DEVELOPMENT AND APPLICATION OF NEW MULTICOMPONENT ELECTRODE MATERIALS FOR DEPOSITION TECHNOLOGIES

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The synthesis of advanced multicomponent nanostructured films by PVD and pulsed electrospark deposition (PED) requires the development of multicomponent electrodes. Self-propagating high-temperature synthesis (SHS) is a promising method for electrodes fabrication, which provides a highly dense, exhibits required mechanical, thermal, and electrical properties needed for such composite materials. The control of chemical composition of targets facilitates the deposition of multicomponent films with required composition.

During the last decade various SHS- composite targets have been developed and synthesized for hard tribological films (TiB_x, $TiSi_x$, TiBN, TiCrB, TiSiB, TiAlBN, TiAlSiB, TiCrSiCN, TiSiBN, TiCrAlC, CrAlBSi, oth.) and for biological films ($TiC_{0.5}$+CaO, $TiC_{0.5}+ZrO_2$, $TiC_{0.5}+CaO+TiO_2$, $TiC_{0.5}+Ca_{10}(PO_4)_6(OH)_2$, $Ti_5Si_3+ZrO_2$, $(Ti,Ta)C+Ca_3(PO_4)_2$, (Ti,Ta)C+CaO) [1-4]. In order to enhance the toughness and thermal-resistance (resistance to thermal-cycling during high-power magnetron sputtering) needed for PVD targets, functionally graded targets have been developed and manufactured. As an example, Fig. 1 shows three layers functionally graded target with $TiC_{0.5}$ -Ti_3PO_x-CaO working layer, TiB-Ti intermediate layer, and Ti bottom layer.

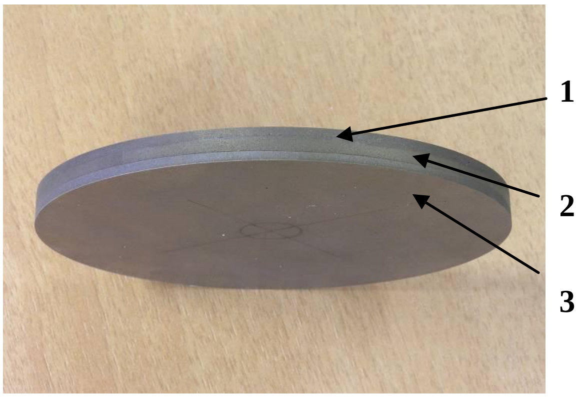

Fig. 1. Functionally graded target with $TiC_{0.5}$–$Ca_3(PO_4)_2$ working layer (1), $TiC_{0.5}$ intermediate layer (2) and Ti bottom layer (3).

In the case of multicomponent target uniform flow of both metal and non metal atoms and ions is realized from the target to substrate. SHS- targets can be especially benefit for the deposition of multifunctional nanostructured films in which both metallic (Ti, Ta, Al, Mo, Cr, Ca) and nonmetallic (Si, B, C, P, O, N) elements.

Taking into account the demand for composite targets for ion-plasma technologies for the deposition of functional nanostructured coatings, this work is a review of recently obtained results on synthesis in the combustion mode of a series of chemical classes of systems. The experimental results for self-propagating high-temperature synthesis are presented. The described ceramics becomes often to be implemented in technology of magnetron sputtering of thin films and coatings characterized by high mechanical properties, high heat resistance to high-temperature oxidation, and thermal stability. Some of considered classes of ceramics are advanced as a biocompatible material for medicine.

The second part of the work is focused on the development of electrodes for PED. Three groups of electrodes are presented: *dispersive-hardening ceramic materials* with effect of simultaneous strengthening of carbide grains and metallic binder by precipitations; *nanoparticles disperse-strengthened composite materials* with nanoparticles based on refractory compounds; *MAX- phases based materials; nanostructured cemented carbides*.

Recent studies concerning ceramic materials with the effect of dispersion hardening by nanoparticles in order to controlling the distribution of alloying elements within carbide grains are reviewed. Combination of the force SHS-pressing followed by annealing makes it possible to synthesize composite materials with desirable structure and properties. Some service properties are increased due to nanosized precipitations to be formed result in concentration separation of supersaturated solid solutions. Composite ceramic materials based on Ti-xC, Ti-Me–xC (Me= Zr, Nb, Ta, Mo) systems were produced by SHS. Contents of third elements are varied from 5 to 25 at.%. Composition and structure of carbide grains and intergranular phase just after combustion process is not equilibrium: supersaturated solid solutions are formed because of high temperature gradient and combustion velocity. Precipitations are appeared result in concentration separation of supersaturated solid solution. Carbide grains content precipitations sized 20-200 nm based on solid solution (Ti-Me).

Precipitations are formed as a results of concentration separation of supersaturated solid solution via two possible schemes [5]:

$$(Ti, Me)_{x+y}C = (Ti, Me)_xC + y(Me\text{-}Ti), \text{ where } Me = Nb, Ta, Zr \text{ (less 6\%)}$$

or

$$(Ti, Me)_{x+y}C = (Ti, Me)_xC + (Me, Ti)_yC, \text{ where } Me = Mo, W$$

Also mixed mechanism was experimentally observed:

$$(Ti, Zr)_{x+y}C = (Ti, Zr)_xC + y(Zr\text{-}Ti) + z(Zr, Ti)_zC.$$

The SHS was successfully used to fabricate MAX-phases in the systems Ti_3AlC_2, Ti_2AlC, Cr_2AlC. A complex study on structure, phase composition, and chemical and mechanical properties of ceramic materials based on the $M_{n+1}AX_n$-phases has been recently presented [6].

PED- coatings deposited on Ti-, Ni-, Fe- alloy substrates with successful combination of hardness, elastic recovery, adhesion strength, heat resistance, and reduced friction coefficient were obtained. Coatings thickness (more than 50 μm) at density till 100%, lower roughness (less than 0.1 μm) were achieved due to high energy expended to erosion of nanostructured anode at high frequency and relatively lower pulse discharge energy. It was shown that MAX- phase based electrodes application and optimization of PED frequency-energy parameters allows depositing coatings with amount of hexagonal phase till 50%.

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