the one in Fig. 4.42 (substrate from supplier 5) contained the two small peaks of W $M_{\beta 2}$ and S. In the spectrum from the substrate from supplier 5 the Zr peak hides the small W $M_{\beta 2}$ peak and there is no S present.

The overall spectra taken at x500 did not show any Ta, although it was known to be present, because its concentration in the materials as a whole was at the limit of detectability by the used EDS system (JSM-840 SEM with a Be window EDS X-ray detector). Some of the Ta peaks overlap with the W peaks, but even the highest Ta peak (which does not overlap with the peaks of the other elements) was not visible.

However, it was expected that most of the Ta present was in the mixed carbide grains (in the form of (Ti,Ta)C or (W,Ti,Ta)C). Therefore, spot analyses were

performed on the mixed carbide grains. They were done at 20 kV and an acquiring time of 100 sec. A typical cross section of the grains selected for analysis measured about 2 μm x 2 μm.

Figures 4.43 to 4.52 show a set of two spectra for each cutting tool substrate. The first spectrum, obtained at a magnification of x500 shows the spectrum of the substrate with the Ta lines. The lines on those spectra indicate where the Ta peaks should be. The highest Ta peak is marked with a red spot and is generally not visible. The second spectrum shows Ta clearly because it is from the analysis of a (W,Ti,Ta)C grain (or (W,Zr,Ta)C grain in the case of the substrate from supplier 5) and not from the material as a whole.

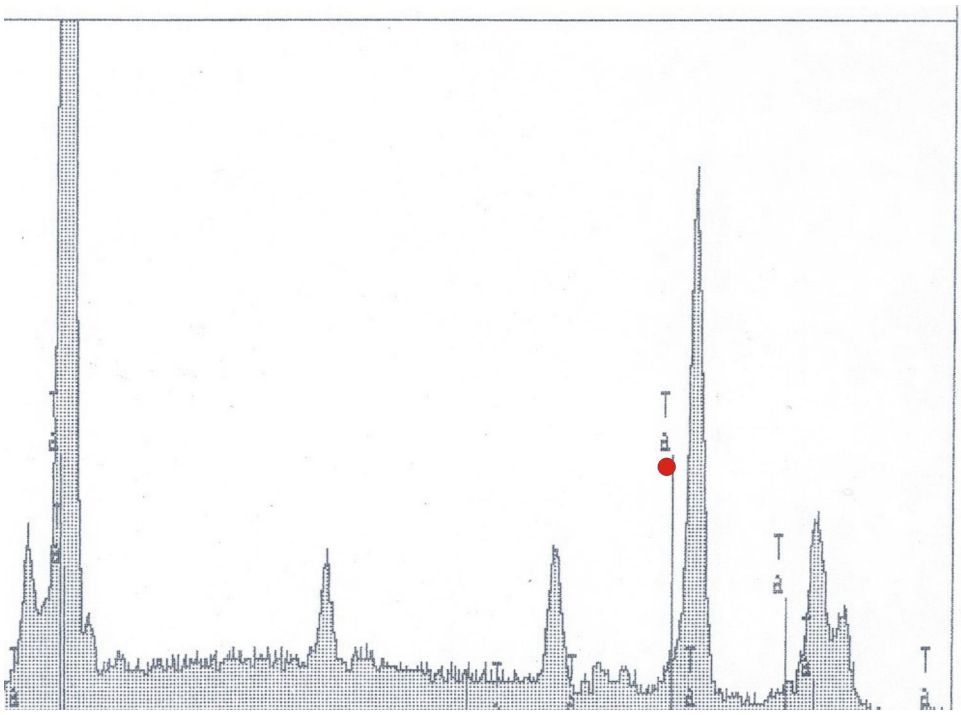

Fig. 4.43: General spectrum of substrate from supplier 1 taken at a x500 magnification with Ta lines

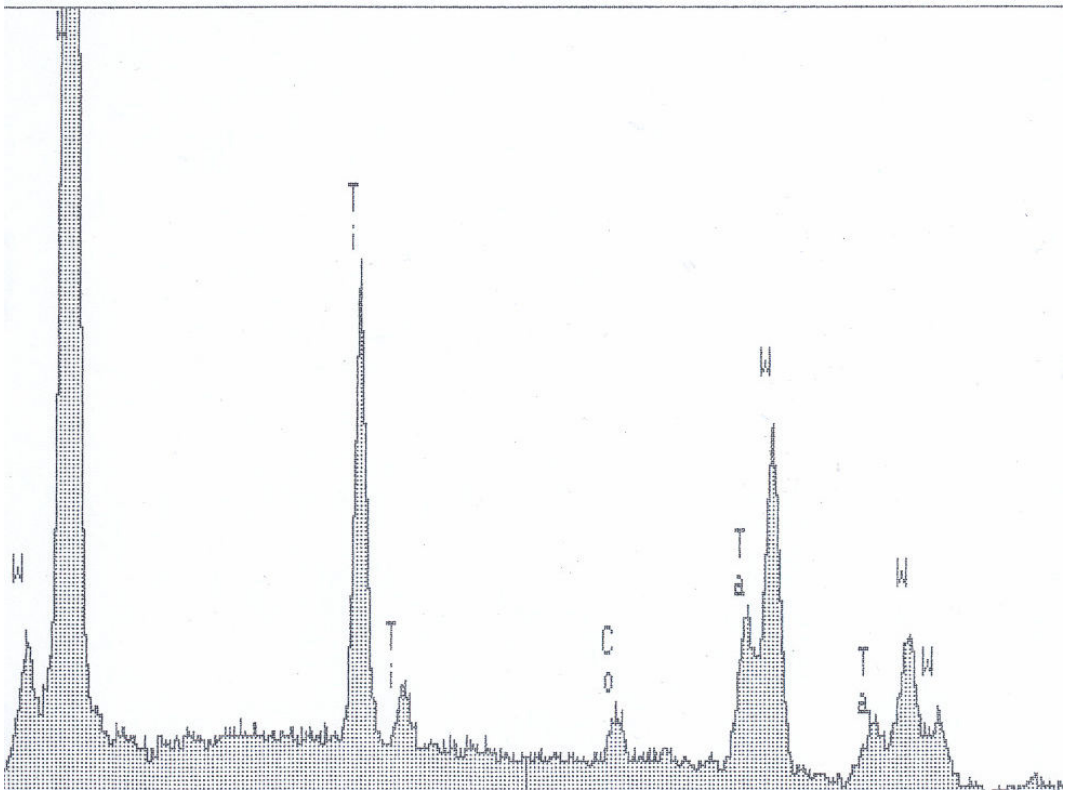

Fig. 4.44: Spot analysis of mixed carbide grain in substrate from supplier 1

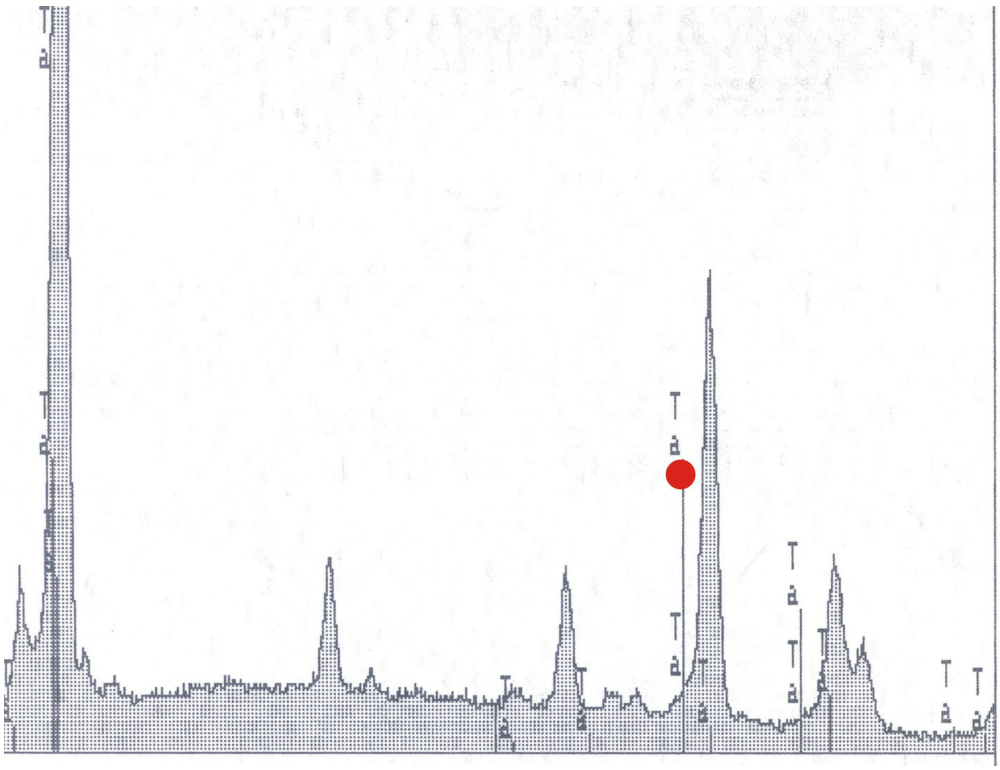

Fig. 4.45: General spectrum of substrate from supplier 2 taken at a x500 magnification with Ta lines