Multimode Conversions in an Overmoded Coaxial Bragg Resonator

Y-X .Lai[a], S-C. Zhang[a], H-B. Zhang[a], Qi. X[a], B. Chai[a], and Y-Y. Kong[a]
[a]Institute of Photoelectronics, Campus Mail Box 50, Southwest Jiaotong University,
Chengdu, Sichuan 610031, People's Republic of China

***Abstract*— Multimode conversion is studied for an overmoded 1-D coaxial Bragg resonator. It is demonstrated that 1-D coaxial Bragg resonator can be expected to have excellent mode selectivity under higher-order mode operation at frequency of hundreds giga Hertz.**

I. Introduction And Background

Bragg resonators are widely applied in many branches of microwave electronics and integrated optics [1]-[5]. In the past several ten years, a Bragg resonator in the form of cylindrical metallic tube has been regarded as the suitable beam-wave interaction structure for cyclotron autoresonance maser (CARM) and free electron laser (FEL) oscillators.

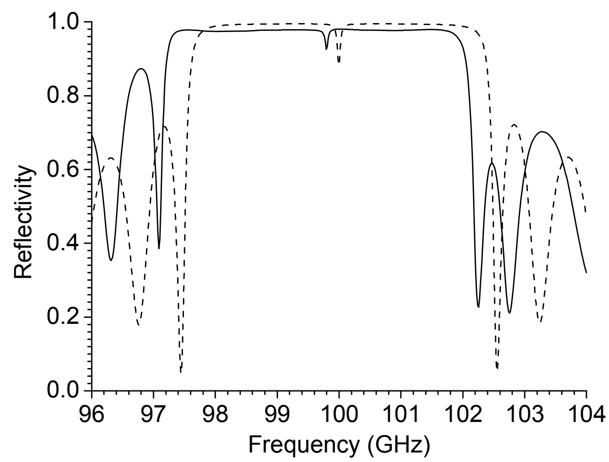
Recently, growing attention has been paid to the two-dimensional coaxial Bragg resonator developed at University of Strathclyde [1]. However, good mode selectivity of such structure can be achieved for only the azimuthally symmetric modes, which leads to operation in the *lowest mode (TEM)* at a frequency of 37.5 GHz. To enable the device operate in a higher-order mode at high frequency, large dimensional size is often required for the consideration of mechanical manufacturing and power handling capacity.

In the case of a higher-order mode operation with a large dimensional size, the 1-D coaxial Bragg structure is favorable to mode selectivity [2]-[4]. On the other hand, however, higher-order mode operation in an overmoded coaxial Bragg structure inevitably leads to multimode-conversion problems [3],[4].

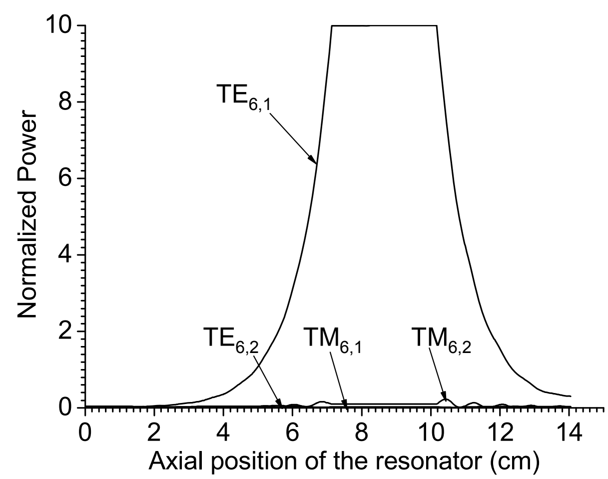
The present paper is contributed to evaluate the influence of multimode conversions on the eigenfrequency as well as axial distribution of field energy in a coaxial Bragg resonator operating in $TE_{6,1}$ mode at a frequency of 100 GHz.

II. Results

The considered coaxial Bragg resonator is formed by two sinusoidally corrugated coaxial Bragg reflectors connected with a smooth coaxial waveguide section. These two Bragg reflectors have the same corrugation parameters: mean outer-wall radius a_0=13.0 mm, mean inner-rod radius b_0=9.1 mm, ripple period p_b=1.552 mm, outer-wall-ripple amplitude l_{out}=0.1 mm, inner-rod ripple amplitude l_{in}=0.095 mm, and initial outer-wall corrugation phase ϕ_{out}=0, initial inner-rod corrugation phase $\phi_{in}=\pi$. In order to prevent the energy leaking to the electron gun and to insure a suitable output-power level, the upstream Bragg reflector is designed to have a length L_u=7.137 cm and the downstream Bragg reflector to have a shorter length L_d=3.879 cm. The smooth section is design to have a length of L_m=3.026 cm, an outer-wall radius of 12.9 mm to be equal to the minimum outer-wall perturbations of the Bragg structure, and an inner-rod radius of 9.195 mm to be equal to the maximum inner-rod perturbations of the Bragg structure. These parameters corresponds to an axial mode index of 20 for the operation mode $TE_{6,1}$ at the operation frequency 100 GHz.



(a)



(b)

Fig. 1. Reflectivity (a) and power distribution (b) in an overmoded 1-D coaxial Bragg resonator.

Reflectivity spectrum of the considered coaxial Bragg resonator is shown in Fig. 1(a), where the solid line depicts the results of four-modes ($TE_{6,1}$, $TE_{6,2}$, $TM_{6,1}$ and $TM_{6,2}$) coupling and the dashed line represents the single-mode results. Since each local minimum in the spectrum lines corresponds to an

978-1-4244-2120-6/08/$25.00 ©IEEE.

eigenfrequency of the resonator, it can be figured out that the mode conversions lead to a slight eigenfrequency offset, and the frequency shift is 0.2 GHz at the operating frequency 100 GHz. Fig. 1 (b) shows the energy distribution of each involved mode along the axial position, where the real operating frequency is 99.8 GHz. One can find that the operation mode $TE_{6,1}$ is plays a dominant role in the resonator, while all the spurious modes have trivial power level. These peculiarities demonstrate that 1-D coaxial Bragg resonator can be expected to have excellent mode selectivity under higher-order mode operation at frequency of hundreds giga Hertz.

REFERENCES

[1] A. W. Cross et al., "Experimental and theoretical study of 2D Bragg structures for a coaxial free electron maser," Nucl. Instr. and Meth. A, vol.475, pp.164-172.2001.

[2] Y.-X. Lai, S.-C. Zhang, and H.-B.Zhang, "A Coaxial Bragg Reflector for Cyclotron Autoresonance Maser Oscillators," IEEE Microw. and Wireless Compon. Lett., vol.17, pp.328 – 330, May 2007.

[3] Y.-X. Lai and S.-C. Zhang, "Multiwave interaction formulation of a coaxial Bragg structure and its experimental verification," Phys. Plasmas. vol.14, pp.113301, Nov. 2007.

[4] Y.-X. Lai and S.-C. Zhang, "Separation of band-gap overlap in a coaxial Bragg structure operating in higher-order mode at Terahertz frequency," Phys. Plasmas. vol.15, pp.033301, Mar. 2008.

[5] Y.-X. Lai et al., "Design of a coaxial Bragg resonator for a 250 GHz Cyclotron Autoresonance Maser Oscillator," The Joint 32th International Conference on Infrared and Millimeter Waves & 15th International Conference on Terahertz Electronics Proceeding, (IEEE, Cardiff, 2007), pp.722-723.

978-1-4244-2120-6/08/$25.00 ©IEEE.