Electrochemical behavior of dielectrics and semiconductors in ionic melts

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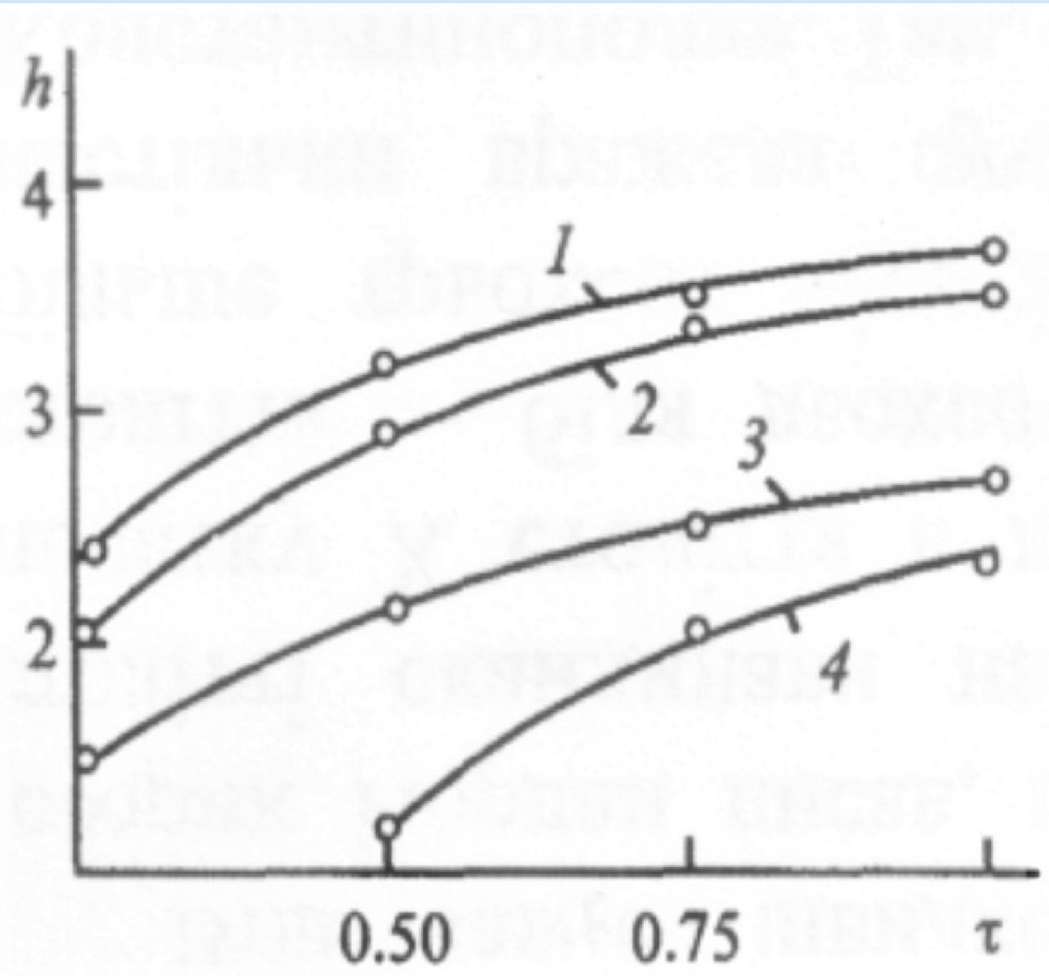
Introduction and Methods

Natural and synthetic diamonds and cubic boron nitride are high-resistance dielectrics (HRD), i.e., they hardly conduct current. We found that HRD crystals, upon the contact with ionic melts of a certain composition, acquire the property to conduct current, and semiconductors crystals, the property to change their potential in relation to the melt composition. This is explicable by the con-cept of the generation of electrochemical potential and surface conductivity as a result of redox processes occurring on the HRD-SC-melt interface [1,2].
To carry out the HTES of molybdenum carbide on the grain surface of dielectrics and semiconductors, those latter were placed into a nickel container. A graphite crucible (MPG-7 grade graphite) was simultaneously a container for a melt and an anode. To estimate the possibility for the HTES of molybdenum carbide on the surface of HRD and SC, we chose the molybdate- and carbonate-containing systems: Na_2WO_4-MoO_3-Li_2CO_3 and KCl-NaCl-Na_2MoO_4-Na_2CO_3.

Results and Discussion



The grains of diamond, boron nitride, and silicon and boron carbides in contact with the melt can be used as a cathode material for the high-temperature electrochemical synthesis (HTES) of molybdenum carbide. To electrochemically coat the high-resistance dielectrics (HRD) and semiconductors (SC) grains, they were held in the melts of the following compositions: Na_2WO_4 - 5 mol % of MoO_3 - 10 mol % of Li_2CO_3 or KCl - NaCl (1:1) - 5 mol % of Na_2MoO_4 - 7.5 mol % of Na_2CO_3 at 1073-1173 K and the cathode current densities 10-100 $A\cdot m^{-2}$. Under such conditions, the HRD and SC surfaces become conducting and play the role of an active substrate for the HTES of molybdenum carbide.
The quality of molybdenum carbide coatings was estimated by their appearance and physical and mechanical properties. The rate of coating diamond grains with Mo_2C substantially depends on both the electrolysis temperature and the cathode current density (Fig. 1).

Fig. 1. Dependence of the thickness h (mm) of, Mo_2C coating on the duration t (h) of coating. T (K): (1 and 2) 1173; (3 and 4) 1123. i_c ($A\cdot m^{-2}$): (1 and 3) 200; (2 and 4) 100.

As these parameters increase, the rate of deposition increases at the equal testing duration. For ASK 125/100 diamond grains, the coefficient of breaking load was found as the ratio of the breaking loads of coated and uncoated grains. Molybdenum carbide coatings deposited under certain operation conditions allows the initial breaking load of the diamonds to be elevated by the factor 1.3-1.9, depending on the electrolysis mode.
For AS-32 500/400 diamond grains, coating with molybdenum carbide enhan-ces the breaking load by a factor of 1.1-1.3. In this case, the load increases as the mass or thickness of the coating increases (Fig. 2).
The serveability of pilot lots of tools made from diamonds electroplated with molybdenum carbi-de at high temperature increased by the factor 1.5-2.0. Similar results were also obtained in the case of molybdenum carbide deposition on the boron nitride grains.
Mo_2C coatings were deposited onto the 400/320 sized silicon carbide grains and onto the 160/125 sized boron carbide grains at 1173 K and cathode current densities 50-200 $A\cdot m^{-2}$ during 15-90 min. The coating degree substantially depends directly on the cathode current density and the electrolysis duration. Upon coating deposition, the breaking load coefficient of the boron and silicon carbides grains was 1.5-2.5, and the capillarity of the boron and silicon carbides grains increased by the factors of 3.4-4.0 and 2.3-2.5, respectively.

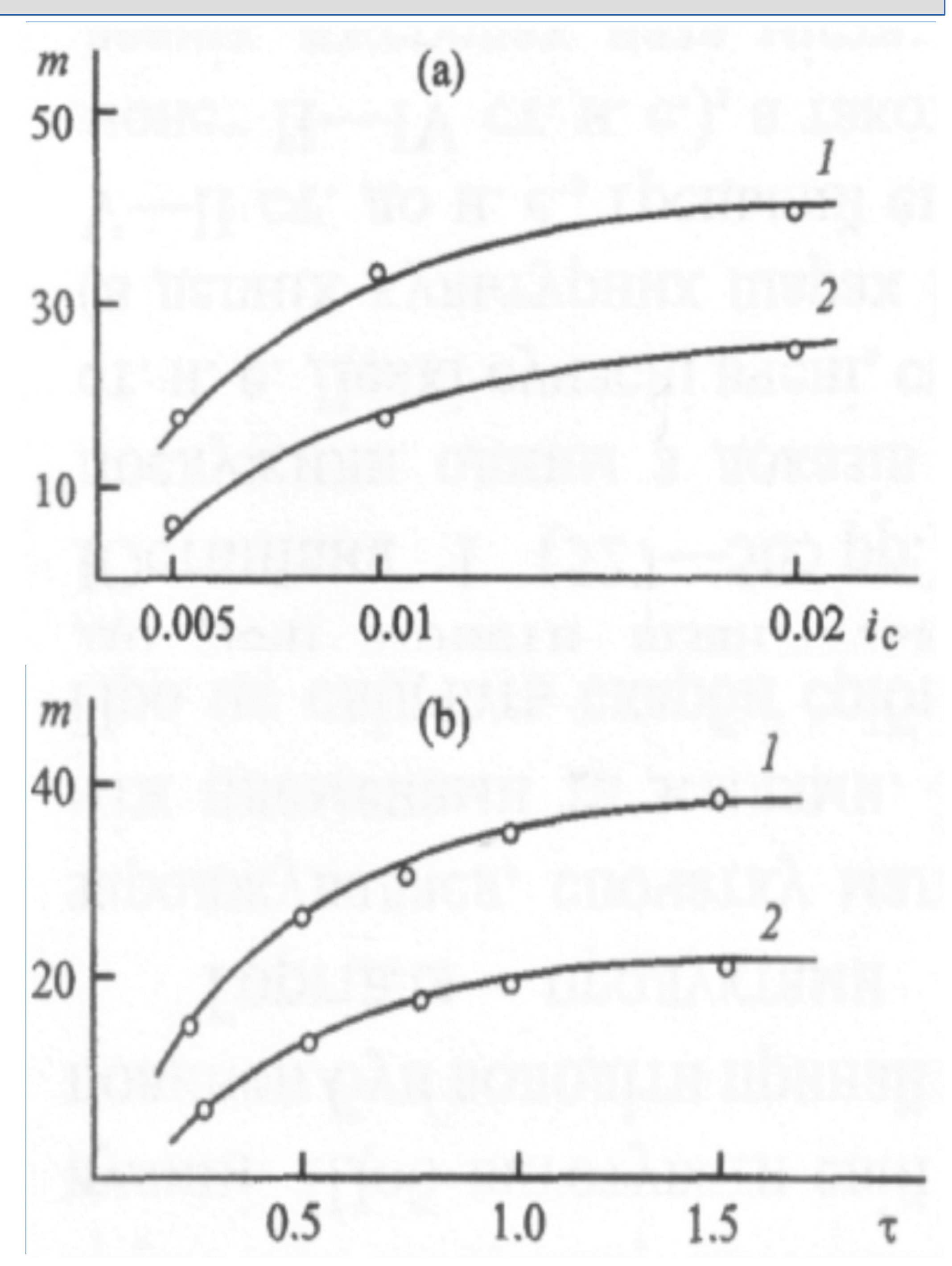


Fig. 2. Dependence of the degree m (wt %) of coating the grains of (1, 3) silicon and (2, 4) boron carbides with molybdenum carbide on (a) the current density i_c ($A\cdot cm^{-2}$) (t = 1 h) and (b) the electrolysis duration t (h) (i_c = 100 $A\cdot m^{-2}$).

Conclusions

Electroplating of the grains of dielectrics and semiconductors with molybdenum carbide favors the in-crease in their breaking load and wettability and in the efficiency of tools.

References

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