

Research of Phase Structure of Multilayered Vacuum-Plasma Coatings of System Ti–C–Si

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Abstract – The phase structure and structure of Ti–C–Si system multi-layer coatings was examined by way of X-ray structure analysis. In accordance with the technological operation a wide range of carbon content was observed in Ti–C–Si system multi-layer coatings. At heat treatment of Ti–C–Si system multi-layer coatings self-organizing interaction processes occur between coating layers that results in redistribution of chemical elements in a coating. To control the redistribution of chemical elements in a coating we considered the method of their heat treatment.

1. Introduction

For the most part fracture begins in a coating at item attack such as deterioration, corrosive and erosive processes and friction. Lately developed different methods of coating treatment allow to construct new materials with higher service properties. Methods of vacuum ionic plasma deposition of multi-layer coatings take the leading place among methods of machine element coating protection due to synthesis of compounds with unique service properties.

2. Phase Structure Multilayered Coatings

More often researches pay attention to multi-layer condensates because of their unique properties as a result of sharp phase boundary increase [1].

Multi-layer coatings were deposited at deposition of titanium and carbon layers out of plasma produced by electro-arc sources located at a definite angle to a substrate surface at HHB 6,6 – II modernized industrial-scale plant. We used “PINK” plasma source to discover ways of different compound synthesis at intensive Ar ion bombardment to generate ions. It is of note that one of the reagents was solid phase carbon (technically pure graphite). The evaporators were located on a flank surface of the cylindrical chamber at angle of 120° to each other. The evaporant was technically pure titanium BT-1.0 and technically pure graphite produced in a electrosmelting furnace by way of its immersion in silicon melt. At coating deposition the device with fixed treated machine parts evenly revolves on its axis and simultaneously on table axis that results in evenness distribution of formed coating thickness. The general thickness made up 3–4 mcm, the number of layers varied from 120 up to 600.

The phase structure and structure of Ti–C–Si system multi-layer coatings was examined by way of X-ray structure analysis at DRON 4.0 general purpose diffractometer in Fe K α radiation.

The research object was Ti–C–Si system multi-layer coatings no less than 5 mcm thick synthesized at the same operating mode of electro-arc evaporators at intensive Ar ion bombardment [2]. The technology of multi-layer coating deposition presumed speed range of treated substrate rotation.

Further, the specimens were subjected to different heat treatment. The thermal annealing was conducted at temperature of 450 °C and 750 °C 1 hour long. The coating phase structure changed at thermal annealing. The stick X-ray graphs of synthesized Ti–C–Si system multi-layer coatings of 120 and 600 layers annealed at temperature of 450 °C and 750 °C were analyzed (Fig. 1). To do this relative reaction intensity was calculated. The received ratios of phase relative intensities of Ti–C–Si system multi-layer coating comprising 120 and 600 layers in accordance with the annealing temperature are given in table 1.

The comparison of stick X-ray graphs given in Fig. 1 shows that at transition to the coating comprising 600 layers we view increase of line strength corresponding to Ti and decrease of line strength corresponding to C, SiC.

The phase structure changed at thermal annealing. The annealing at temperature of 450 °C results in line strengthening of TiC-phase, TiSiC-phase that testifies to increase of bulk concentration. Here, the line strength of Ti, SiC, C-phase decreases. High-temperature annealing of specimens leads to significant intensity increase of corresponding X-ray graphs reaction and to several additional reaction appearance (TiSiC).

It is of note that on the diffractograms of coatings comprising 120 and 600 Ti and C layers we detected TiSiC solid solution lines that testifies to transition zone between Ti and C layers in surface volume. On the diffractograms received after annealing the line strength of TiSiC solid solution is significantly increased that testifies to portion increase of transition zone between Ti and C layers. Thus, extension of transition zone increases. In the coating comprising 600 layers solid solution is generated more actively that confirms layer fusion.

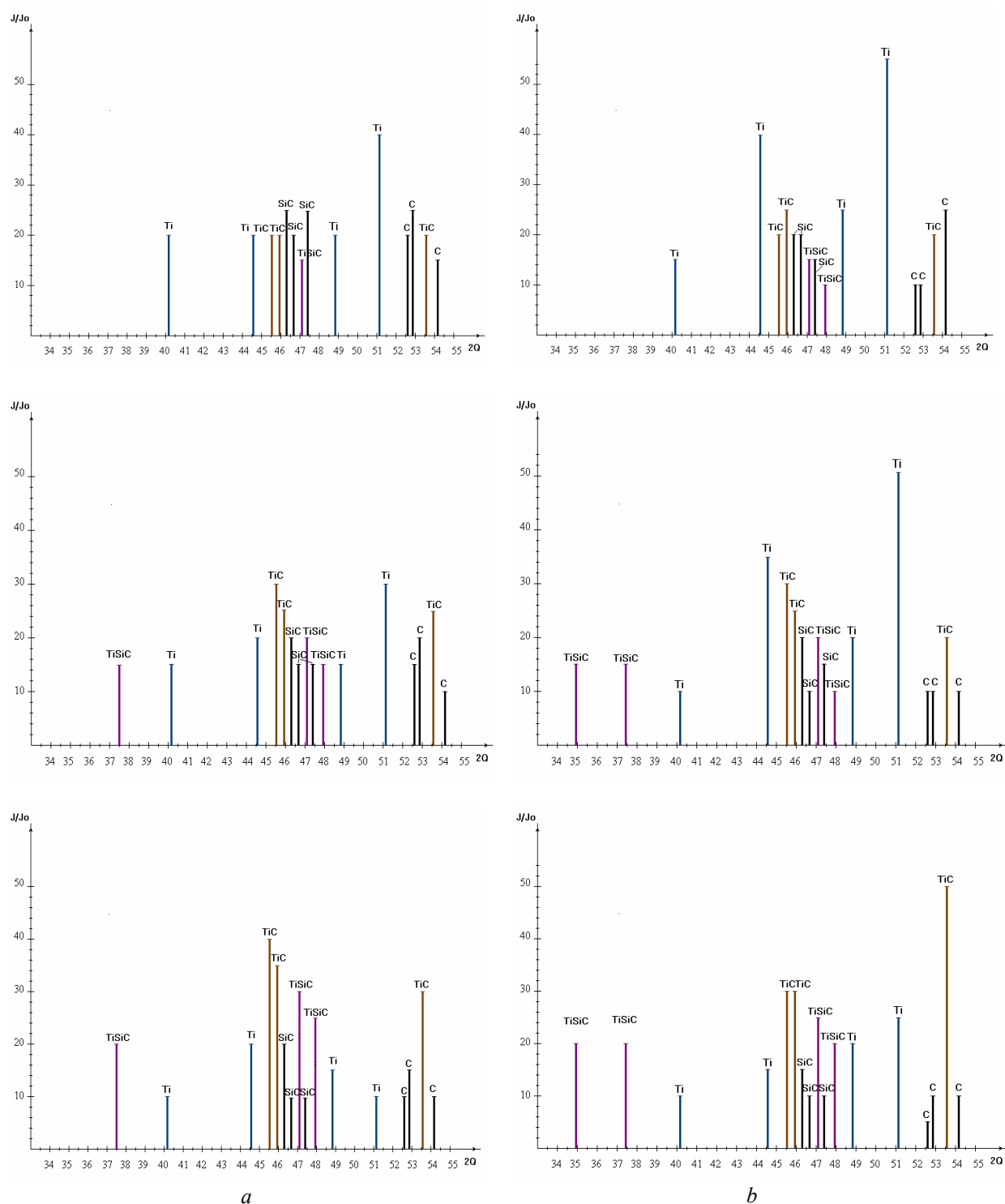


Fig. 1: *a* – Stick X-ray graphs of synthesized Ti–C–Si system multi-layer coatings of 120 (I) and 600 (II) layers: without heat treatment (*a*), with heat treatment 450 °C (*b*); *b* – Stick X-ray graphs of synthesized Ti–C–Si system multi-layer coatings of 120 (I) and 600 (II) layers: without heat treatment (*a*), with heat treatment 750 °C (*b*)

Table

Temperature, °C	Quantity of layers	Ti	TiC	SiC	C	TiSiC
450	120	0.8	1.33	0.71	0.67	3.57
	600	0.64	1.33	0.8	0.75	4.29
750	120	0.6	1.83	0.57	0.5	5.0
	600	0.5	1.83	0.6	0.5	5.71

Thus, the conducted examination of coating phase structure change in accordance with the coating deposition mode and the way of subsequent heat treatment allows to make up the following conclusion:

1. We discovered that at Ti alternating with C deposition at intensive Ar ion bombardment transition zones are formed, which consist of TiSiC and TiC solid solution.

2. In Ti–C–Si system multi-layer coatings created by vacuum ionic plasma spraying a wide range of carbon content can be observed in accordance with the

technological operation. At carbon content increase coating microhardness is also increased. Thus, when changing number of layers it is possible to a certain extent to control the processes of chemical elements redistribution.

3. At heat treatment of Ti–C–Si system multi-layer coatings self-organizing interaction processes occur between coating layers that results in redistribution of chemical elements in a coating. Thus, there is a way to control the redistribution of coating chemical elements by means of their heat treatment.

References

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