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高周波ジャイロトロンにおけるエミッタの熱絶縁と電子ビーム特性への影響
Influence of thermal-insulation structures for thermionic cathode on electron-beam characteristics in a sub-THz gyrotron

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Thermionic cathode is a critical component of magnetron injection guns (MIGs) which are widely used in electron tube devices including high frequency gyrotrons [1, 2]. The emitter is made of porous tungsten impregnated with barium compounds. There are small gaps in order to thermally isolate the emitter from the other elements of the cathode [3]. In this study, two kinds of MIG cathodes with different gap position arrangements were fabricated to investigate the effect of those gaps on electron beam characteristics. Each cathode was installed in a 0.2 THz gyrotron, FU CW GIA [4].

Figure 1 and 2 show the two types of MIG electrodes with different thermal insulation structures, and show electron-beam trajectories calculated with a computer code EGUN. In case of Fig. 1 (MIG-1), the thermal insulation gaps are placed a little bit 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 EGUN calculations predict generation of high-quality laminar electron beams in a wide range of expected operation voltage V_K, current I_B and velocity pitch-factor α up to -20 kV, 0.5 A and 1.3, respectively. The spreads in the velocity pitch-factor $\Delta\alpha$ is no more than 5%. However, this structure has also disadvantage that undesired emissions might occur from the high-temperature areas other than the emitter owing to dispersion and adhesion of impregnated barium from the emitter. In such a situation the beam quality is deteriorated, and electrical breakdown can be induced between the cathode and anode.

On the other hand, only the emitter is heated to high-temperature in case of Fig. 2 (MIG-2). This structure is more preferable from the view point of avoiding the undesired emissions and discharges for long term operations. In addition, the loads to the heater can be significantly reduced. However, distributions of the electric potential 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 $\Delta\alpha$ is estimated as several tens of percent.

Oscillation tests of FU CW GIA were carried out with the two MIGs under the same operating conditions. The output power with MIG-1 was approximately 10% higher than that with MIG-2. Moreover MIG-1 could be stably operated in wider regions of parameters as compared with those for MIG-2. At least in a short term operations, MIG-1 showed better characteristics than those of MIG-2. The potential distribution near the emitter in MIG-2 should be improved by optimizing the electrode shape in order to decrease the velocity spreads.

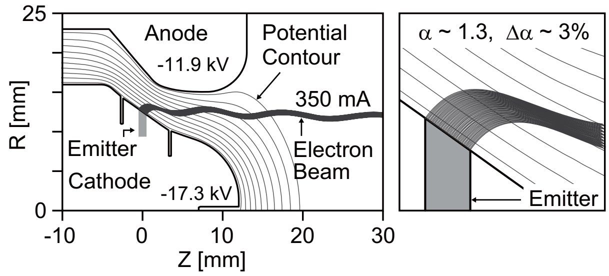

Fig. 1 (MIG-1) The thermal insulation gaps are placed a little bit apart from the emitter.

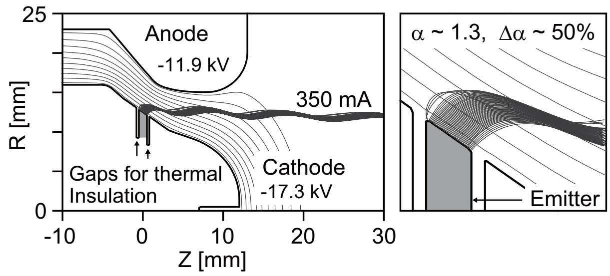

Fig. 2 (MIG-2) Only the emitter is isolated from the other parts of the cathode.

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