METHOD for MEASURING PLASMA DENSITY IN A WIDE RANGE OF VALUES using small-sized harpin PROBE

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The resonant microwave probe, first proposed by R. L. Stenzel [1], is successfully used for local measurements of plasma concentrations in scientific laboratory experiments. The probe is a miniature quarter-wave resonator in the form of a segment of a two-wire line shorted on one side and open on the other. The resonance frequency ω of this diagnosis depends on the permittivity of the plasma. By measuring the natural frequency of the resonator without plasma ω0 and in plasma ω, it is easy to find the plasma frequency ωp, and, consequently, the plasma concentration.

In the study of plasma using a microwave probe important parameters are the dynamic range, sensitivity and spatial resolution of the diagnosis. With the standard method of measuring the shift of the maximum of the resonance curve [1], the sensitivity of the microwave probe is determined by the accuracy of measuring the shift of the resonance frequency Δω. This value is determined by the q quality factor of the resonance system, and Δω=ω0/Q. The minimum measured value of the concentration corresponding to the frequency shift Δω, in accordance with [1] is determined by the expression . If it is necessary to measure lower plasma concentrations, it is necessary to use a microwave probe with a lower resonant frequency and a longer resonator length, which worsens the spatial resolution of the diagnosis. In this paper we propose a method of measuring the plasma concentration using a microwave probe, which allows not increasing the geometric parameters of the resonator to reduce the minimum measured value of the concentration by several orders of magnitude, thereby significantly expand the dynamic range of the measuring system down the concentration. Within the framework of this method, measurements are carried out at a fixed frequency corresponding to the resonant frequency of the microwave probe without plasma, and small changes in the resonant frequency of the system within the width of the natural resonance are recorded by amplitude-phase measurements.

The paper presents a theoretical model of the measurement technique and its experimental approbation on the ionosphere plasma bench (IAP RAS) in the study of space-time distributions of plasma concentration by a microwave probe with its own resonance frequency of 2034 MHz. It is shown that the developed technique increases the dynamic range of the microwave probe down the concentration by three orders of magnitude and together with the traditional measurement technique significantly expands the diagnostic capabilities of the microwave probe.

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References

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