DOI: 10.34854/ICPAF.51.2024.1.1.128

INVESTIGATION OF CONTRACTION OF MICROWAVE DISCHARGE SUSTAINED IN A PLASMOCHEMICAL REACTOR IN A HYDROGEN-METHANE GAS MIXTURE *)

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Chemical vapor deposition of diamond at high pressures (above 300 Torr) is currently being actively studied in order to increase the growth rate. However, the synthesis of CVD diamond at high pressures is still not as thoroughly studied as compared to the case of lower pressures (20-200 Torr). One of the little-studied phenomena is the contraction of a high-pressure discharge in a microwave plasma-chemical reactor in a hydrogen-methane gas mixture, in which an abrupt transition of the discharge from a homogeneous form to a contracted one with a bright thin filament in the center of the discharge is observed [1].

This report presents the results of a study of the phenomenon of microwave discharge contraction in a hydrogen-methane gas mixture in the pressure range 250-500 Torr. The results of studying the range of parameters (gas mixture pressure, microwave power, methane content) at which the contracted mode occurs and is stably maintained in various CVD reactors are presented, and the results of measuring the electron concentration in the contracted mode are also presented. Photographs of the discharge before and after contraction are shown in Figure 1.

The experiments have shown that discharge contraction in a CVD reactor for diamond synthesis is not an effect specific to a particular reactor, but is observed in various CVD reactors. The existence of the contracted mode was demonstrated in three different CVD reactors. The measurements showed a significant increase in the electron concentration ($[Ne] > 10^{14}$ cm^{-3}) and the hydrogen flux onto the substrate during contraction. Moreover, this mode is stable and can be maintained for a long time. Measurements of the electron concentration and estimates of the skin depth allow us to conclude that the radial size of the filament corresponds to the skin depth.

Contraction may be of interest for testing numerical discharge models. Contraction is sensitive to the ratio of methane to hydrogen content in the gas mixture and has clear pressure thresholds, which should be reproduced in a numerical model that claims to provide a detailed description of microwave discharge plasma in reactors for diamond synthesis.

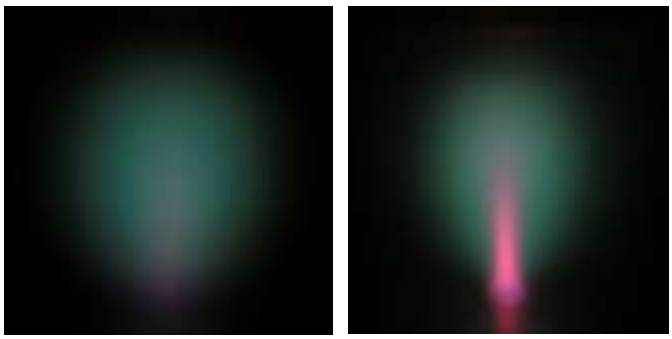

Figure 1. Contraction of microwave discharge with increasing pressure from 345 to 355 Torr.

References

[1]. S.A. Bogdanov, A.L. Vikharev, A.M. Gorbachev, D.B. Radishev, M.A. Lobaev, Plasma Processes Polym. 20, e2300073, (2023)

*) abstracts of this report in Russian