Millimeter Wave Oscillator Based Dielectric Hemisphere with Cylinder Shield

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The quasioptical open dielectric resonators with whispering gallery modes (WG) have wellknown properties in millimeter wave band. Solid-state oscillators based these resonators with Gunn diodes, IMPATT diodes have a high value of the frequency stability and relatively clear spectrum of the forced oscillattions [1], especially in the case of the hemispherical dielectric resonator application [2]. However, at the same time such oscillators have demerits, for example, their open property leads to the parasite coupling with others millimeter wave devices and elements. It can leads to the non-control characteristics variation of both considered solid-state oscillators and compatibilited with their others devices. One of this problem solutions is the shielding of dielectric resonators [3, 4]. In this case the arrangement of the metal shield in the dielectric resonator field influences at the behaviour of the oscillator characteristics and leads to the dense spectrum of oscillations. Therefore the metal cylinder which is open with the plane sides is used for the shielding of the dielectric hemisphere at this paper.

The paper [5] shows that the oscillator characteristics mainly depend from the electrodynamic properties of the used resonant system, such as the value of Q-factor of the excited oscillations and the coupling levels with their. The investigations of the power characteristics considered of the shielded hemispherical dielectric resonator (SHDR) have shown, that at the certain ratio between the sizes of the metal shield and dielectric resonant structure the Q-factor value of the excited WG modes is appreciable increased in comparison with a case of the similar open resonator [4, 6]. The obtained results can have the large meaning at creation of the millimeter wave oscillators on the basis of SHDR with WG modes. Therefore, the purpose of this paper is the investigation of the main Gunn diode oscillator characteristics with dielectric resonator which is shielded by metal cylinder: frequency, output power and electronic tuning of frequency, which steepness allows to estimate a stability of frequency in relation to parasitic change of a Gunn diode voltage, and their comparative analysis with the characteristics of generation in similar open dielectric resonator.

A basis of an experimental model is the plane metal mirror 1 (fig. 1), in which rectangular slot the containing Gunn diode, elements of fastening, matching and coordination is placed the diode module 4. On the one hand mirrors the diode module is connected to output rectangular hollow metal waveguide (in a fig. is not shown), and with another - with the dielectric hemisphere 2, shielded by the metal cylinder 3 with a semicircle in the bases open from end faces.

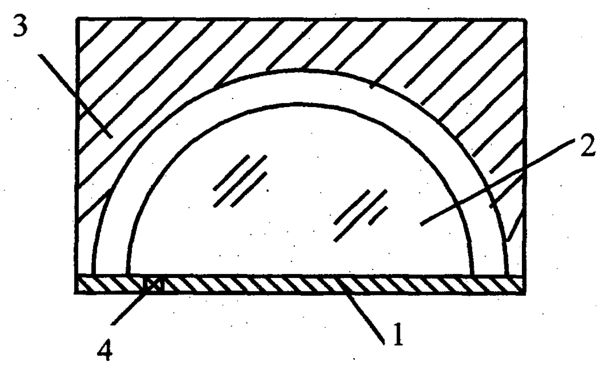

Fig.1 Experimental model of investigations

In the investigated range of frequencies (30-45 GHz) the hemisphere is made from teflon by radius 39mm. The metal cylinder has radius of 42 mm and height of 120 mm. The output aperture of the diode module is guided in such a manner that in the resonator are excited the WG modes with TM polarization. The space

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between the dielectric hemisphere and metal cylinder is filled with air. On radial coordinate the diode module is placed in the field of an intensity maximum of the working WG mode field. In the oscillator model there is an opportunity to change the radial coordinate of the shield, bringing in thus asymmetry of an air space between the dielectric structure and metal cylinder. The asymmetry of an air space of SHDR is convenient for considering as the relation $\delta d / d$, where d is a size of a symmetric from different directions SHDR air space, and δd is the deviation from this value.

In a fig. 2 the dependences of the output power P and change of the generation frequency δf of WG modes in SHDR from a Gunn diode voltage U are given at various width of the air space between the dielectric structure and metal shield (symmetric and asymmetric) (fig. 2a) and the generation frequency f from asymmetry of SHDR air space $\delta d / d$ (fig. 2b).

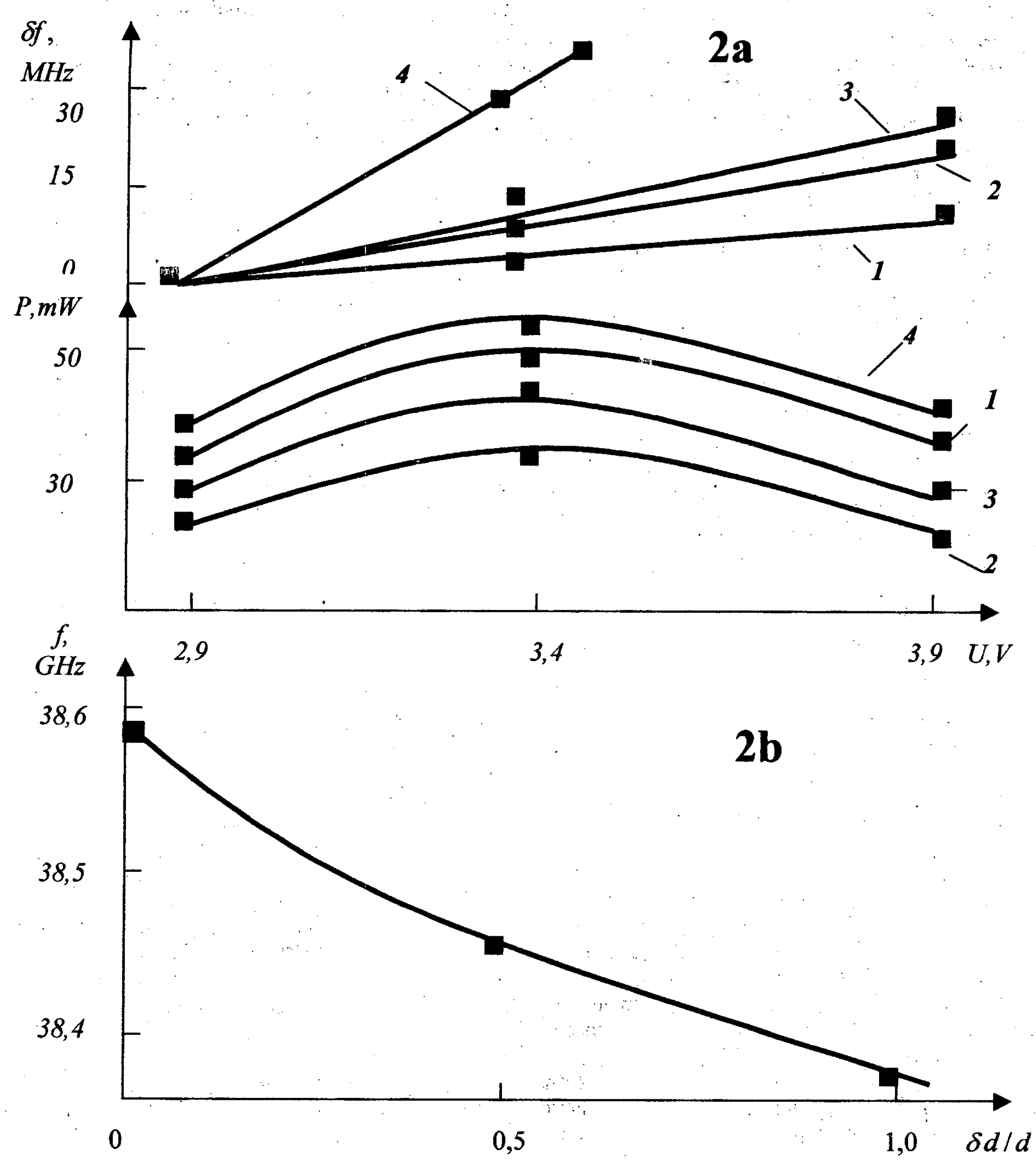

Fig. 2 Frequency and power characteristics of Gunn diode generation of WG modes in SHDR

The curves 1 show behaviour of the investigated dependences for the SHDR with a symmetric air space, and the curves 2 correspond to the case of the asymmetric SHDR air space in the resonator with $\delta d/d \approx 0,7$. For comparison the curves 3 connect the investigation results of the WG modes generation characteristics by the Gunn diode in similar open dielectric resonator. The curves 4 represent the output power and electronic tuning of the frequency in waveguide oscillator design of the oscillator consisting from backshort diode module on the part of the investigated resonator. The submitted results correspond to the measurements which have been carried out near to resonant frequency of SHDR $f \approx 38.6$GHz.

From a fig. 2 it is visible, that at a symmetric air space in SHDR the maximal output power of generation and least steepness of electronic tuning of frequency $\delta f(U)$ is observed in comparison with generation in open resonant system and in the shielded resonator at asymmetric air spaces. In comparison with the case of the waveguide oscillator design there is essential decrease of a steepness of electronic frequency tuning (the range of the electronic frequency tuning is narrowed almost in 15 times) and insignificant change of output power of thegeneration. The explanation of the obtained results can be carried out on the basis of results of the electrodynamic investigations [7, 8]: at such ratio of the sizes of the dielectric hemisphere and cylindrical shield the maximal values of WG modes Q-factor in SHDR were observed. Thus the least losses of the oscillations energy of in resonant system are the basic reason of improvement of the characteristics of their generation by an active element.

It is necessary to pay attention to the results of the investigation of the dependence $f(\delta d/d)$. From the fig.2b it is visible, that by creation of the SHDR asymmetric air space by increase of the value $\delta d/d$ from 0 up to 1, it is possible almost in 35 times to increase a range of the frequency tuning of the generation in comparison with the electronic tuning. However at creation of an asymmetric air space the range of the electronic frequency tuning extends also, that speaks about the decrease of the generation frequency stability. It is explained to that at asymmetry of the SHDR air space the unloaded Q-factor of WG modes, excited in the shielded resonator, is less, than in case of the SHDR symmetric air space.

The results of the carried out investigations of the generation characteristics on different working frequencies have shown, that they are approximatly equal to the working frequencies of the oscillator based of open dielectric resonator. At the creation in SHDR asymmetry of an air space the distinction between them, is increased also frequency thus is lowered (fig. 2b).

Thus, it is shown that at the creation of the solid-state oscillator based shielded hemispherical dielectric resonator the output power and frequency stability are increased in comparison the case of oscillator with similar open dielectric resonator. The variation of the air space width in investigated resonator creates the relatively wide frequency range of the generation.

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