

DIAMONDS PRODUCED BY ELECTRIC WIRE EXPLOSION

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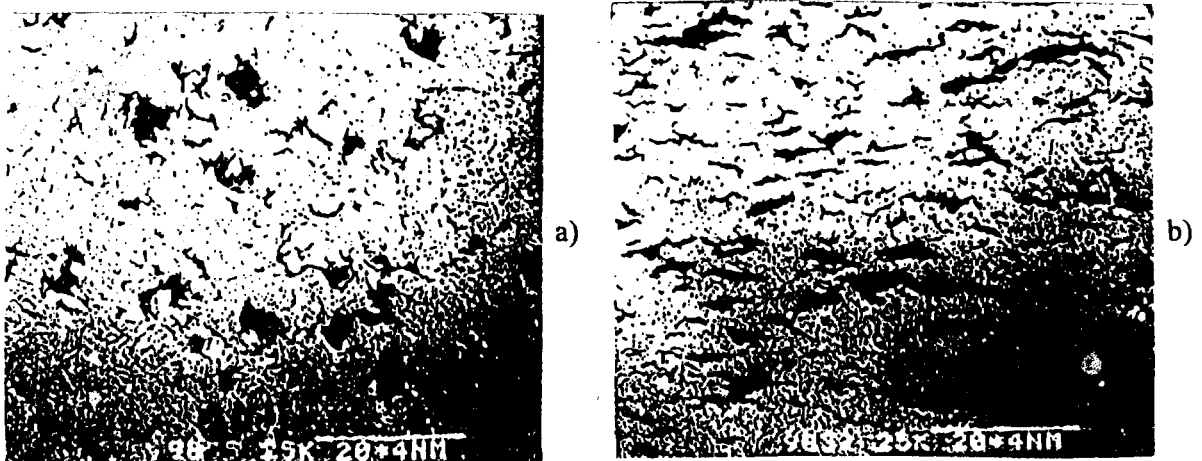
After publishing the classic papers of (Leipunski 1939), (Bundy 1963b), and (Bundy 1979 and 1989) as well, the two main directions of obtaining diamond phase have been established: stationary method and pulse method (with the help of explosive, on the whole).

One of the first paper dealt with the production of diamond phase with the help only electric current, without initial external pressure, was (Bless 1972). Current pulse of several MA-s heated copper tube (diameter was 2.9 mm). The isolated rod of graphite sample (diameter - 1.65 mm) was placed inside the tube. Pressure 50-300 kbars arises from the compressed metal tube. Hexagonal forms of diamond were observed (in separate cases) under pressure more than 200 kbars. The transition graphite-diamond, according to the valuation of the author, took place under temperature 1000 C. Non-constant yield of the diamond phase, high values of the currents, — these main circumstances did not give a real chance to create in (Bless 1972) a new method for diamond powder production.

In (Bushman et al. 1990) a new method of heating the mixture (graphite-metal) was suggested to reach the phase diagram graphite-diamond with the help of electrical current only. This method is more ecology attractive and safe than others using the explosives. The theoretical part of this method was published in (Bushman et al. 1990 ; 1993).

High pressure arises from the current itself (pinch-effect), high temperature — from the Joule heating. Patent was published in (Bushman et al. 1992).

In this publication we consider experimental results fulfilled during last five years. Three series of the experiments were made. Different specimens were used in every series. In the first series rods with the diameter 2 mm were made of Copper-Graphite-Lead-Tin blocks. Such blocks are usually used as collector brushes. The content of the graphite: 9 mas.% (it is nearly 40 vol.%); copper content is 82 mas.%. In the 2-nd series the specimens had 2×1.5 mm cross section and were made of Copper and Graphite (4 mas.%) only. Microstructure of these specimens are presented in Fig.1. The initial resistivity $\rho = 3.5 \mu\Omega \text{ cm}$.



**Fig.1. Microstructure of the mixed specimen CG (Copper-Graphite); the content of the graphite is 4 mas.%.
Black areas — graphite, light-coloured — copper. Both pieces of a line - 200 μm .**

Black areas — graphite, light-coloured — copper. Both pieces of a line - 200 μm .

a) Polish section is in the plane of pressing, and along the current passage.

b) Polish section is in the plane across the direction of current passage.

In the 3-d series Copper and Graphite (9 mas.%) mixture was used. The initial resistivity was 5.3 $\mu\Omega$ cm. The destruction products for all specimens of the third series were collected for one probe for X-ray phase analysis. For 1-st and for 2-d series — every specimen was undergone to X-ray analysis.

In our experiments electrical current (close by 500 kA) was produced by discharge of six 12- μF 25-kV low-inductance capacitors. They were arranged near the transmission plate, designed for low inductance. All capacitors through two vacuum discharge gaps and then through 24 cables (each length is 1 meter) were connected to the collector. To measure current the integrated Rogovski coil was used. Fig. 2 shows an explosion chamber, 20 litres by volume.

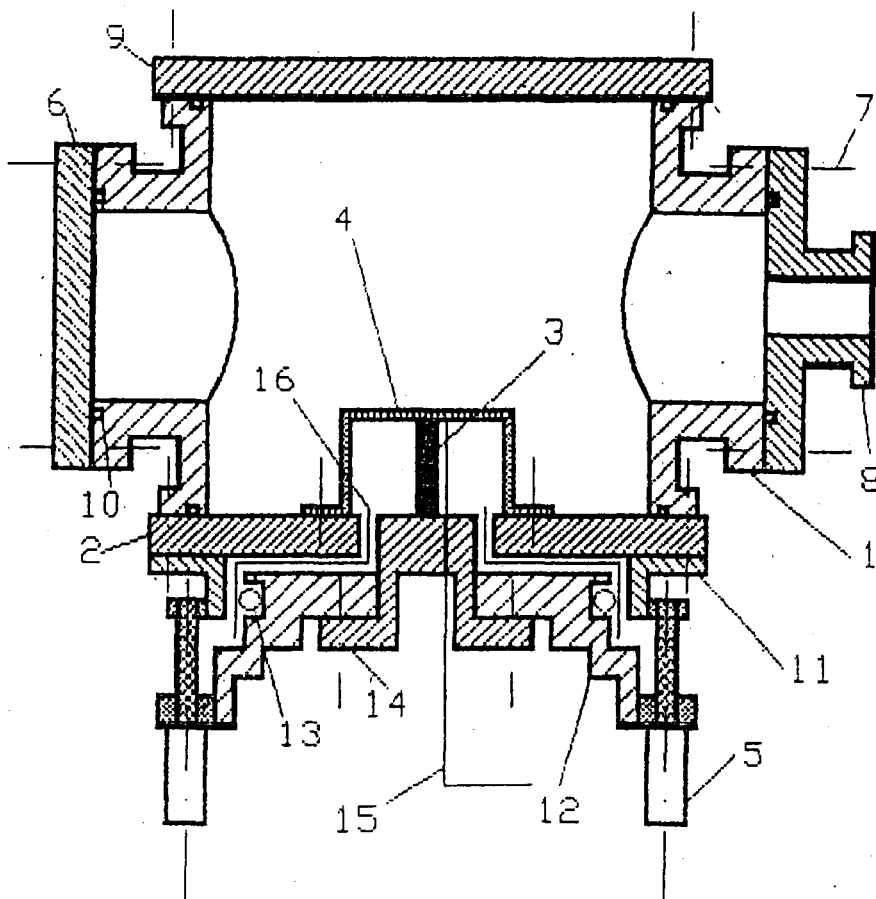


Fig.2. Explosion chamber.

1- Stainless steel body (diameter is 30 cm). 2 - Base. 3 - Specimen (diameter is 2 mm). 4 Staple (copper). 5 - Coaxial cables (around the circle). 6 - Observation window (perspex).

7 - Bolt. 8 - Flange for gas (N₂). 9 - Steel top. 10 - Rubber rings. 11 - Collector (aluminium). 12 - Ground collector. 13 - Rogovski coil. 14 - Steel insertion with specimen above. 15 - Insulated wire for measuring voltage. 16 - Layers of the polyethylene, total thickness 1 mm.

Fig.3 shows the currents for several pulses of heating. Interruption of heating was organised by destruction of the insulation and by the shunting of the current.

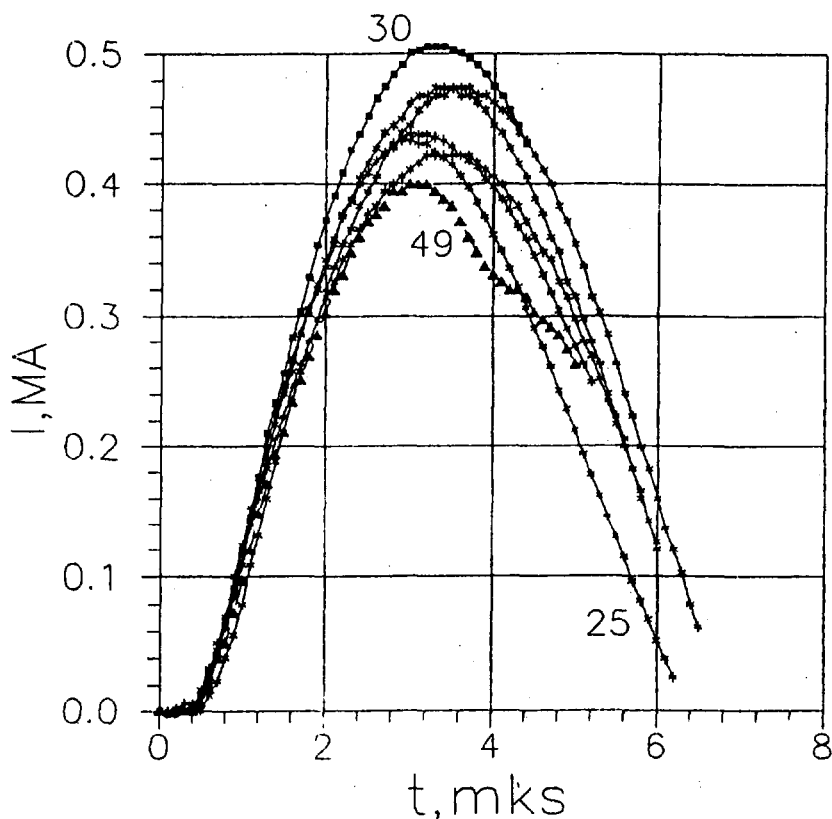


Fig.3. Current pulses for several specimens. (Note specimen's numbers: 25,30,49).

The compositions of the elements after the shot were identified by X-ray spectroscopic analysis; the phase composition — by X-ray phase analysis. In the 1-st series of the experiments the next diamond phases were registered: lonsdeilite as a main diamond substance, also hexagonal diamond (20H) and cubic diamond. In the 2-d series there are: lonsdeilite and cubic diamond, less than in the 1-st series, also hexagonal diamond (20H). In the 3-d series there are: cubic diamond as a main diamond substance, also lonsdeilite (small quantity). In the last case the yield of the diamond phase reached 30% from the carbon that was in the probe after the experiment.

It should be noted here that the employment of the specimens with 4 mas.% graphite content did not give a better result, even though the current (pressure) was higher. The percentage yield of diamond phase remained constant. Thus, the employment of the specimens with high graphite content is rather favourable. We tried (Ivanov 1995) to get diamond yield under fast heating of graphite alone (without any metal). It gave us only diamond-like phases : lonsdeilite and hexagonal forms (8H, 12H, 16H, 20H), but not cubic diamond.

The valuation of the crystal size of the diamond phase was fulfilled through the width of the diffraction spectrum's lines. Semi-width of the diamond line in our experiments is equal to the case of diamond powder ASM 3/1 (the size of the grain — from 1 to 3 μm).

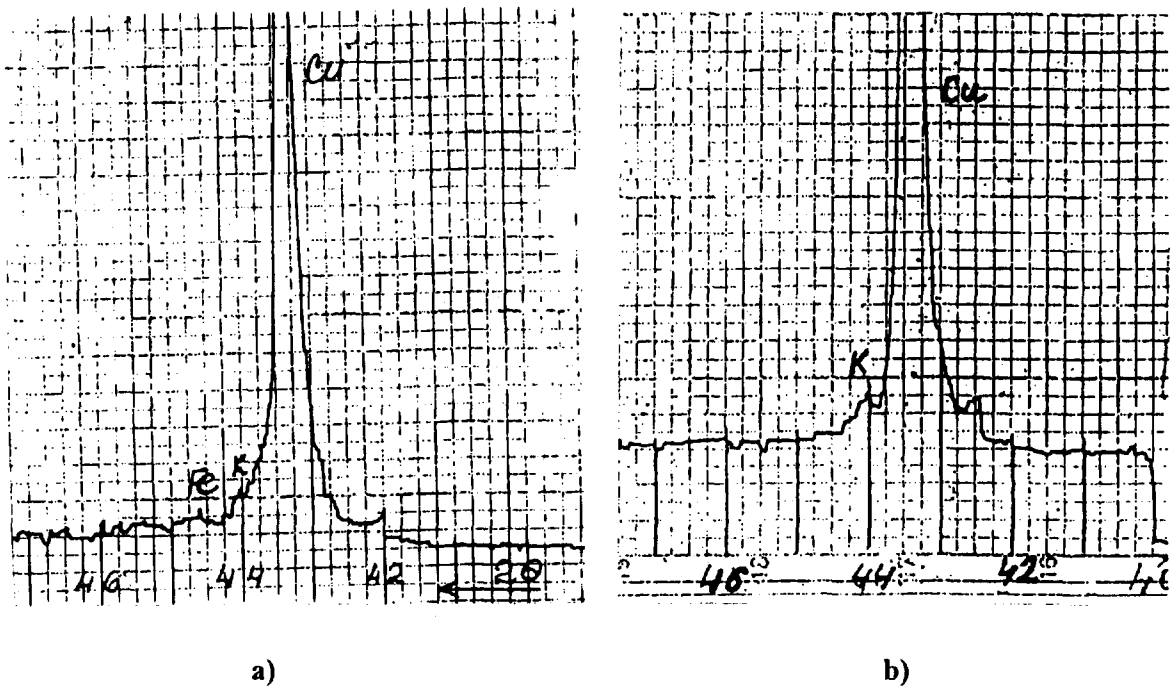


Fig.4. **Cubic diamond in the probes.** a) For specimens of the 3-d series. b) For the control probe, mixture: 1 mas.% of cubic diamond powder ASM 1/0 (size 0-1 μm) and 99 mas.% of initial specimen CGLT (copper, graphite, lead, tin) of the 1-st series.

The letter “k” means the diamond. For the comparison in Fig.4b there is a diffraction spectrum of the artificial mixture. Thus, the size of the diamond crystals in the 3-d series will come to more than 0.1 μm .

The main advantages of this method are:

1. The average size of the single crystals is larger than in explosive methods.
2. The production of diamond powder can be made cheaper.
3. The automation of the production can be easily made.
4. Destruction in surroundings is relatively small.
5. The conditions of labour are more safe than with the explosives.
6. The by-products of this technology are not toxic.

Market competition ability of the diamond powder production will be reached only when high repetition rate will be used. We hope that after the creation a frequency (1 pulse per 2 seconds) installation it will be reached the production of 150 kg of the diamond powder a year.

Acknowledgements

The authors are grateful to T.I.Borodina, and G.E.Valiano, who fulfilled all spectroscopy and diffraction diamond analysis.

Diamond experiments were supported in part by the Ministry of Science and Technical Policy of Russian Federation (project 2-3-10) and Russian Foundation Technology Development (project 73-123-1).

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