

# Microstrip Resonant Sensors for Scanning Microwave Microscopy

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**Abstract** - The researches of properties of resonant transducers based on segments of microstrip lines, topology of which contains the probe tip structure are carried out. Numerical model studies of the distribution of the fields and the dependence of amplitude-frequency responses of resonant microstrip structures with probes of various configurations are carried out and value of communication and parameters of samples possible diagnosis are determined.

**Keywords** – microstrip, sensor, microwave microscopy, topology, probe structure.

## I. INTRODUCTION

Using resonant transducers in a scanning microwave microscope allows greater measurement sensitivity, which is largely dependent on quality of the resonator. Spatial resolution depends on the construction and geometry of the aperture part of the probe. Degree sharpening and tip geometry is largely determined by spatial resolution.

Implementation resonant transducers based on strip and microstrip structures open the possibility of creating integrated devices for forming information signals SMM, these devices include both transducer (sensor) and system for generating and pre-processing, as well as the creation of such constructive microprobe, which can be used both for atomic force and tunneling microscopy [1, 2].

The objective of this work is the analysis and consideration of the factors determining the possibility of providing the resonance properties of transducers based on microstrip lines at intervals topologies probe structures representing an integral part of the cavity measuring instrument.

## II. MAIN PART

The simplest in design and technology of the resonance element based on a half-wave microstrip line resonator. Calculating the parameters of such a resonator can be performed using the formulas in the handbook [3].

Simulation was carried out at  $f = 10$  GHz,  $h = 1$  mm,  $Z_y = 50$  Ohms,  $\epsilon_d \approx 9.6$  (polycor),  $\text{tg}\delta \approx 10^{-4}$ ,  $\rho = 0,0172 \cdot 10^{-6}$  Ohm·sm.

This model is shown own (unloaded) quality factor of a half-wave microstrip resonator  $Q_0 \sim 5 \cdot 10^2$  ( $L = 5,84$  mm,  $W = 1$  mm)

The resulting calculated value of quality factor is the maximum possible for the considered structure.

In practice, when configuring a half-wave resonant microwave line segment in the form of a half-wave length of the probe with the structure, and the need for such resonant transducer communication to external circuits of the measuring system, the real business value of Q will be a half to two times less.

In this regard were carried out numerical modeling studies of the nature and distribution of the fields depending on the frequency response of microstrip resonant structures with probes of various configurations of switching circuits, the values of communication and diagnostic parameters of samples possible.

Topology investigated half-wave resonant structures with terminal capacitive connection shown in Fig. 1.

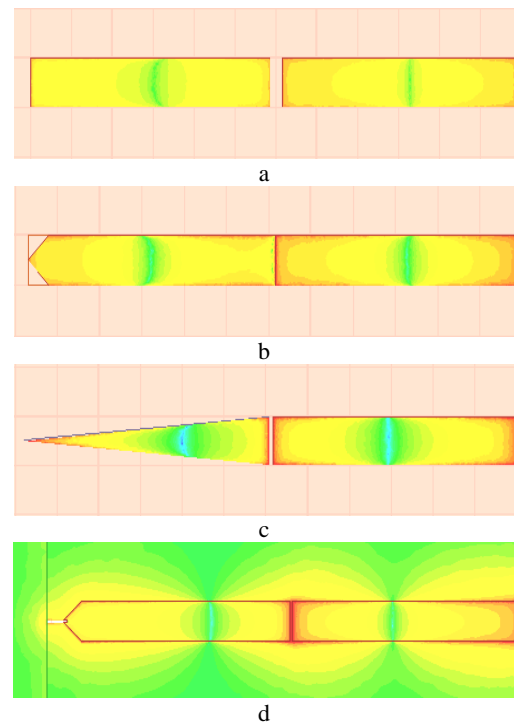


Fig. 1. Topology of half-wave resonant structures

The analysis was conducted for the resonant half-wavelength microstrip line (Fig. 1a), a half-wave of the line segment with a special  $45^\circ$  angel (Fig. 1b), a half-wave of the line segment in the form of a triangular irregular structure with sides:  $a = b = 5,84$  mm,  $c = 0,981$  mm (Fig. 1c) and a half-wave of the line segment with a special  $45^\circ$  angel and the tip length of  $\sim 0,1$  mm and a radius of 30 microns (Fig. 1d).

In all cases, the open end of the resonance interval provided excess values of the electric field component in half to two orders of magnitude, and the degree of localization is determined by the geometry of the tip end.

Since the resonance properties largely depend on the magnitude of communication research has also been undertaken to the influence of capacitive gap element of communication in response considered resonance structures (Fig. 2 and 3). It is revealed that the maximum of the resonance properties of the studied structures are shown when the minimum clearances between the resonant elements and lines. This is typical for reflective inclusion at the coefficients of communication, not reaching the critical value.

The quality of resonators in this case is low (of the order of several tens). For irregular cut (Fig. 1c), there are rather strong dependence of the resonance frequency on the value of communication, due, perhaps, to the peculiarities of the formation of the resonance response in such a structure.

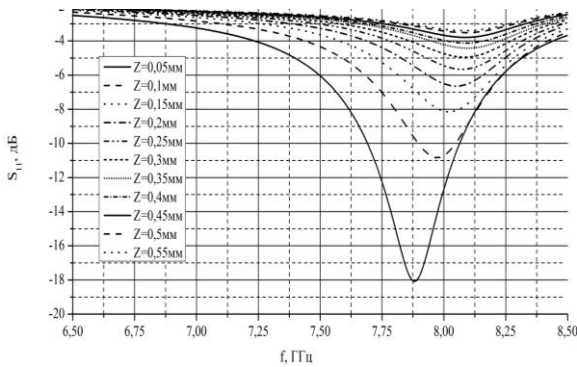


Fig. 2. Depending on the amplitude-frequency characteristic of the half-wave of the line segment with a special 45° angle (Fig. 1b) from the size of the capacitive gap element connection

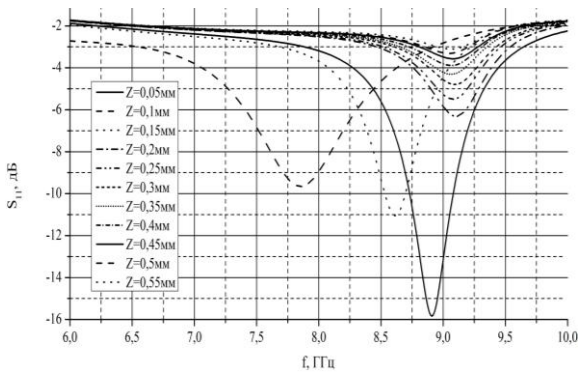


Fig. 3. Depending on the amplitude-frequency characteristic of the half-wave of the line segment in the form of a triangular irregular structure (Fig. 1c) from the size of the capacitive gap element connection

The results of numerical evaluations of the impact change of dielectric permeability of the material located near the sharpened probe parts microstrip resonant

structure, changes the amplitude-frequency characteristic shown in Fig. 4.

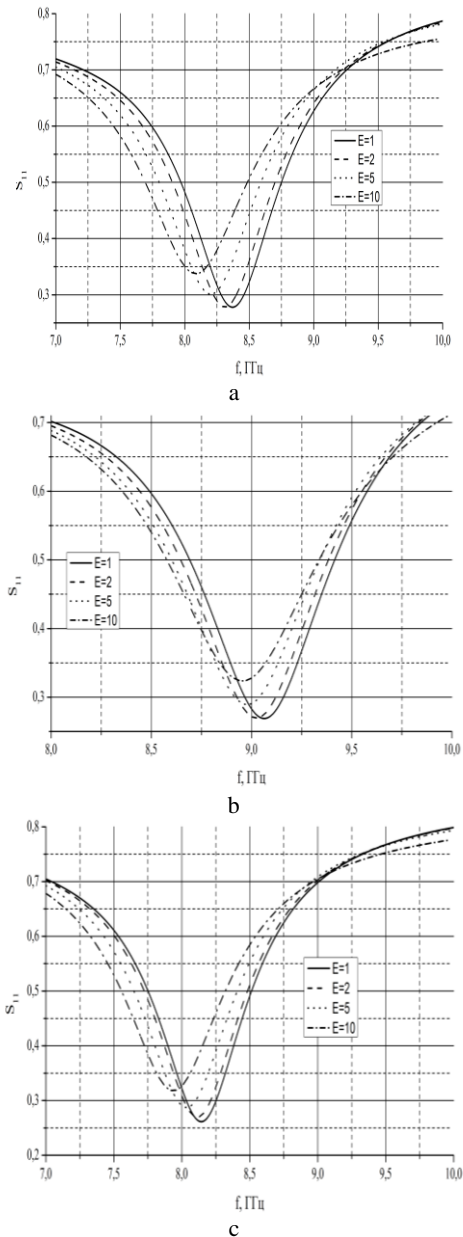


Fig. 4. Depending on the amplitude-frequency characteristic of the resonant structures on the value of the permittivity of the diagnostic object: a – a half-wave of the line segment with a special 45° angle (Fig. 1b), b – a half-wave of the line segment in the form of a triangular irregular structure (Fig. 1c), c – a half-wave of the line segment with a special 45° angle and the tip (Fig. 1d)

For all topologies resonant structures probes with increasing the permittivity of the object diagnosing a central resonance frequency decrease, which, in general, naturally as it increases the magnitude of  $\epsilon_{ef}$ . On the other hand, the presence of such a shift indicates the sensitivity characteristics of the considered structures to modify the objects are located near areas of localized with their means of electromagnetic fields.

Studies have also microstrip half-wave resonance structures for bushing inclusion. The topology of the studied structures are shown in Fig. 5. This is a half-wave of the line segment with a special 45° angel (Fig. 5a) and a half-wave of the line segment with a special 45° angel and the tip (Fig. 5b).

While the analyses of the type and character of change of a resonance curve depending on the value of the connection (Fig. 6, a, b) and the dielectric constant of the object is placed near to probe parts of the resonance structure (Fig. 7, a, b) are carried out.

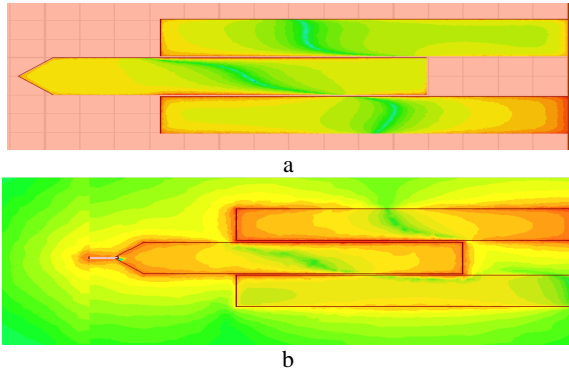


Fig. 5. The topology of the studied structures: a – a half-wave of the line segment with a special 45° angel; b – a half-wave of the line segment with a special 45° angel and the tip

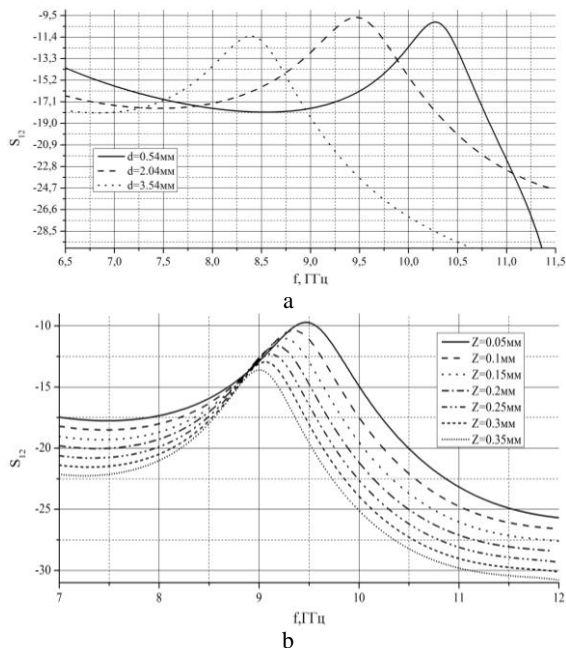


Fig. 6. Depending on the amplitude-frequency characteristic of the resonant structure (Fig. 5a) on the value of overlap between microstrips (a) and gap (b).

The graphs show a strong dependence of the resonance frequency and shape of the resonance curve of the magnitude of the communication. Upon further review of the selected size of the overlap region  $d = 2,04$  mm and a gap of  $z = 0.35$  mm.

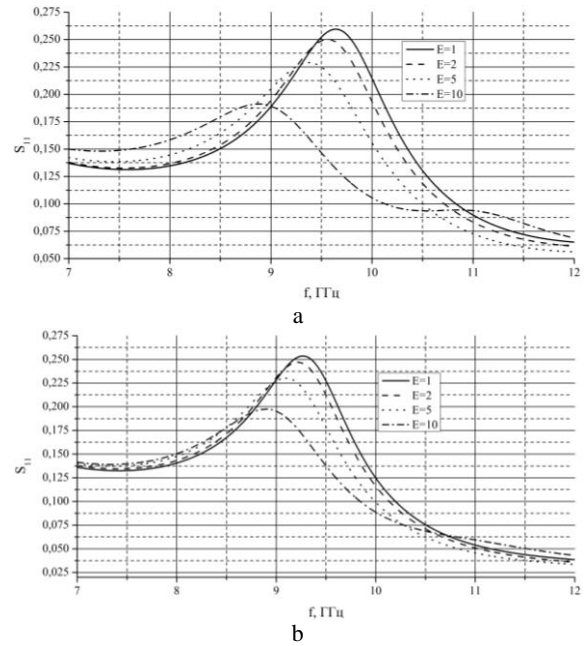


Fig. 7. Depending on the amplitude-frequency characteristic of the resonant structures on the value of the permittivity of the diagnostic object: a – a half-wave of the line segment with a special 45° angel (Fig. 5a), b – a half-wave of the line segment with a special 45° angel and the tip (Fig. 5b)

### III. CONCLUSION

Studies suggest the following conclusions:

- half-wave resonant topology changing does not significantly change resonant properties;
- on sharpened areas (prototype probes) achieved higher a half to two orders of localized field strength values;
- amplitude-frequency characteristic considered structures have sensitivity to changes in parameters of the objects near the disposable probes that can be used for diagnosis.

At the same time, to the practical experimental realization of half-wave resonant structures with probes necessary to carry out more research on the analysis of the transmission-type inclusion, as well as opportunities making full use of resonant properties.

### REFERENCES

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