§8. Study of Periodically Corrugated Cavity for Oversized Slow-Wave Oscillator

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This project is aimed at developing periodically corrugated cavities for weakly relativistic oversized slow-wave devices. The slow-wave devices like backward wave oscillator can be driven by an axially injected electron beam without initial perpendicular velocity and has been studied extensively as a candidate for high or moderate power microwave sources. As a resonant cavity in such devices, slow-wave structure (SWS) is used to reduce the phase velocity of electromagnetic wave to the beam velocity. In order to increase the power handling capability and the operating frequency, oversized SWSs have been used with the diameter D of SWS larger than free-space wavelength λ of output electromagnetic wave by several times or more.

In the previous K-band and Q-band oversized BWOs in the weakly relativistic region less than 100kV, output powers in the range of hundreds of kW are obtained by using sinusoidally corrugated cavities. The sinusoidal corrugations are important in view of the discharge in the cavity due to strong electric fields at an extremely high power of GW or more. For moderate power level of MW or less, the discharge in the cavity may not be so serious problem. In order to overcome the manufacturing difficulties of sinusoidal corrugation, an alternative shape is studied in this project, i.e., rectangular shape. Rectangular corrugations can be fabricated more easily and may be accurately than sinusoidal corrugations.[1)]

By introducing an inner conductor into an open cavity of microwave souse, it is expected to increase the operation frequency and stabilize the electron beam propagation. Coaxial SWS in Fig.1 is composed of a hollow waveguide and an inner conductor and both of them are corrugated. The corrugations have a rectangular shape with average radius R_0, corrugation amplitude h, corrugation width d and periodic length z_0. The corrugation wave number is given by $k_0=2\pi/z_0$. In Fig.1, the phase difference θ between inner and outer corrugations is π. The dispersion characteristics may be controlled by changing R_0, h, d, z_0 and θ.[2)]

Figure 2 shows dispersion curves of coaxial cavity with parameters for a K band operation listed in Table 1 and θ=0. The inner conductor has a surface wave near its corrugation. This is an inner surface wave and is denoted ISW in Fig. 2. Note that the ISW can exist without the outer waveguide. The TM_{01} mode in Fig. 2 is an upper mode and is attributed to the outer corrugation. The TM_{01} mode is also a surface wave. For the parameters of Table 1, the distance between conductors $(R_{out}-h)-(R_{in}+h)$ is relatively large compared to the damping length of surface wave. And hence the inner and outer surface waves are rather isolated with each other. In such a case, θ has little influence on the dispersion characteristics.[3)] On the other hand, for non-oversized SWSs, θ has significant effects on the dispersion properties.[2)]

Table 1 Parameters of rectangular SWS

	R_0 [mm]	h [mm]	z_0 [mm]	d/z_0 [%]
Outer corrugation	15.1	1.1	3	50
Inner corrugation	8.4	1.1	3	50

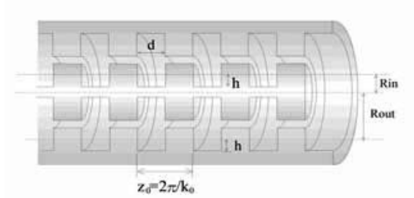

Fig.1 Periodically corrugated coaxial SWS with $\theta=\pi$. The average radius of inner corrugation is $R_0= R_{in}$ and that of outer corrugation $R_0= R_{out}$.

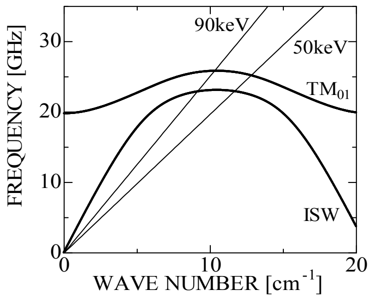

Fig. 2 Dispersion curves of K-band coaxial SWS with θ=0. The beam lines with 50 and 90 keV are also plotted.

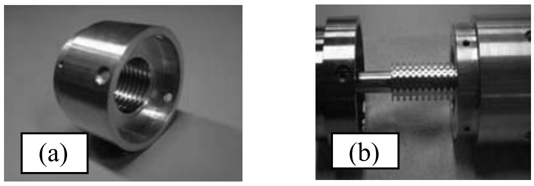

Fig.3 Periodically corrugated cavity; (a) corrugated hollow waveguide and (b) corrugated inner conductor.

We test rectangularly corrugated coaxial cavities with the parameters of Table 1. Figure 3(a) is one modular section including ten periods ($10z_0$). In the experiments, oversized hollow SWSs consist of two modular sections and the total length of corrugation is $20z_0$. Figure 3(b) shows the corrugated inner conductor with total length $20z_0$. Beam-particle interactions are expected at the Cherenkov and the slow cyclotron resonances. The microwave generations based on these interactions are studied experimentally and theoretically. And the inner and outer surface waves are confirmed.[3)]

1) K. Bansho, K. Ogura *et. al.*, Plasma Fusion Res. 5 (2010) S1049.
2) S. Abe, K. Ogura *et. al.*, *19th International Toki Conference on Plasma Physics and Controlled Nuclear Fusion* (December, 2009, Toki, Japan) P1-70.
3) H. Yoshimura, K. Ogura *et. al.*, *19th International Toki Conference on Plasma Physics and Controlled Nuclear Fusion* (December, 2009, Toki, Japan) P2-72.