高周波ジャイロトロンにおける熱陰極からの不要放出の抑制 Suppression of undesired emissions from a thermionic cathode in a sub-THz gyrotron

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Thermionic cathode is an important component of magnetron injection guns (MIGs) in high frequency gyrotrons [1, 2]. The emitter is made of porous tungsten which is impregnated with barium compounds. There are small spatial-gaps in order to thermally insulate the emitter from other elements of the cathode [3]. Such gaps should be closer to the emitter, otherwise undesired emissions will occur from high temperature areas other than the emitter owing to dispersion and adhesion of impregnated barium in the long term operations. However, those gaps deform the potential profile near the emitter, and degrade performances of the electron beams. In this study, two MIGs with different gap configurations were constructed to investigate the effect of those gaps on the electron beam and resultant oscillation characteristics. Each cathode was installed and tested in a 0.2-THz gyrotron, FU-CW-GIA [4].

Figure 1 shows two MIGs with different thermal insulation structures. In case of MIG-1, the thermal-insulation-gaps are placed apart from the emitter which is in contact with the non-emissive elements in both sides. The surface between two gaps is flat such that the electric potential is uniform in the vicinity of the emitter. The electron beam simulations with a computer-code EGUN predicted high-quality laminar electron-beams in a wide range of operation voltage $V_{\rm K}$, current $I_{\rm B}$ and velocity pitch-factor α up to -20 kV, 0.5 A and 1.3, respectively. The spreads in the velocity pitch factor $\Delta \alpha$ ($\equiv [\alpha_{max} - \alpha_{min}] / \alpha_{ave}$) in the cavity is no more than 5%. However, this structure will cause the undesired emissions due to the long-term deterioration. In such a situation, electrical breakdown can be induced in the MIG.

On the other hand, only the emitter is heated in case of Fig. 2 (MIG-2). This structure is more MIG-1 MIG-2



Fig. 1. Thermal insulation structures of two cathodes, MIG-1 and MIG-2.

preferable to prevent the undesired emissions. In addition, the heater loading can be extremely reduced. Nevertheless, the potential distributions are deformed near both sides of the emitter, from which electrons are extracted with a variety of initial velocities. As the result, the laminarity decreases and $\Delta \alpha$ increase significantly [5].

Oscillation tests of FU-CW-GIA were performed with the two MIGs under the same operating conditions. To evaluate the power variation owing to the velocity spreads, a calculated power ratio $P(\Delta \alpha)/P(0)$ was compared with the observed value of P_{MIG-2}/P_{MIG-1} for different V_K (Fig. 2). As predicted by the calculations, decreases in the power with MIG-2 were observed at lower $V_{\rm K}$. MIG-1 could be stably operated in wider region of parameters than that for MIG-2. When the oscillation became unstable with MIG-2, large amount of currents flowing into the anode was observed. It indicates the magnetic mirror reflection of a portion of electron beams. However, contrary to the high $\Delta \alpha$ of MIG-2, P_{MIG-2} was comparable to P_{MIG-2} at high V_{K} . This result suggests that reduction in the oscillation efficiency can be suppressed by optimizing the operating condition.



Fig. 2. Comparisons of the calculated (plotted with curves) and observed output powers (plotted with closed circles).

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