Radiation losses in resonator measurement converters for scanning microwave microscopy

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In this document, we present the results of calculations on numerical model of the microwave converter with the coaxial measuring aperture are discussed. Conditions at which it is necessary to consider radiating losses are found.

Currently, scanning microwave microscopy (SMM) is widely used for the study of different materials and structures. The advantage of SMM is the opportunity to conduct research not only the surface of the sample, but the volume near the surface area. Almost all the work in this direction are experimental, without analyzing the characteristics of the probing devices and the optimization of the geometry of the probe to increase the spatial resolution [1].

Resonator measurement converters with coaxial measurement aperture (RMC CMA) have wide application in SMM [2]. In each of the above spheres optimal designing of such converters depends upon various criteria; however, it is practically demonstrated that the necessity of considering the radiation losses is found in both cases.

Usually simulation characteristics of RMC are based on the oscillatory mode of the electromagnetic field in the resonator. For closed systems it is quite admissible. But in RMC CMA influence of the object upon the resonator field is altering radiation properties of the measurement aperture.

Purpose of work is the calculation and analysis of RMC CMA with the influence of the sample and selection criteria when one can neglect of radiative losses.

For theoretical investigation of such a RMC it is necessary to find a total distribution of the electromagnetic field in the resonator and in the object from the solution to the Maxwell equations. The contribution of the radiation component in variation of the RMC Q-factor at the influence exerted by the object depends upon electromagnetic properties of the object and the aperture geometry. At the general setting of solution to this problem it is impossible to separate the indicated aspects (radiation and oscillatory loss).

The Q-factor is determined from the frequency dependence of the parameter S11 calculated using direct numerical methods for solving the Maxwell equations for field distribution on the basis of the finite elements technique [3] without considering active losses in the resonator walls.

It follows that only at $R_2/\lambda < 0,01$ and $tg\delta_2 > 10^{-2}$ there can be neglected the radiation losses as compared the oscillatory ones.

The performed investigations provide a convincing proof of the fact that while using coaxial measurement equipment in SMM of the dielectrics with $tg\delta_2 < 10^{-2}$, it is not allowed to neglect the influence of losses upon the radiation.

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[2] Yu.Ye. Gordiyenko, N.I. Slipchenko, V.V. Petrov Radio Electronics and Informatics **3**: (2007).
[3] G.I. Marchuk, V.I. Agoshkov Introduction to the projection-grid methods (1981).