Analysis of Beam-Wave Interaction in Plasma Assisted BWO

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Abstract: *Plasma assisted devices are unique source for microwave radiation. This paper presents the simulation results of beam-wave interaction in rippled waveguide SWS for plasma assisted BWO.*

Keywords: BWO, rippled waveguide, plasma, SWS, PCE gun.

Introduction

The Plasma assisted BWO uses a unique plasma-cathode electron (PCE) gun and plasma filled slow-wave structure (SWS) to produce efficient microwave radiation [1]. In such plasma filled microwave sources where the electron beam's two dimensional motion provides better coupling which is responsible for efficient operation. In conventional tubes (without plasma) the beam space charge forces play a destructive role in the beam transport. However in plasma assisted microwave sources, it is largely compensated by the presence of ions in plasma. The electron beam propagates in the ion-focusing regime (Bennett pinch) [2], so the requirement of external magnetic field is eliminated. Hence in turn it also results in efficiency enhancement**.** As the plasma formation is not closer to the accelerating anode, higher beam current operation can be achieved easily. These devices are capable of producing coherent radiation in the centimeter and millimeter wavelength regimes at a power level of hundreds of megawatts with efficiency close to 60%.

A single gap Pseudospark based plasma cathode electron gun has been developed in CEERI. A pseudospark discharge is a viable possibility due to the emitted linear beam's characteristic properties such as, high current density and high brightness as well as self-focusing during its propagation [3]. During a pseudospark discharge, low temperature plasma is formed as a copious source of electrons and ions and can be regarded as a low work function surface that facilitates electron or ion extraction by applying voltages of different polarities. This plasma electron gun (40kV, 100A) will be used as electron beam source for plasma filled BWO.

Design of rippled SWS

The SWS has been taken as rippled wall cylindrical waveguide having radial profile given by $R(z) = R_0 + h \cos(k_0 z)$, where R_0 is the mean radius, h is the rippled height and $Z_0 = 2*pi/k_0$ is the spatial periodicity. Attempts have been made for designing the slow wave interaction structure for X-band using MAGIC (Fig.1 and Fig. 2) and OOPIC-Pro. The optimization has been carried out for rippled waveguide structure by varying different structural parameters. Finally SWS has been designed using MAGIC code having following dimensions.

$R_0 = 1.65cm; h=0.3cm; pitch=1.5cm.$

By using above dimensions, the simulation has been carried out using OOPIC-Pro where we can create plasma inside the SWS and analyze the plasma profile.

Result and discussion

In this paper the results of simulation which has been done using MAGIC code have been presented. This work has been used for further analysis of beam profile in interaction region using OOPIC-Pro. The electron density is found to be ranging between 1e14 per m^3 and 1e15 per m^3 in interaction region as shown in fig (3) while ion density is ranging between 1e13 per m^3 and 6e14 per m^3 as shown in fig (4) which is satisfying the essential condition for plasma formation. Axial electric field is varying periodically as shown in fig (5). From fig.(2) we are getting central frequency as 8.0699GHz which is desirable result.

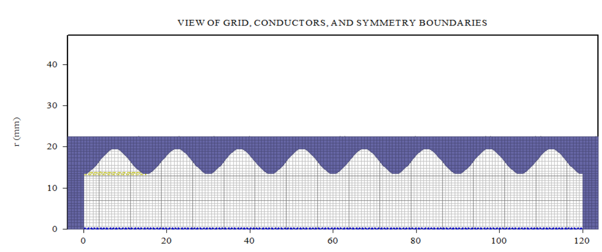

Figure 1. Design of rippled structure for X-band.

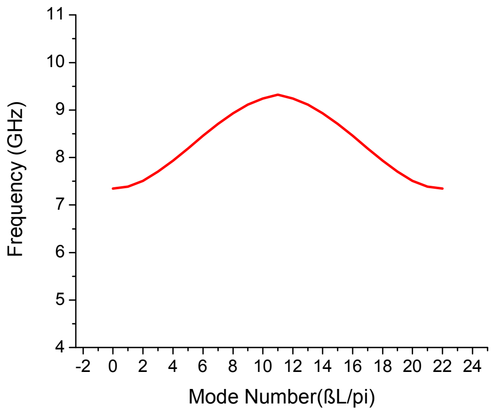

Figure 2. Dispersion diagram.

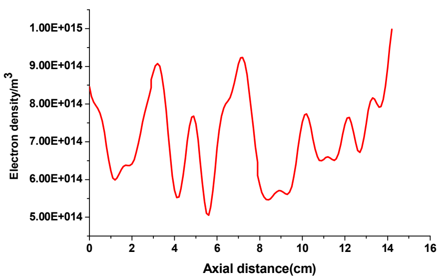

Figure 3. Electron density vs axial distance in interaction chamber.

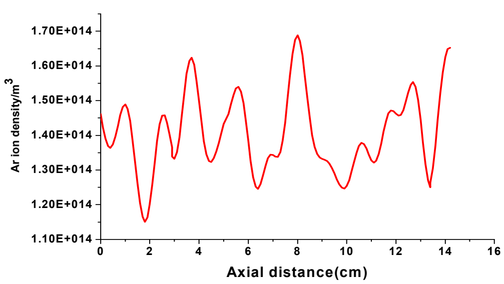

Figure 4. Argon ion density vs axial distance in interaction chamber.

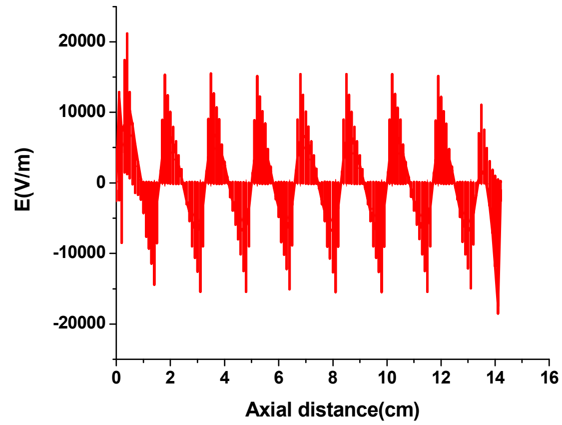

Figure 5. Axial electric field.

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