0272-8842(95)00087-9

Ceramics International 22 (1996) 219–222
© 1996 Elsevier Science Limited and Techna S.r.l.
Printed in Great Britain. All rights reserved
0272-8842/96/$15.00

Chemical Reactions Occurring at a BN–AgTi Interface

E. Benko

Institute of Metal Cutting, ul. Wrocławska 37 A, 30-011 Kraków, Poland

(Received 29 March 1995; accepted 28 June 1995)

Abstract: A plate of cubic boron nitride (BN) whose surface was covered by an AgTi 1.5 layer was subjected to thermal annealing at 950°C and $3*10^{-3}$ Pa for 1 h. After this treatment the sample was polished on the transverse section. The BN–alloy interface was studied using Auger electron spectroscopy (AES). From the studies of the elemental distributions (Ag, Ti, B, N) on the surface of the polished section it can be concluded that all titanium diffuses from the AgTi 1.5 alloy to the BN–alloy contact layer. As a consequence, Ag is not present in the contact layer. At the BN–Ti interface titanium boride is formed, whereas further from the interface towards the alloy, formation of the TiN layer can be observed.

Diffusion of titanium towards BN and formation of new phases at the BN–Ti interface proves its great chemical affinity to BN.

1 INTRODUCTION

Boron nitride (BN) is widely used in modern technology. Due to its unique properties (hardness in the range of 60–80 GPa, high resistance against oxidation in air up to 1200°C, compressive strength of 5–6.5 GPa), cubic boron nitride is widely used in the production of polycrystalline super hard materials for the machine-building industry. Cutting elements fabricated from boron nitride are used for cutting hardened steel, cast iron and other materials which are difficult to process. In the fabrication of blades from boron nitride by sintering, special binding admixtures (such as metals, alloys, nitrides, borides or carbides) must be added.[1]

The main goal of this communication is to elucidate the nature of the interactions between the alloy (in this case AgTi 1.5) and boron nitride.

2 EXPERIMENTAL

Plates of cubic boron nitride (Tieplonit, Ukrainian production) covered by an AgTi 1.5 layer were thermally annealed at 950°C and $3*10^{-3}$ Pa for 1 h. After this process samples were polished on the transverse section. The BN–alloy contact layer was studied by Auger electron spectroscopy (AES) using VSW equipment. An FEJ electron gun was applied. Electrons in the energy range of 3–10 keV served as the excitation source. The electron beam current was about 30 nA. The Auger electrons' energy was analysed using the hemispherical analyser HA 150 produced by VSW which worked in FRR 10 regime. The pressure of residual gases in the analysis chamber was kept below $2*10^{-9}$ mbar. Before each measurement the sample's surface was cleaned from the adsorbed gases by bombardment with a 4 eV argon stream whose current was about 0.4 mA. The bombardment time was about 20 min.

3 RESULTS AND DISCUSSION

On the analysed surface three distinct areas were observed. In the first area a high concentration of Ag was registered; in the second one titanium and nitrogen were the main elements; and in the third one boron, carbon and nitrogen were predominant. These results are shown in the spectra obtained by point analysis in all three areas (Figs 1–3). Auger electron energies of the elements studied are given in Table 1.

Analysis of elemental distributions was performed along the line perpendicular to the area boundaries. Results of this analysis are shown in Fig. 4. The y-axis in the diagrams represents the ratio of the Auger peak intensity of a given element to the background. This ratio is proportional to the concentration of the analysed element in a given point. Because of the possible adsorption of carbon present in the residual gas in the spectrometer the distribution of this element on the analysed surface may not be relevant to its concentration in the sample studied. Therefore, the carbon content was not analysed. The distribution of nitrogen content was obtained by the indirect method since the peaks originating from titanium (381.362 eV) and the main nitrogen peak (375 eV) overlap. Thus the peak at 375 eV (shown in Fig. 4) represents the sum of titanium and nitrogen concentrations. The amount of nitrogen can be deduced from the comparison of changes of this peak with respect to the changes of the Ti peak at 416 eV.

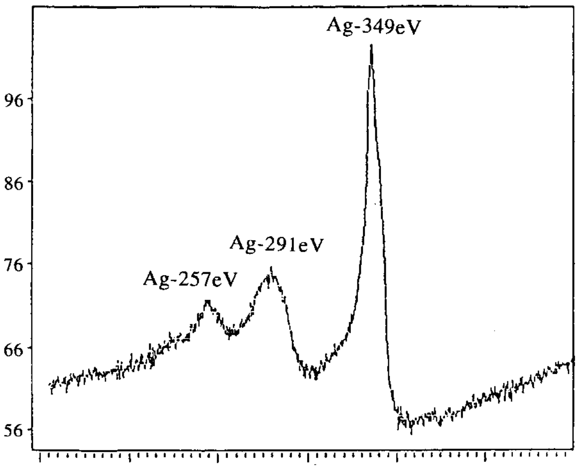

Fig. 1. Diagrams of energetic spectra, area 1 (traversing from AgTi towards BN).

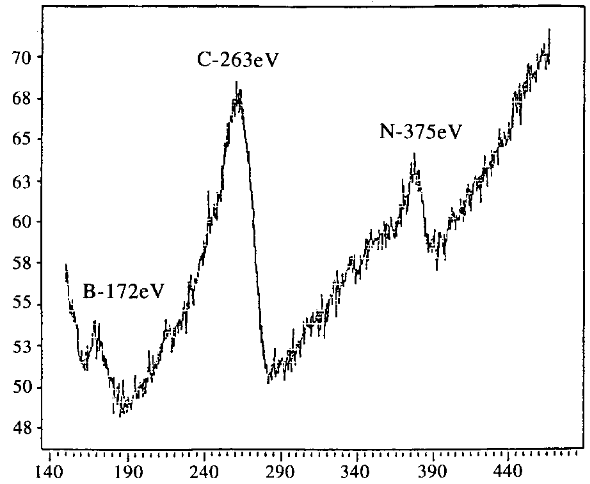

Fig. 2. Diagrams of energetic spectra, area 2 (traversing from AgTi towards BN).

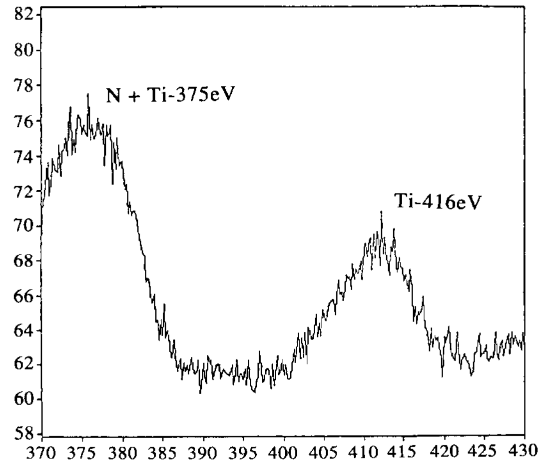

Fig. 3. Diagrams of energetic spectra, area 3 (traversing from AgTi towards BN).

The analysis of the elemental distribution based on Auger peak intensities is not always sufficient. A more accurate method involves the analysis of the peak areas. Such a procedure was applied for the more precise analysis of Ti, N and B concentrations at the Ti–BN interface. In order to carry out this procedure a number of secondary electron spectra in the points located on the line perpen-

Table 1. Auger transition energies for separate elements

Element	Auger transition type	Transition energy[3] [eV]
Boron (B)	KLL	**172**
Carbon (C)	KLL	**263**
Silver (Ag)	MNN	**349**, 257, 291, 354
Nitrogen (N)	KLL	**375**, 358
Titanium (Ti)	LMM	**381**, 362, 416

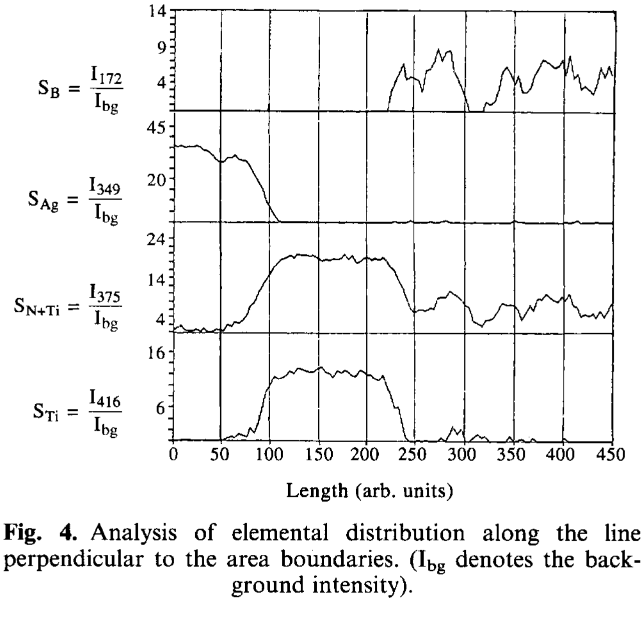

Fig. 4. Analysis of elemental distribution along the line perpendicular to the area boundaries. (I_{bg} denotes the background intensity).

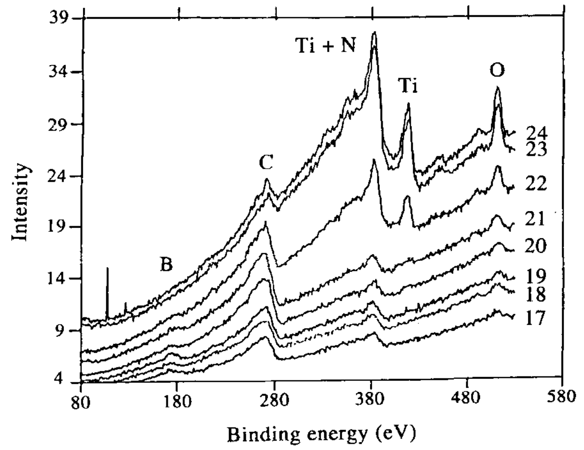

Fig. 5. Secondary electron spectra in the points located on the line perpendicular to the boundary studied.

Table 2. Values of peak areas and peak area ratios for separate elements in given measurement points

Number	Peak	Area	Area/(Ti+N)
24	B		0,00
	C	69	0,12
	Ti+N	588	1,00
	Ti	65	0,11
	O	57	0,10
23	B		0,00
	C	58	0,11
	Ti+N	508	1,00
	Ti	70	0,14
	O	64	0,13
22	B		0,00
	C	153	0,55
	Ti+N	278	1,00
	Ti	34	0,12
	O	45	0,16
21	B	8	0,11
	C	206	2,75
	Ti+N	75	1,00
	Ti	12	0,16
	O		0,00
20	B	4	0,11
	C	231	6,60
	Ti+N	35	1,00
	Ti		0,00
	O	20	0,57
19	B	18	0,20
	C	139	1,56
	Ti+N	89	1,00
	Ti		0,00
	O	13	0,15
18	B	11	0,20
	C	120	2,22
	Ti+N	54	1,00
	Ti		0,00
	O	16	0,30
TiN	Ti+N	221	1,00
	Ti	21	0,10
TiB_2	Ti+N	251	1,00
	Ti	36	0,14

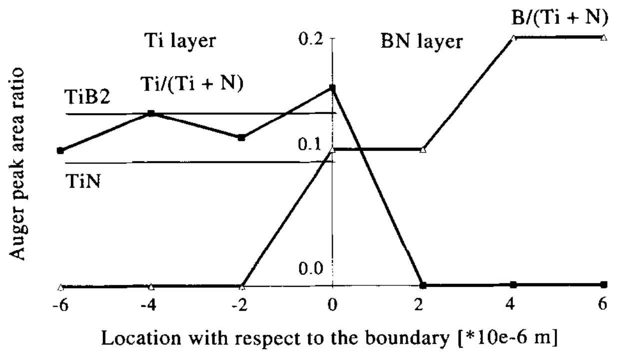

Fig. 6. Auger peak area ratios for separate elements located on the line perpendicular to the Ti–BN interlayer.

dicular to the interface studied were recorded. These spectra are shown in Fig. 5, in which the measurement number denotes particular measuring points. The distance between them was approximately 2 μm. After abstraction of the background using Sharley's method, areas of the separate peaks were determined. In order to determine semi-quantitatively the changes in the elements' concentrations the peak areas were normalised to the area of the peak at 380 eV which corresponds to two elements: Ti and N. This peak was denoted as Ti + N. The values obtained are summarised in Table 2 and Fig. 6. Additionally, the ratios of the peak areas, namely Ti/Ti + N were determined for two standard samples: TiN and TiB_2.

Analysis of the Ti–BN interface shows that in the Ti area a small amount of N exists, since the value of Ti/Ti + N ratio is lower for this sample than the one obtained for the standard sample which did not contain nitrogen (TiB_2). However, at the Ti–BN interface this ratio is higher which suggests that nitrogen is not present. Simultaneously boron appears in this area. Thus at the interface TiB_2 is formed.

4 CONCLUSION

Results of the studies of the BN–AgTi 1.5 system by Auger electron spectroscopy (AES) show that Ti exhibits very high chemical affinity towards BN. As a result of a chemical reaction taking place at the interface, titanium diboride and nitride are formed. Titanium diboride is created directly at the Ti–BN interface. These results confirm the results of chemical equilibria calculations carried out for the Ti–BN system as well as the model studies.[2] Auger electron spectroscopy allows for localisation of new phases formed which is not possible using X-ray diffraction studies.

REFERENCES

1. NICOLS, M. G. & MORTIMER, D. A., *J. Mater. Sci.*, **25** (1990) 2679.
2. BENKO, E., *Proc. Powder Metallurgy World Congress*, Paris, 1994, p. 1469.
3. *Handbook of Auger Electron Spectroscopy*. JOEL Ltd, Tokyo, 1982.