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Plasma devices for the synthesis and processing of powder materials

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Introduction

- The results of the development and research of electroplasma equipment for the production of new materials and the modification of the synthesis products using electric arc plasma are presented. A characteristic feature of plasma systems is the high repeatability of technological processes of material processing during long-term operation of equipment. Structural schemes of arc plasmatrons for powder modifications, including for coating, a plasma-arc reactor for the synthesis of silicon carbide nanopowders are considered. It is shown that a long life of plasma devices is a necessary condition for the effectiveness of the technology.

- Plasma equipment and technologies for the modification of powder materials based on it are most widely used in the application of various types of protective coatings. For these purposes, small-sized electric arc plasmatrons with a power of 10-50 kW with an axial feed of working gas (argon or its mixtures with nitrogen or hydrogen to increase the jet enthalpy) are traditionally used. The voltage drop across the discharge is low (30-80 V), and to obtain a plasma torch power sufficient for high-quality spraying, it is necessary to increase the current to 300-500 A. In this case, the resource of the thermionic cathode and the output electrode-anode is significantly reduced.

- To eliminate the aforementioned drawbacks of electric arc plasmatrons with a self-stabilizing arc length and to improve the parameters of the plasma jet and the technology of applying powder materials, plasmatrons with a sectioned interelectrode insert (IEI) have been developed and are successfully used. For an example in fig. 1 shows the design of such a plasma torch.

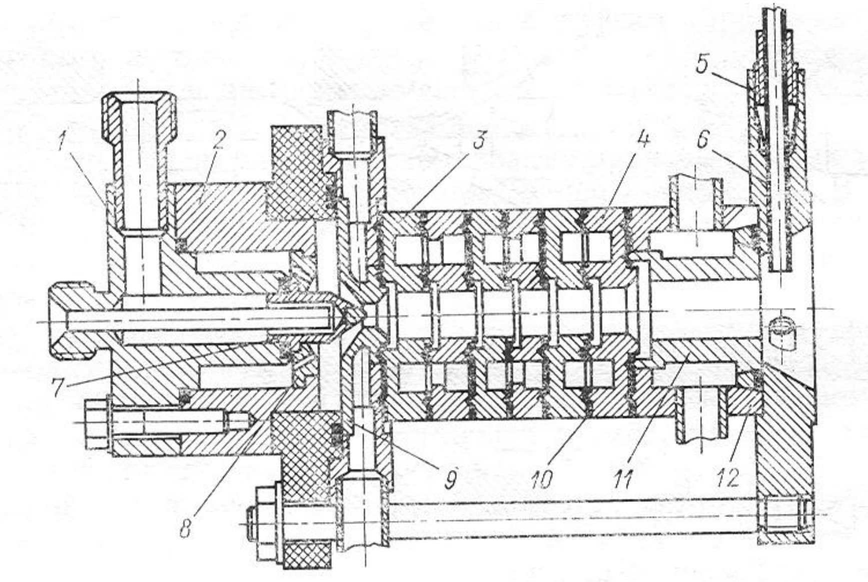

Fig. 1. Plasmatron with a sectioned interelectrode insert. 1, 2, 7, 8 - cathode assembly, 3, 4 - MEW section, 5, 6 - powder input, 11, 12 - anode assembly.

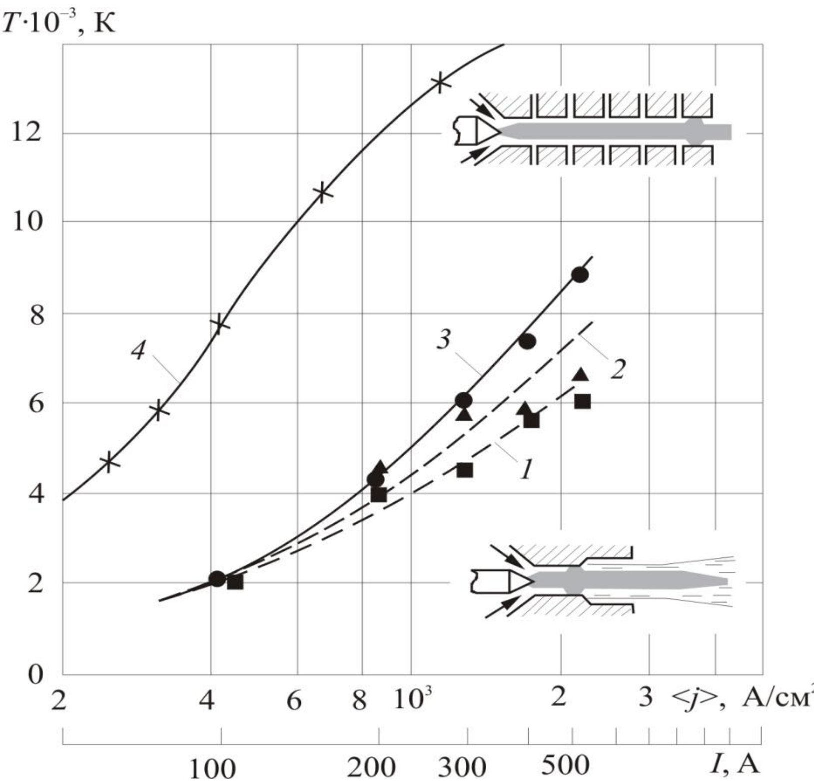

Fig. 2. The mass-average temperature of the argon plasma jet for plasmatrons with MEM and GN-5P at gas flow rates, g / s: 1 - 0.39; 2 - 0.67; 3 - 1.23; 4 - 0.67.

The experimental data on the temperature of the plasma jets of the plasma torch from the UPU-3D installation (curves 1–3) and a plasma torch with IEI (curve 4) are presented here. It can be seen that a plasmatron with a self-stabilizing arc length provides a mass-average temperature of the jet of 6000 K at a current strength of 300-500 A, and a plasmatron with a sectioned IEI at a current of 80 A.

PLASMA ARC REACTOR

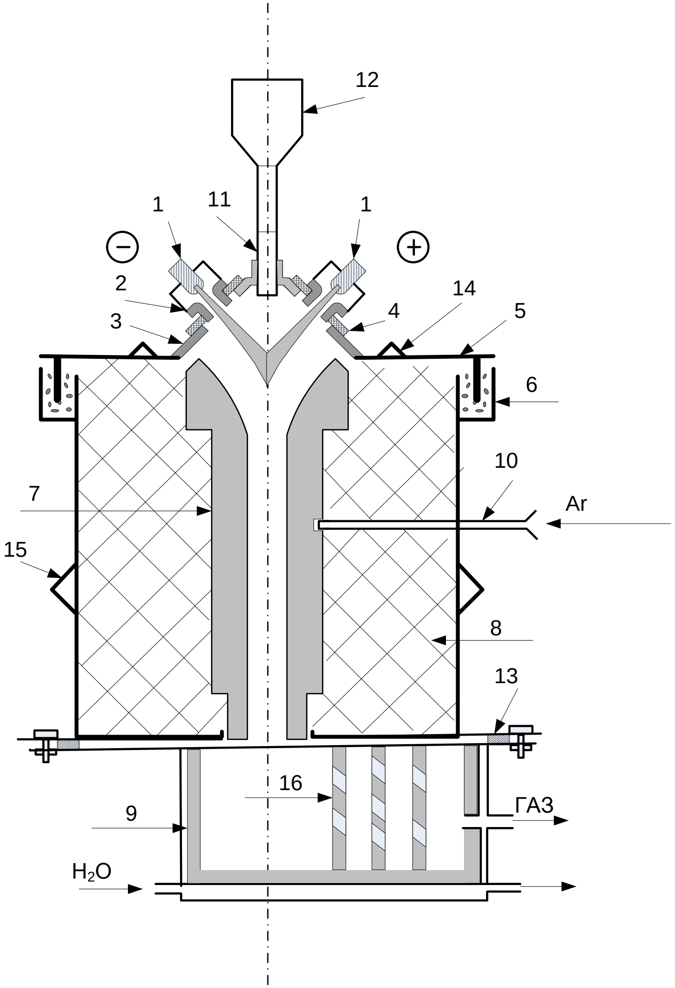

Fig. 4. Scheme of a plasma reactor.

- The experiments were carried out with a mixture of silicon dioxide SiO2 powder with grain sizes up to 100 microns and finely dispersed carbon up to 45 microns in size. The carrier gas is argon or methane. In order to increase the yield of silicon carbide, water vapor with a temperature of ~ 300 ° C was introduced into the plasma stream.
- The arc current varied from 100 to 150 A, the voltage on the arc - 80-250 V. In this case, the reactor power during operation of the plasma torch on argon was 12–20 kW. Adding about 10% nitrogen to the plasma-forming argon gas led to an increase in power by 30%. The temperature of the graphite sleeve of the reactor during the experiment was maintained at a level of 1100-1600 ° C. The residence time of the treated particles in the reactor was $9 \cdot 10^{-2}$ s.

Results

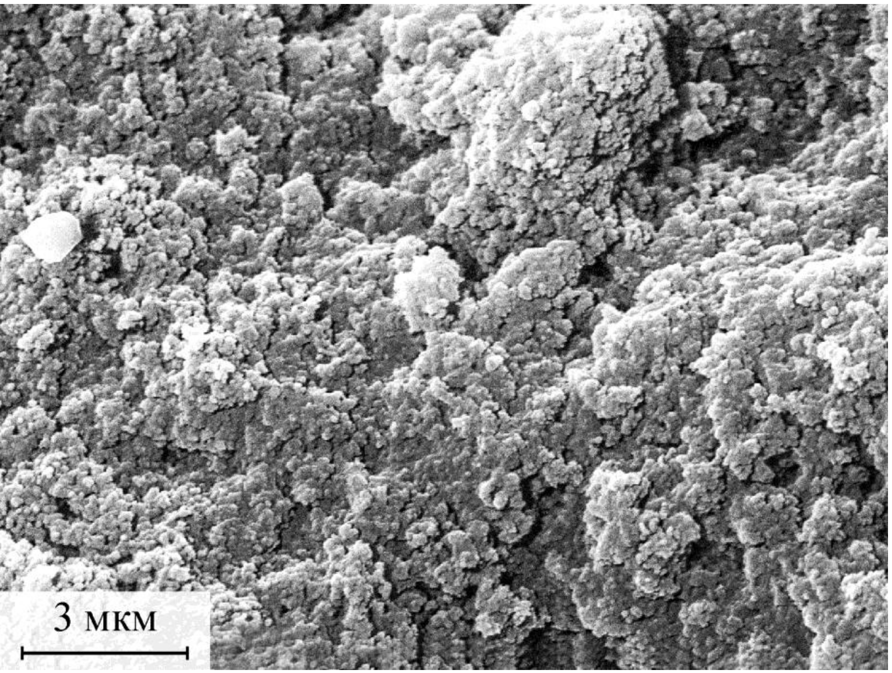

Fig. 5. Micrograph of the synthesized product.

- A photograph of the target SiC product is shown in Fig. 5. It can be seen that the particle size of the resulting powder is generally significantly less than 1 μm. Particle size analysis was carried out on a LEO 420 scanning microscope, the resolution of which does not allow us to unambiguously interpret the resulting structure as nano-formation. The results of these studies confirm that, when SiC is produced in a low-temperature plasma, the reaction proceeds in the gas phase. Therefore, it should be expected that the particle size of the obtained silicon carbide in the two-jet reactor is from 5 to 100 nm.

CONCLUSION

- 1. The developed plasma-thermal devices satisfy the requirements of technological processes for the synthesis and modification of powder materials in gas-discharge plasma flows with specified physicochemical properties.
- 2. Created electroplasma devices allow you to enter the source material into the arc discharge or at the meeting point of high-temperature flows in order to significantly reduce the processing time.
- 3. The experiments and operation in technological production have shown the high efficiency of the developed plasma devices for processing powder materials in coating, obtaining ultra- and nanodispersed powders.

Thank you for attention