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OXIDATION BEHAVIOR OF METALS TREATED WITH COMPRESSION PLASMA FLOWS

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Modification of different metals and its alloys with plasma flows and charged particles beams is widely used for improvement the physical properties and exploiting parameters. The pulse mode of interaction between the plasma flow or particle beam with the metal target is used. Taking into account both the short time of the pulse (not more than several hundred microseconds) and quite high energy density (several tens J/cm^2), just the surface layer of the material is subjected to the modification of structure and phase composition. Many published works demonstrate the increase in hardness, wear resistance after the treatment. Other interesting and practically important problem connecting to investigation of oxidation resistance of the modified structures. Indeed, a lot materials work at elevated temperature that are much higher than room one and oxygen diffusion occurs very fast. Due to diffusion of oxygen atoms an oxide layer grows on the surface and the physical properties of the material degrade. So, the main aim of the present work is to find the main peculiarities of oxidation process in refractory metals subjected to compression plasma flows impact.

The samples of commercial pure titanium, zirconium and tungsten were subjected to compression plasma flows (CPF) which were generated in magnetoplasma compressor of compact geometry. The plasma impact was made in pulsed mode with a pulse duration of 100 μs. The samples were treated with plasma flows in the nitrogen residual atmosphere. The energy parameters of the plasma flows provided the absorbed energy density enough for melting of the surface layer. After this, the samples were placed in the furnace for annealing in open air atmosphere at temperatures 500 – 800 °C.

The plasma impact melts the surface layer with a thickness of several micrometers and more. Due to high cooling rate of the melt the grain structure of the solidified layers is characterized with a small size of the grains. The oxidation process of the untreated samples shows the formation a set of oxide phases – TiO_2 (rutile) for titanium, ZrO_2 (monoclinic type) for zirconium and volatile oxide WO_3 for tungsten. According to the well-known diffusion law the amount of the oxide phases increases with the annealing time. The appearance of the oxide phase was found by means of X-ay diffraction method. The treated samples demonstrate the decrease in the diffraction signals from oxide phases after the oxidation at the same condition. Moreover, the time of beginning of oxide growth also increases, i.e. it requires more time for oxide film growth. The measurement of mass gain of the samples after the oxidation shows very weak difference between the treated and untreated samples. It means, the absolute amount of oxygen atoms penetrated inside the surface layer doesn't depend of the plasma impact. Nevertheless, the small grain size increases the density of the grain boundaries which can work as ways for enhancement diffusion. The rate of the diffusion rises and prevent the surface layer from the oxygen accumulation and distortion of the lattice for phase transformation.

Additional alloying of the samples with other elements during the plasma flows impact producing the solid solutions with distorted crystal lattice. In this case the oxidation process goes more slowly as the internal stress decelerated the diffusion of oxygen,

The main results of the works show the promising approach of compression plasma flows influence on materials preventing them from oxidation at elevated temperatures.