Physico-Chemical nanomaterials

The effect of tungsten on the kinetics of nanodiamonds oxidation

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Scientists with the Institute of Superhard Materials created the composite "diamond-tungsten carbide" by sintering at high pressure and temperature diamond nanopowders and tungsten that was chemically introduced into the composite. The composite possesses high hardness, fracture toughness, and thermal stability. An important characteristic of the composite is its chemical resistance against oxygen at high temperatures. In the represented study, we reports the kinetics of oxidation of static synthesized diamond ASM5 0.1/0 without or with additives (1, 3, and 5 mass%) of tungsten oxide, WO_3. The experiment was performed by the gravimetric method in the temperature range of 825–965 K using the model "coal in the cup." It was found that the diamond oxidation rate decreases in the presence of tungsten. The time dependence of mass change show different trends. The kinetic curves over time for diamond ASM5 0.1 /0 taken without additives are smooth. The curves for ASM5 0.1/0 with additives can be split on two parts that are abrupt, the first, and flat, the second. A kinetic scheme, which accounted the oxidation of diamond without or/and with the participation of tungsten, is proposed. The scheme explains the decrease in the rate of oxidation of diamond by the chemical modification of the active center with tungsten, two-parts consisting kinetic curves by passing of two parallel reactions, where active centers of the diamond are unmodified (I) and modified (II), correspondingly, dependence of the degree of oxidation of the composite in a transition point between I and II (D_{ox}) on the temperature and the content of tungsten. By using a mathematical model of the two parallel reactions it was revealed that the modification occurs in the process of the composite oxidation, and a part of modified centers increases with the temperature and the tungsten content. The ability to explain (i) the nature of inhibitory action of the tungsten in the diamond oxidation, (ii) two-part type kinetic curves and (iii) D_{ox} dependence versus the temperature and the content of tungsten as well as (iv) relatively small values of activation energy of (I), which are grounded on assessments of the degree of active centers modification in the framework of the model of two parallel reactions, is an evidence of the adequacy of the proposed kinetic scheme of the diamond oxidation in the presence of tungsten. Since tungsten additives reduce the oxidation rate of the diamond with oxygen, so, they should increase the thermal stability of diamond tools and therefore have a high potential when applied in the design and creation of the processing instruments.