ON THE QUESTION OF DIAMOND ETCHING

M. I. KARKLINA, Yu. P. MASLAKOVETS

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Abstract

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M. I. KARKLINA, Yu. P. MASLAKOVETS

ON THE QUESTION OF DIAMOND ETCHING

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In most cases ($^{1-7}$), in the etching of diamond, molten alkalis and nitrates were used as the solvent; in this, primary attention was devoted to the study of the surface structure of etching of diamond crystals. Without access of air at temperatures below 880°, neither KOH nor NaOH acts on diamond (^{2}). When etching in these same reagents in air, dissolution of diamond proceeds at a noticeable rate.

To investigate the etching of diamond, several Yakut diamonds were selected —octahedra with flatter faces. One and the same group of crystals was used in different series of experiments. The crystals were subjected to the action of molten KOH, KNO_3, KOH + Na_2O_2 (in a ratio of 5 : 1), NaOH and $NaNO_3$ with an admixture of KOH, NaOH + Na_2O_2 (in a ratio of 5 : 1), and NaOH in an air atmosphere. Etching was carried out in a nickel crucible. The temperature of the melts was varied from 560 to 700° and was regulated with an EPV-2-10A potentiometer with an accuracy of up to ±5°. The usual duration of an experiment was from 1 to 5 hours. After etching, the melt was poured off, and the crystals were thoroughly washed with distilled water and dried. Weighing of the crystals before and after the experiment was performed on torsion balances with an accuracy of up to ±0.0001 g.

The dependence of the diamond etching rate on the temperature of various melts is shown in Fig. 1. The rate was calculated for visually flat surfaces of the diamond. As can be seen from Fig. 1, at temperatures below 600° no etching of diamond could be detected. When the temperature is changed from 650 to 700°, the etching rate in potassium-containing melts increases from 2 to 10 μ/hour.

Fig. 1. Dependence of the diamond etching rate on the temperature of melts. *a*–KOH; –KNO_3; –KOH + Na_2O_2; –NaOH + KOH; –$NaNO_3$ + KOH; –NaOH + Na_2O_2; –NaOH.

In (^{1}) it is mentioned that burning of diamond in air becomes noticeable already at a temperature of 550-600°, whereas the first signs of dissolution of diamond

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Figure 1: Fig. 1. Dependence of the diamond etching rate on the temperature of melts. *a*–KOH; –KNO_3; –KOH + Na_2O_2; –NaOH + KOH; –$NaNO_3$ + KOH; –NaOH + Na_2O_2; –NaOH.

Fig. 2

Figure 2: Fig. 2

crystals in alkalis were observed by the authors of (1) only at 700–750°. In contrast to this, the results of our experiments show that etching of diamond can be observed already at a temperature of 620°.

In the course of the experiments it was found that the rate of dissolution of diamond in potassium-containing melts (curve *I*) is approximately twice as great as in sodium-containing melts (curve *II*) under the same experimental conditions. The etching rate in NaOH and $NaNO_3$ with an admixture of 0.014% KOH is the same as in pure KOH and KNO_3 (curve *I*).

The catalytic action of potassium on the process of diamond oxidation had previously been found in (2). This was explained by the fact that potassium apparently facilitates the formation of surface carboxyl groups upon rupture

C–C bonds of diamond. It is interesting to note that in (8), in studying the etching of α-SiC in caustic potassium and sodium, it was also found that the addition of KOH to NaOH leads to a sharp increase in the intensity of etching.

Fig. 2. Surface structure of diamond etching in a KOH + Na_2O_2 melt at a temperature of 680°; 340×

Using an MIM-2 microscope, microphotography of the surface etch figures of diamond was carried out. It turned out that the appearance of the treated surface does not depend on the composition of the melt and is determined only by its temperature. At temperatures from 630 to 700°, figures are obtained with individual elements up to 5 μ in size which, according to the terminology of A. A. Kukharenko (5), may be called shingle-like.

Figure 2 shows the surface structure of diamond etching in a KOH + Na_2O_2 melt at a temperature of 680°. As already mentioned, the etching rate was calculated for visually flat crystal faces. According to a rough estimate from the microphotographs, the actual surface is approximately 3 times larger than the surface used in the calculations.

The dependence of the logarithm of the rate of dissolution of diamond on the reciprocal temperature of melts containing potassium (*I*) and sodium (*II*) is presented in Fig. 3. As can be seen, the rate of dissolution of diamond depends

Fig. 3

Figure 3: Fig. 3

exponentially on temperature. The activation energy of the diamond dissolution process was found to be 45 ± 2 kcal/mol in melts containing both potassium and sodium. This value is close to the activation energy of diamond combustion in air (9). Apparently, the mechanism of diamond combustion in air and the mechanism of etching in the melts we studied are one and the same.

Fig. 3. Dependence of the logarithm of the rate of dissolution of diamond (in $g/cm^2 \cdot h$) on the reciprocal temperature of the melts (designations are the same as in Fig. 1)

Institute of Semiconductors
Academy of Sciences of the USSR

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