Measurements method of surface polariton fields distribution through the excitation of resonance in a single planar double split ring

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Abstract

It has been shown experimentally the possibility of using resonance in a single planar double split ring for investigating of field distribution and local polarization properties of surface polaritons supported by planar grating with parallel cut wires.

1. Introduction

It is well known conditions which are necessary to excite microwave resonance effects in planar split rings (**PDSR**) [1, 2]. One can separate electric and magnetic resonance types and excite resonance by both the magnetic and electric microwave field placing the necessary ring orientation. In addition, type of the resonance can be identified by separation of positive and negative pass-bands in a cutoff waveguide [3]. Therefore if we measure resonance intensity and identify the type of the resonance in dependence on ring orientation and location one can analyze polarization properties and distribution of the magnetic and electric fields of exciting wave using a single ring as probe. In this presentation we show that resonance in a single split ring can be used as effective probe to analyze properties of the surface polariton fields, because it has been revealed a more than tenfold increase in the resonance intensity in comparison with free double split ring excited by plane wave. Experimental investigation of the structure of surface polaritons' magnetic and electric fields near different surfaces is necessary to develop new effects which are observed under surface polariton excitation [4, 5].

2. Analysis of polarization properties of surface polariton fields excited by wire grating

Here we show amplification of resonance effects in a single planar double split ring (**PDSR)** in the case when the ring is placed near supporting surface polaritons grating (**SSP)**, placed along propagation direction of microwaves. The **SSP** contains cut wires parallel to the microwave electric field **E.** We measure frequency dependencies of the transmission coefficients **T** in a rectangular waveguide (48x24 mm) and in below cutoff waveguide (16x24mm) in the case when a single **PDSR** is placed on waveguide axis without the **SSP** and when **PDSR** is placed in different orientations near the **SSP** and excited by surface polaritons. In below cutoff **WG** positive or negative pass-bands are observed depending on excitation. In paper [3] it has been shown that in the case when resonance is excited by microwave electric field **E** positive pass-band is observed on a low-frequency side of the resonance (in **WG**). In the case when resonance is excited by microwave magnetic field negative pass-band is observed on a high-frequency side of the resonance (in **WG**). Here we show results for following sizes: external diameter of a single **PDSR** is 6.5 mm and length of cut wires $\mathbf{l_{sp}}$ is 18 mm. Using such sizes one can observe the resonance in a single **PDSR** in given frequency band 3 – 6 GHz exciting the resonance in existence domain of surface polaritons on a low-frequency side of the **SSP** resonance (above 6 GHz). Distance **s** between the **SSP** and a single **PDSR**-centre is 2.5 mm.

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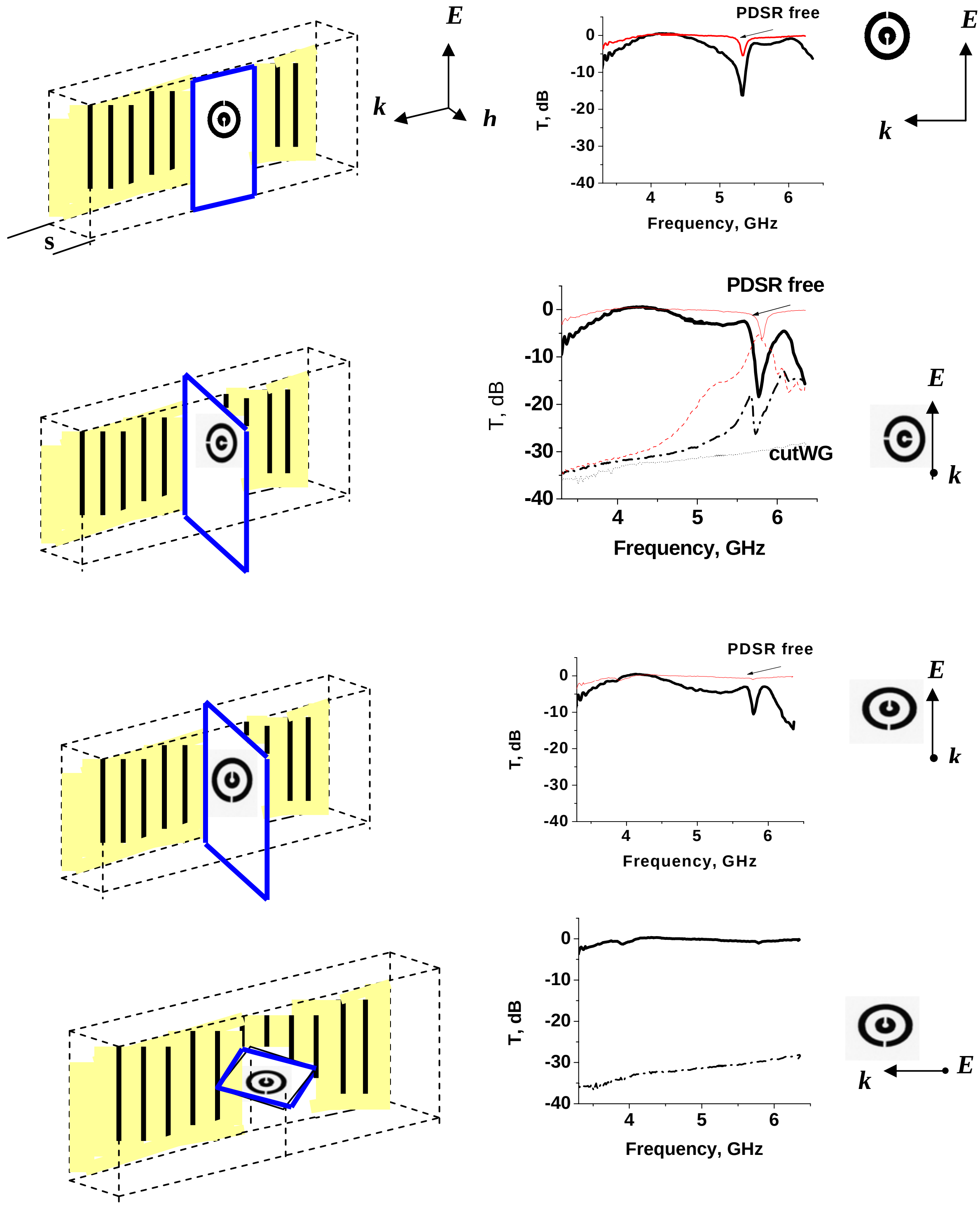

Fig. 1. Resonance effects in **PDSR** placed in **WG** without the **SSP** –red, with **SSP** – black bold type; in cutoff **WG** (without the **SSP** –red dash; with the SSP –black solid bold type; cutoff **WG** empty - dot):
(a) **PDSR**|| the **SSP**, **PDSR** axis ⊥ k, E-field ⊥ line closing ring break
(b) **PDSR** ⊥ the **SSP, PDSR** axis|| k, E-field|| line closing ring break
(c) **PDSR** ⊥ the **SSP, PDSR** axis|| k, E-field ⊥ line closing ring break
(d) **PDSR** ⊥ the **SSP, PDSR** axis|| $\mathbf{l_{sp}}$, E-field ⊥ ring plane, line closing ring break|| the **SSP**

Experimental results are presented in figs. 1, a - d. In fig. 1a a single **PDSR** is placed along the propagation direction of microwaves and parallel to the **SSP**, the ring axis is perpendicularly to the wave vector **k**; line, closing break of the ring, is perpendicularly to the microwave electric **E**-field. In the case of free **PDSR** resonance is excited at 5.5 GHz by microwave magnetic field **h,** corresponding resonance intensity (resonance level) in **WG** (see red curve) is -5.4 dB. In the case with the **SSP** resonance intensity (see black bold type) is -16.7 dB, what is more than tenfold increase in the resonance intensity.

In fig. 1b a single **PDSR** is placed perpendicularly to the **SSP,** the ring axis is parallel to the wave vector **k;** line, closing the break of the ring, is parallel to the microwave electric **E**-field. In the case of free **PDSR** resonance is excited by microwave electric field **E,** corresponding resonance intensity in **WG** is -6.2 dB and positive pass-band (red dash) is observed in a cutoff **WG** on a low-frequency side of the resonance (in **WG**). In fig. 1b we also see that in the case when a single **PDSR** is placed near the **SSP** resonance intensity is -18.4 dB, what is more than tenfold increase in the resonance intensity. In this case in cutoff **WG** it is observed both positive (on a low-frequency side of the resonance) and negative (on a high-frequency side of the resonance) pass-bands, that is, with the **SSP** resonance is excited by both the **E** and **h**-field, what indicates that surface polariton magnetic field has longitudinal component parallel to the ring axis and can excite the resonance too.

In fig. 1c a single **PDSR** is placed perpendicularly to the **SSP,** the ring axis is parallel to the wave vector **k** as in fig. 1b**;** but line, closing the break of the ring, is perpendicularly to the microwave electric **E**-field. For this orientation resonance effect in free **PDSR** is absent. But in the **SSP** presence resonance is excited. So, surface polariton magnetic field has longitudinal component and can excite the resonance in **PDSR.**

When the ring axis is parallel to wires $\mathbf{l}_{sp}$, and line, closing the break of the ring, is parallel to the **SSP,** resonance is not excited (fig. 1d), what testifies, that surface polariton electric field has not longitudinal component and magnetic field has not component parallel to the ring axis (to wires $\mathbf{l}_{sp}$), which could excite the resonance in **PDSR**.

3. Conclusion

Measurements of frequency dependences of the transmission coefficients in a rectangular and below cutoff waveguides show that a single planar double split ring can be used as effective probe to analyze properties of the surface polariton fields. Proposed method can be easily realized in free space and can be used to develop new effects which are observed under surface polariton excitation.

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