Structure and properties of metal-carbon a-C coatings alloyed with Ti, Zr and Al with a high concentration

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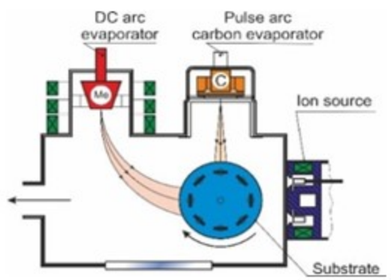
Introduction

The aim of this work is to determine the effect of the nature of alloying metals Zr, Al, Ti, which have a high concentration, on the phase composition and mechanical properties of carbon coatings.

Materials and methods



Scheme of the formation of composite metal-carbon coatings

The phase composition

Raman (Senterra, Bruker)

The mechanical properties

Nanoscan 4D, Russia

The thickness and morphology

S-4800 FE-SEM, Hitachi

The weight element concentration

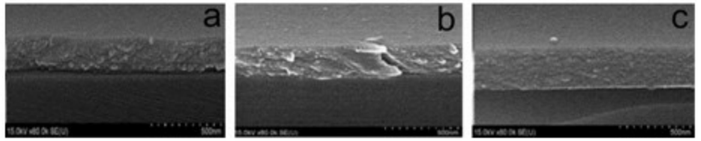
SEM equipped with EDS

Elastic recovery

$$\eta = \left(\frac{h_{max} - \Delta h}{h_{max}}\right) \cdot 100,$$

where h_{max} – maximum penetration depth of the indenter obtained upon reaching the maximum load, nm; Δh – full recovery value, nm.

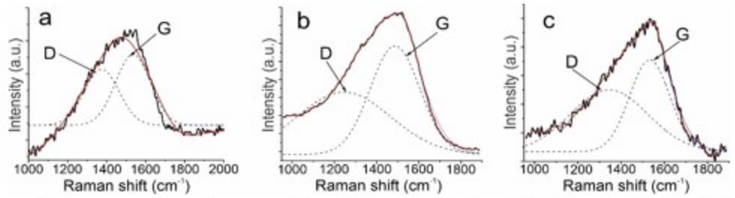
Results



SEM image of a chip of coatings: a) a-C:Zr, b) a-C:Al, c) a-C:Ti

Table 1. Elemental composition of composite metal-carbon coatings.

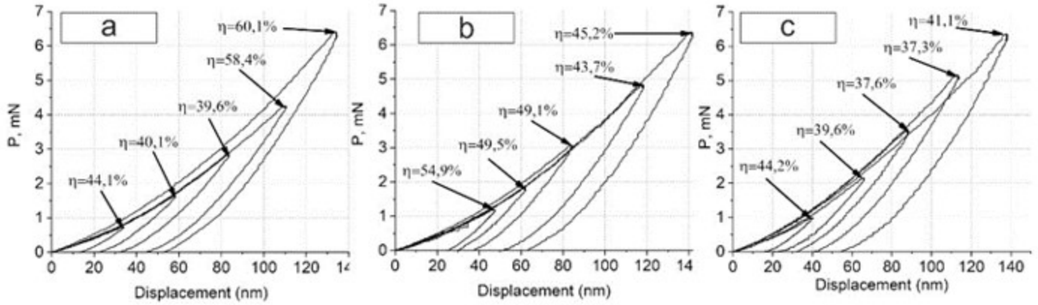
Coating	C, wt.%	Me, wt.%	O, wt.%	Thikness d, nm
a-C:Ti	53.8	45.0	1.2	262
a-C:Zr	42.2	56.5	1.3	183
a-C:Al	57.4	38.6	4.3	254



Raman spectra of composite a-C coatings: a) a-C:Zr, b) a-C:Al, c) a-C:Ti

Table 2. Parameters of Raman spectra and mechanical properties of alloyed carbon coatings.

Coating	G peak position, cm^{-1}	G peak width, cm^{-1}	I_D/I_G Ratio	H, GPa	E, GPa
a-C:Ti	1532,2	187,1	1,28	24.8	195.2
a-C:Zr	1535,5	211,2	0,78	20.2	178.6
a-C:Al	1487,3	235,8	1,08	20.8	187.1



P-h curves and values of the coefficient of elastic recovery η for coatings: a) a-C:Zr, b) a-C:Al, c) a-C:Ti

Conclusions

The work established morphological features, phase composition and mechanical properties of carbon coatings doped with Zr, Al, and Ti with a volume concentration of 38 to 56 %. It was found that a decrease in the size of Csp^2 clusters and an in-crease in the degree of ordering of the carbon matrix takes place in coatings doped with Zr, Al, and Ti, respectively. It is shown that in highly alloyed carbon coatings, the nature of the alloying metal has a decisive effect on the structure of the coating; the fineness of the coating is the highest when alloyed with aluminum. The hardness of the coatings is highest when alloyed with titanium, a-C:Al coatings are characterized by higher viscoelastic properties.

Literature cited

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2. Kulesh, E.A., Piliptsou, D.G., Rogachev, A.V., Hong, J.X., Fedosenko, N.N., Kolesnyk, V.: Boron-carbon coatings: structure, morphology and mechanical properties. Journal of En-gineering Sciences, 7(1), C1–C9 (2020). doi: 10.21272/jes.2020.7(2).c1