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PHYSICAL AND MECHANICAL PROPERTIES OF Ti COMPOSITES BASED ON THE c-BN

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The composites are the multiphase materials. The proper mixture of compounds imposes the desirable physical and mechanical properties. Nevertheless, to estimate the correlation between particular properties and the given phase formation is not easy task.

Ti composites based on cubic boron nitride (c-BN) are widely used in machining industry as a cutting tool because of mechanical and physical properties such as: extreme wear, hardness, high resistance to oxidation, good thermal conductivity and chemical inertness to iron and iron alloys. The manufacturing of wear and corrosion resistant coating materials is an important area in modern technology. The c-BN, with diamond structure, is thermodynamically stable under high pressure and temperature. The incorporation of the transition metal (*e.g.*, Ti or Ti compounds) into BN system introduce metallic bonding which may increase better adhesion between the coating and grains thus enhancing the wear properties of these materials. Chemical reactions between the activators and boron nitride occur resulting in formation of several Ti compounds. Additionally calculation of phase equilibrium carried out using VCS (Villars, Cruise, Smith) algorithm, indicated that at this kind of materials TiB_2 compound should be present which probably is responsible for good wear properties of these composites. On the other hand the high hardness of these composites is a serious problem in proper phase analysis because the samples cannot be properly grounded for powder diffraction analysis.

The aim of present study is to estimate the amount of TiB_2 compound in composites with Ti_3SiC_2, TiC additives and with different volume ratio of compounds (1:1, 1:3 Ti_3SiC_2 and c-BN; and 11:7 TiC and c-BN) and to check influence of the amount of formed TiB_2 phase on hardness of materials.

To evaluate the contribution of the phases formed during technological processes in composites we used the X-ray absorption spectroscopy. The shape of the element's K-edge is a fingerprint for a chemical bounding. In the case of the multiphase material X-ray Absorption Near Edge Structure (XANES) represents the weighted sum of the individual spectra of different phases. At the HASYLAB (A1 station) in Hamburg we performed the measurements of the Ti XANES at the K-edge. Studies were carried out on the single-phase reference samples and titanium composites described above. Commercial powders of TiB_2, TiC (HC Starck), with 3-5μm grains size, $TiSi_2$, TiO_2, $TiC_{0.3}N_{0.7}$, $TiC_{0.7}N_{0.3}$ and Ti_3SiC_2 were used as reference samples. Spectra were measured at the liquid nitrogen (LN) temperature. The double-crystal Si (111) monochromator was used. All samples were electrically isolated from the spectrometer and drain current from the samples was measured (total yield mode). The linear combination of the reference spectra fitted to the composites spectra was used to estimate the contents of different Ti compounds formed in the composites (program XANDA) [1] and is presented in Fig. 1. To check the goodness of our estimation next the XANES of the mixture of compounds weighted according to estimated proportion was measured, Fig. 1d. The perfect agreements with the XANES from composites prove that applied procedure give the reliable results.

The hardness of the Ti composites was measured by Vickers method using an indentation load of 1N. The results of this measurement together with the amount of TiB_2 phase resulted from XANES analysis are presented in Table 1. One cannot see very simply relation between the amount of formed phases and hardness. In the case of composite with TiC addition only about 8% of TiB_2 was formed but the hardness of sample is comparable with hardness of 1:3 sample where the highest amount of TiB_2 was formed. We think that also the distribution of the phases between the BN grains is very important for the mechanical properties of composite. The TiC sample was additionally heated by 2 h at 1400°C that can homogeneously spread the formed phase between the BN grains. The influence of the ratio of the volume of binding phases to the volume of BN grains should be also considered.

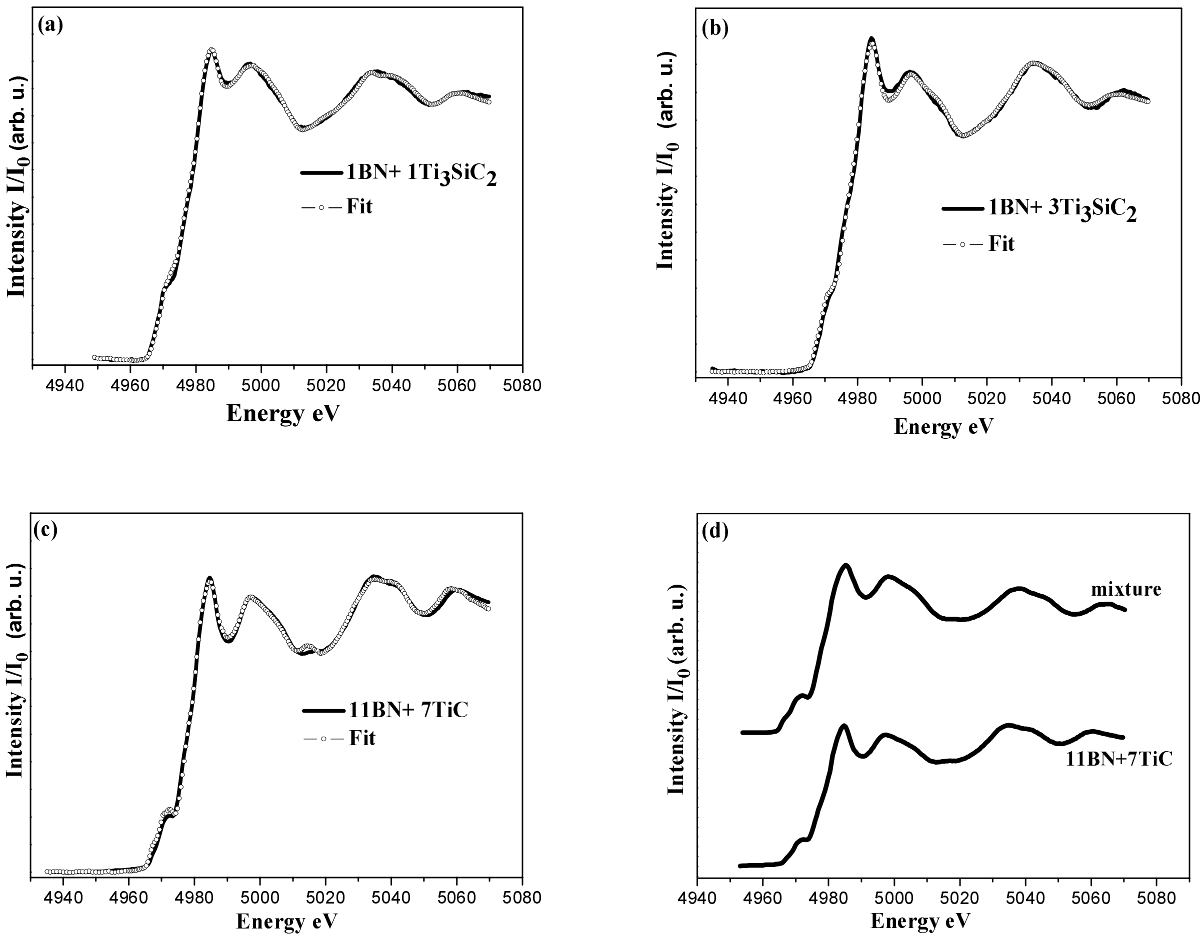

Figure 1. XANES spectra at Ti K- edge and linear fits of the reference compounds: a) sample with 1:1 volume ratio of BN and Ti_3SiC_2; b) sample with 1:3 volume ratio of BN and Ti_3SiC_2; c) sample 11:7 volume ratio of BN and TiC; d) sample 11:7 volume ratio of BN and- mixture of compounds as estimated in XAFS analysis.

Composites	XANES	HV [GPa]
	TiB_2	
BN+ Ti_3SiC_2	24.5±4.6	27.6
1BN+3Ti_3SiC_2	27.7±1.7	23.5
11BN+ 7TiC	7.7±2.8	22.6

Table 1. The content, in percent, of TiB_2 compounds in c-BN composites estimated by XANES analysis and measured hardness of samples.

Concluding, we would like to stress that X- ray absorption technique due to their atomic selectivity and high penetration depth is the unique source of information about amount and kind of compounds formed in volume of investigated material, therefore is the perfect tool for the investigation of micro-chemical mechanism taking place in composites.

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Reference

1. K.V. Klementiev, XANES dactyloscope for Windows, freeware: www.desy.de/~klmn/xanda.html