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OPEN HEMISPHERICAL IMAGINE DIELECTRIC RESONATOR WITH WHISPERING GALLERY MODES

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The imaging dielectric resonators with whispering gallery modes (WGM's) for the creation of new class millimeter waves solid-state oscillators, devices for the investigation of high temperature superconductors were suggested [1-3]. They contain a dielectric element as a semidisk or a cylinder or a hemisphere and a flat metal mirror. The latter is a necessary element for placing in the resonator field active elements, conductor samples of materials. There is an important question about the dependence of the resonant frequencies and Q-factor of these resonators on impedance of the resonator mirror. In the present paper new investigation results of the open hemispherical imaging dielectric resonator (HIDR) with WGM's are represented.

Consider the homogeneous isotropic dielectric hemisphere with radius R . It is limited at $\theta = 90^0$ by flat metal mirror (insert , Fig.1). The mirror has a surface impedance $Z = \sqrt{\frac{\omega_q}{2\sigma}}(1-i)$, where σ is a metal conductivity, ω_q is a resonant frequency. The influence of small impedance value $Z << 1$ lead to frequency shift, which for TM modes is

$$\omega - \omega_q \approx \frac{(1+i)c(n-m)!}{\pi R(n+m)!}(2n+1)(n+1)^{2m-3}(n-m+1)^2\sqrt{\frac{\omega_q}{8\sigma}}.$$

where n and m are the variation number along polar and azimuth coordinates, respectively.

Let us consider the numerical and experimental investigation results of TM_{nm1} WGM's in the resonator. The relative deviation of their resonant frequencies $\Delta\omega / \omega_{q1} = (\omega_{q2} - \omega_{q1}) / \omega_{q1}$ due to the mirror conductivity is shown in Fig.1.

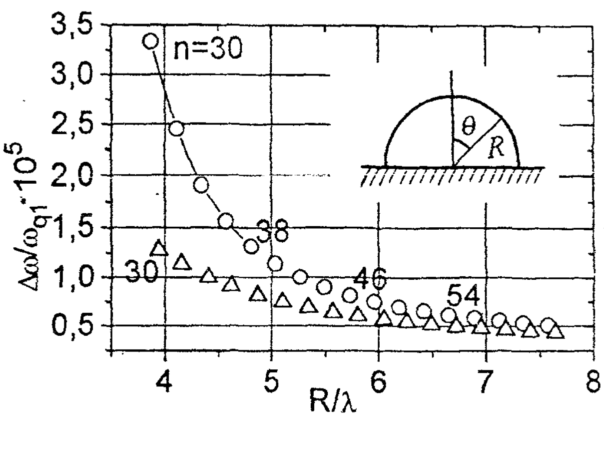

Fig. 1. The dependence the relative deviation of the resonance frequencies on parameter R / λ .
○ TE_{n81}, △ TM_{n91}

In the Fig.2 it is represented the dependence of unloaded Q-factor of TM_{nm1} modes on relative hemisphere radius R/λ (λ is the wave length in the open air) for teflon resonator ($\varepsilon' = 2.08$, $\tan\delta = 1.78 \cdot 10^{-4}$) with $R = 39mm$. The value Q_{01} is calculated for ideal case of the metal mirror $(Z = 0)$, and Q_{02} is obtained real case of copper one (conductivity $\sigma = 1.5 \cdot 10^{-7} c^{-1}$) for two values of $m = 9{,}17$. Here by the

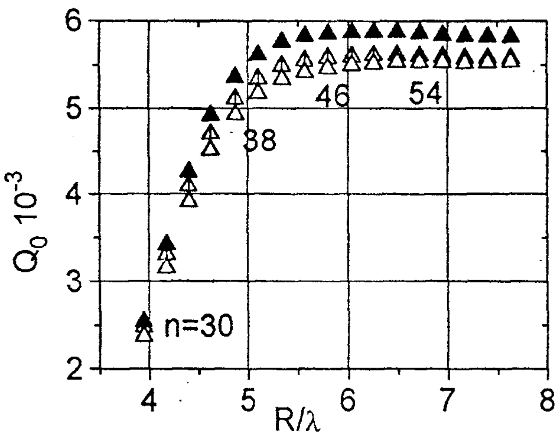

Fig.2 The dependence of Q-factor of TM modes on parameter R/λ

▲ Q_{01}, ▲ $Q_{02}(m = 9)$ △ , $Q_{02}(m = 17)$

vertical limited lines it is shown trust intervals of experimental measured Q_{02} mode values. TM modes there exist in HIDR only with odd index sum $(n + m)$. The characteristics of HIDR TE modes are the same as TM ones., but TE modes exist in HIDR only with even index sum $(n + m)$. The numerical investigation of mode characteristics of HIDR, which is made of polycortexes ($\varepsilon' = 9.6$; $\tan\delta = 3 \cdot 10^{-4}$) shows that they are the same as in teflon one.

The theoretical analysis and the experimental results of the WGM's in HIDR investigation show that their spectral characterictics can be obtained with the sufficient precision by means of the integral equation method at the small mirror resonator impedance. In compare with the modes of the dielectric ball the WGM's in hemispherical resonator have the following differences: their spectrum has low density, e.g. TE amd TM modes exist only with even and odd index sum $(n + m)$, accordingly; their resonant frequencies are higher, but the value of deviation in the case of copper mirror is -0.001%, i.e. it is neglected; their unloaded Q-factor is smaller and its difference can be 8 --- 10 %.

The unloaded Q-factor WGM's of HIDR is decreased at the increasing azimuth index m. The mirror hemishperical dielectric resonator with WGM's can be used as an oscillator system of devices in millimeter band (solid state oscillators, devices for study material and so on).

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