W-band Extended Interaction Oscillator based on a pseudospark-sourced electron beam

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The pseudospark discharge is a low-pressure gas discharge, capable of generating extremely high currents within short rise times by means of a hollow cathode structure. A high-quality, sub-millimetre diameter electron beam was generated during the discharge process which possesses a high current density and brightness. A pseudospark (PS) sourced electron beam did not require the use of an external guide magnetic field as the beam is self-focused by ion channel focusing. The PS electron beam was used to drive a W-band (75-110 GHz) Extended Interaction Oscillator (EIO). The EIO combines the merit of a short interaction length and is best suited to be driven by a small diameter, high current density electron beam. The pseudospark discharge is therefore an ideal cathode for an EIO. Experimental results presented will show that with a 35 kV discharge voltage, the EIO successfully produced W-band radiation pulses with 200 W peak power and 20 ns duration, agreeing well with the 3D Particle-in-Cell (PIC) simulations using MAGIC.

1. Introduction

A pseudospark (PS) is an axially symmetric, self-sustained, transient, low pressure (typically 50–500 mTorr) gas discharge in a hollow cathode/planar anode configuration, which operates on the low pressure side of the hollow cathode analog to the Paschen curve [1]. The production of higher current-density electron beams, compared to thermionic cathodes, from a pseudospark discharge has been convincingly demonstrated [2]. The current density of a pseudospark-sourced electron beam can achieve ~1kA/cm^2 [3], which enables a wide range of applications in generating millimetre and terahertz radiation.

2. Experimental results

A four-gap pseudospark discharge chamber was used which can hold-off a discharge voltage of up to 40 kV, was connected to a W-band EIO, fig 1.

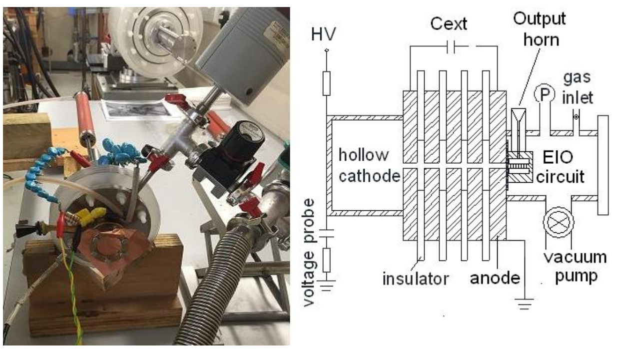

Fig. 1. Experimental setup of the W-band EIO based on a pseudospark-sourced electron beam and the schematic drawing of the experiment.

The discharge voltage was swept from 38 kV to 25kV to achieve the maximum output power. The peak power of the radiation was measured to be 200W. The output frequency was measured to be ~94GHz.

3. Conclusion

The pseudospark-sourced electron beam which is focused by the positive ion channel generated from the pseudospark discharge process was successfully used to drive a W-band EIO circuit to generate coherent radiation. The background unmagnetized plasma can be considered as a dielectric media with a dielectric constant of $\varepsilon_r=1-\omega pe^2/\omega^2$. As the operating frequency is far away from the plasma frequency the plasma would have negligible effect on the output power of the EIO. As the current density of the pseudospark-soured electron is much higher than a thermionic electron beam, it is an excellent electron beam source to drive a pulsed EIO circuit operating at higher frequencies with reasonable high radiation power.

3. References

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