APPLICATIONS OF PSEUDOSPARK PRODUCED ELECTRON BEAMS IN BACKWARD WAVE OSCILLATORS

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***Abstract*— Pseudospark electron beams have been studied recently with their application to millimetre-wave and terahertz radiation generation. To this end, backward wave oscillators (BWO), a form of vacuum tube which utilises the interaction between an axial electron beam and a slow-wave structure has been designed and modelled using the particle-in-cell code MAGIC and VORPAL. Millimetre radiation has been generated from a BWO driven by a 14-gap pseudospark discharge. The investigation of a higher frequency BWO at 200 GHz will also be presented.**

I. INTRODUCTION and BACKGROUND

There is an increasing demand for millimetre-wave and terahertz radiation. This leads to the desire for development of lower-cost, reduced size sources, for which the BWO is a possibility as it offers a wide variety of advantages. These include tuneablity, compactness and they do not require any form of RF input, a feature which reduces bulk and cost. BWOs operate via the synchronism between the space-charge wave of an electron beam and the lower eigenmode of a slow-wave structure. Slow-wave structures may be of various configurations, for example an axially- or sinusoidally-rippled waveguide, or through the lining of a waveguide with a dielectric material.

In order for a BWO to act as an efficient generator of radiation, a high quality electron beam is necessary. Explosive emission cathodes have been used as an electron beam source in high power microwave experiments[1] which are capable of generating high current densities but the electron beam quality can be limited[2]. A pseudospark (PS) has been proven to be a very promising electron beam source[3,4,5]. During a PS discharge, low temperature plasma is formed acting as a copious source of electrons and can be regarded as a low work function surface that facilitates electron extraction[6,7,8,9]

II. Results

A BWO slow wave structure in the W-band region excited by an annular 100 kV, 25 A electron beam was simulated using MAGIC-3D. BWO experiments were configured using a 14-gap PS discharge chamber powered by a cable pulser capable of producing 120 ns duration and 170 kV voltage pulses. The cable pulser can produce a nominal four times multiple of its charging voltage from a dc power supply when the load impedance is much larger than its characteristic impedance of 200 Ω (fig 1). The pseudospark discharge was initiated by the application of a 20kV pre-trigger pulse to the hollow cathode region of the pseudospark chamber. Careful adjustment of two delay units ensured the initiation of the pseudospark discharge was followed by the generation of the voltage pulse by the cable pulser with both time correlated to produce an electron beam.

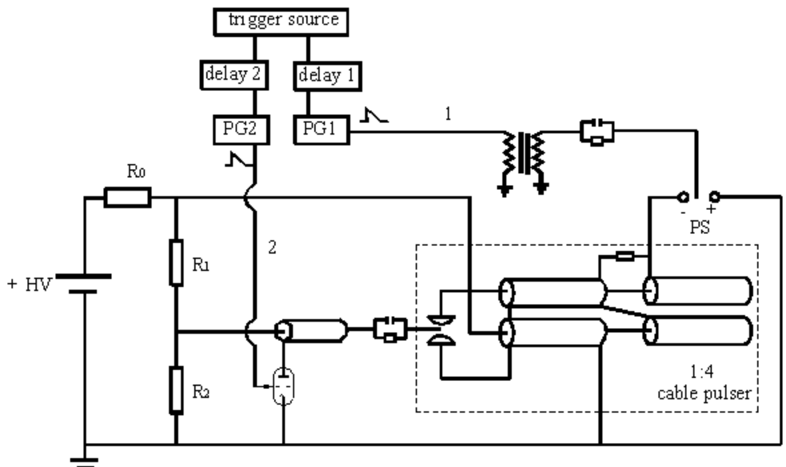

Fig 1 Trigger system for the pseudospark powered by a cable pulser.

The 14-gap pseudospark discharge chamber was designed and constructed to generate electron beam pulses of energy as high as 170keV as shown in figure 2.

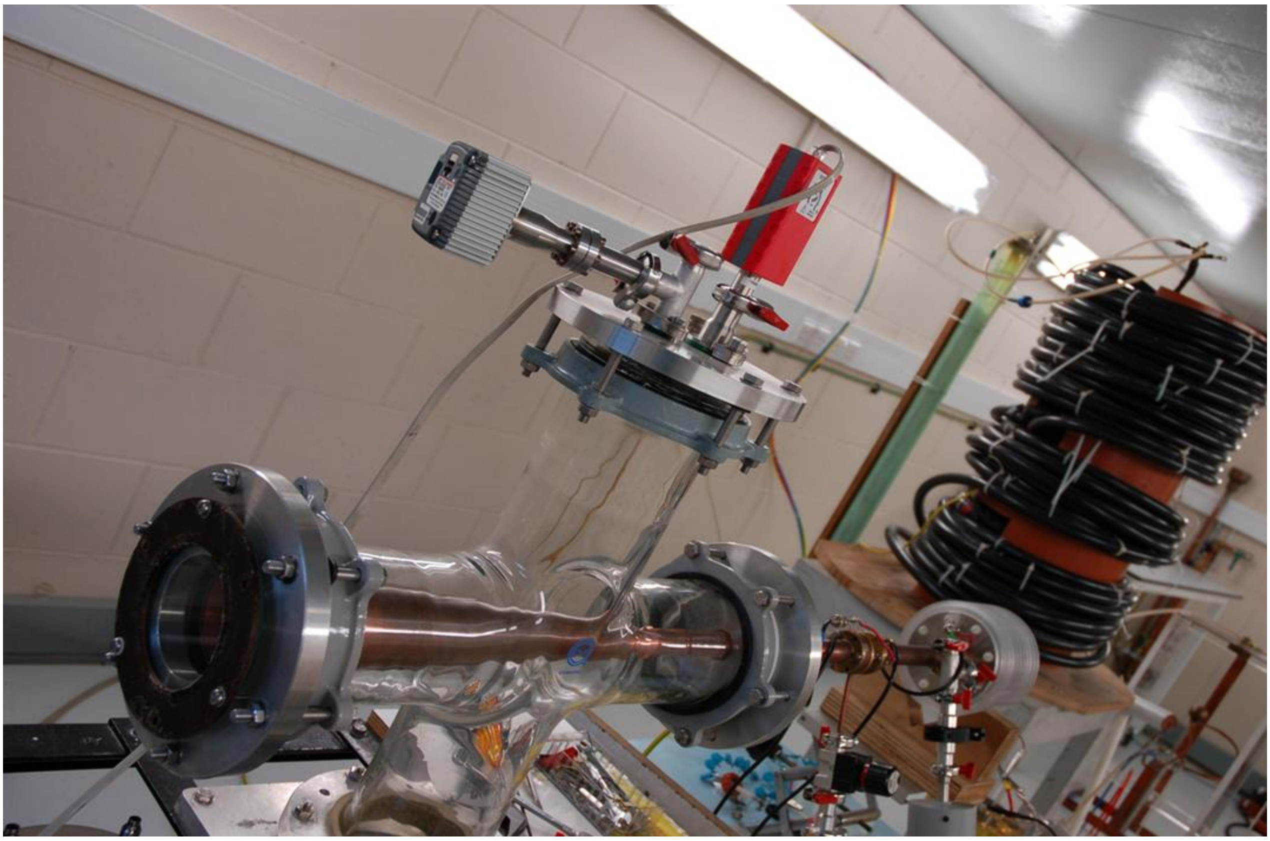

Fig 2 Experimental setup of a W band BWO driven by a 14-gap PS discharge

In the beam-wave interaction region, a copper backward wave oscillator (BWO) slow wave structure was used for the BWO experiments. The Backward Wave Oscillator interaction region consisted of a 28mm long corrugated copper structure of mean radius 3.75mm, period 1.75mm and depth 0.375mm as shown in figure 3.

Fig 3 67GHz BWO Interaction region

The BWO interaction region was manufactured by machining a positive aluminium former and chemically depositing a 3mm thick layer of copper on the aluminium former, which was later dissolved away in an alkali solution. The microwave launching horn was located just downstream of the interaction region. The resultant microwave pulse was detected using a W-band detection system located downstream of the BWO output and electrically isolated. Fig.4 shows the detected time-correlated millimetre wave pulse which has a measured frequency above 67GHz from the BWO with the electron beam current measured using an in-line Rogowski coil and the voltage measured using a fast (<15ns), high impedance, voltage divider[10]. The experiment shows that the PS BWO is a very promising source for the generation of high frequency radiation[11].

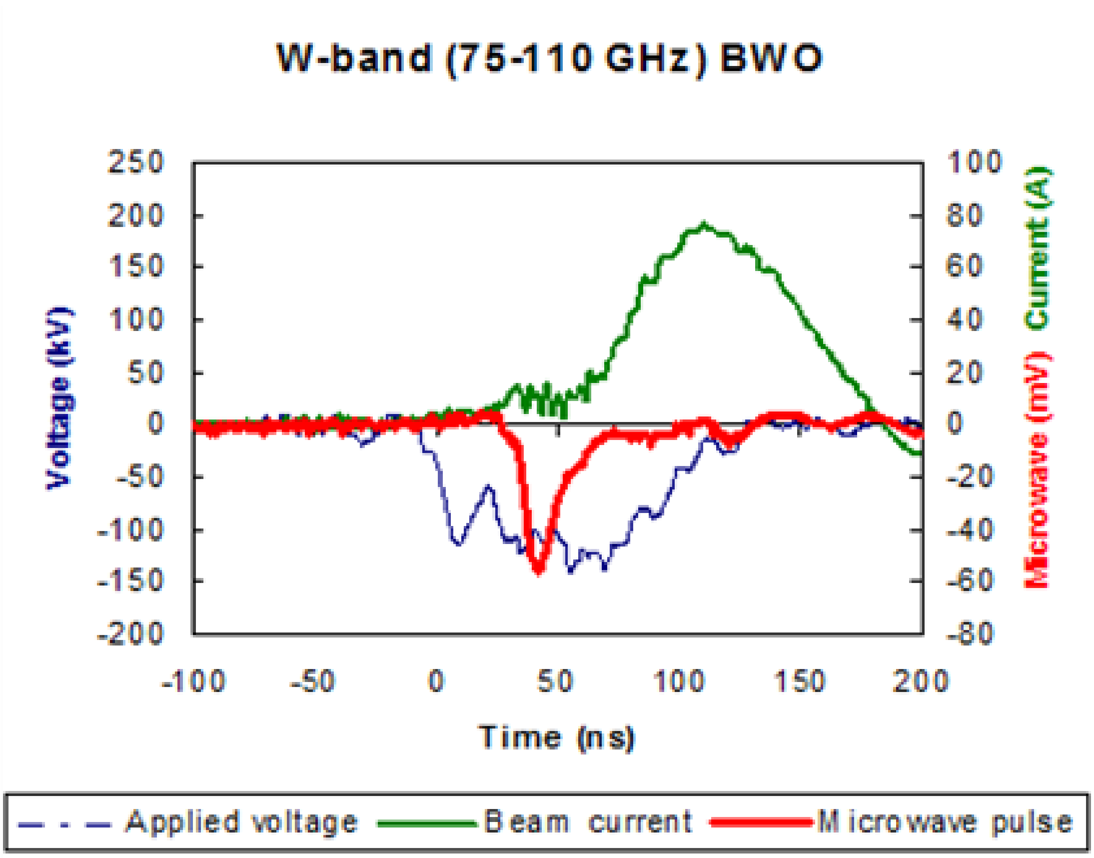

Fig 4 Time-correlated electron beam pulse, applied voltage pulse & mm-wave pulse from the W-band BWO

III. Conclusion

The unique electron beam pulses generated by a pseudospark discharge were used to generate coherent, millimetre wave radiation from a Backward Wave Oscillator with microwave radiation above 67GHz measured. A pseudospark discharge is a very promising electron beam source for use in the generation of high frequency radiation. As the frequency increases it becomes increasingly difficult (if not impossible) using conventional cathodes to focus and form high current density, high quality electron beams through the small size interaction region of the THz maser. To demonstrate the scaling down of the size of the pseudospark beam the discharge chamber was re-configured to generate sub-mm diameter electron beam pulses, which were then propagated down the beam-wave interaction region of a high frequency (200GHz) Backward Wave Oscillator. Particle-In-Cell code numerical simulations and recent measurements from this higher frequency 200GHz BWO experiment will be presented.

ACKNOWLEDGMENT

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