§6. 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 the slow-wave 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/or the operating frequency, oversized SWSs have been used successfully. The term "oversized" means that the diameter D of SWS is 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 power in the range of hundreds of kW is obtained by using a sinusoidally corrugated cavity. 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 a 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.

Rectangularly corrugated cavity is shown in Fig. 1. Dispersion characteristics of the cavity are determined by the average radius R_0, corrugation amplitude h, corrugation width d and periodic length z_0. The corrugation wave number is given by $k_0=2\pi/z_0$. The dispersion characteristics of structure are controlled by changing R_0, h, d and z_0.

We design and test two types of rectangularly corrugated cavities.[1] Their parameters are listed in table 1. Note that the ratio of d/z_0 differs: 50 % for type A and 20 % for type B. Upper cut-off frequencies are about 25GHz for both types. Type A has dispersion characteristics parallel to the sinusoidal SWS and type B has dispersion characteristics which can be realized by using rectangular corrugation.

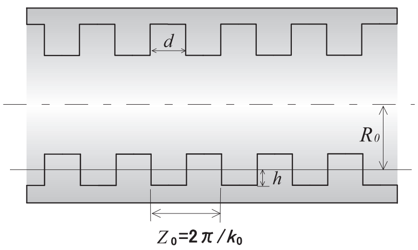

Fig.1 Periodically corrugated cavity.

Table 1 Parameters of rectangular SWS

	R_0 [mm]	h [mm]	z_0 [mm]	d/z_0 [%]
Type A	15.1	1.1	3	50
Type B	15.38	1.38	2.2	20

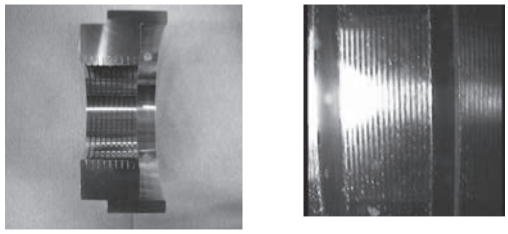

Fig. 2 Photographs of type B rectangular corrugation.

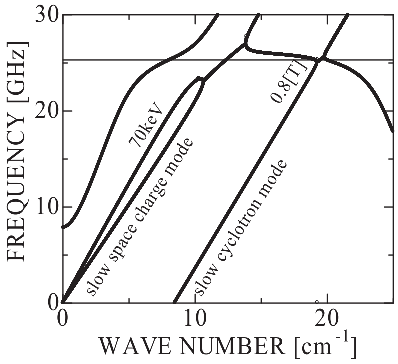

Fig. 3 Dispersion curves of type B cavity. The beam energy and current are 70 keV and 800 A, respectively.

In Fig. 2, photographs of type B corrugation are shown: a cross section (left) and an enlargement (right). The cavity consists of ten periods and is manufactured as one piece. The manufacturing accuracy is of the order of 0.01mm. Fine lines in the enlargement are grinding marks of the lathe cutting tool. The arithmetic mean roughness and the maximum height of roughness are about 1.6 μm and 6.3μm, respectively. The surface is sufficiently smooth for the K-band operations.

Figure 3 shows the dispersion characteristics of axisymmetric transverse magnetic (TM_{01}) mode for type B, including the beam effects based on a field theory with an infinitesimally thin annular beam.[2] The dispersion curve around the upper cut-off becomes very flat and this is the most remarkable feature of type B. According to Floquet's theorem, the dispersion curves of spatially periodic SWS are periodic in the wave number space. 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.[1,2]

1) K. Bansho, K. Ogura *et. al.*, *18th International Toki Conference on Plasma Physics and Controlled Nuclear Fusion* (December, 2008, Toki, Japan) P2-59.
2) Y. Takashima, K. Ogura *et. al.*, *International Congress on Plasma Physics 2008* (September, 2008, Fukuoka, Japan) EPP.P1-244.