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A Novel Pseudospark Sourced High Current Density (~1kA/cm^2) Sheet Electron Beam Source and its Diagnostics

Niraj Kumar[1], U.N. Pal[1] and Ram Prakash[1]

[1] CSIR-Central Electronics Engineering Research Institute (CSIR-CEERI) Pilani, Rajasthan-333031

The pseudospark discharge is a cold cathode discharge and is recognized as a class of discharge capable of producing round shaped electron beams with the highest combined current density and brightness than that of any other known type of electron sources [1]. However, such round shaped electron beams have their own limitations as compared to sheet-electron-beam especially in high frequency microwave sources due to space charge effect [2]. In fact, a sheet beam is not stable while propagating through a uniform magnetic field due to E x B velocity shear effect [2].

In this work, we report a novel sheet beam source based on pseudospark discharge for the generation of high current density (~1kA/cm^2) sheet-electron beam and its successful propagation for more than 190 mm without any assistance of external magnetic field, maintaining its sheet structure, inside the plasma filled drift space region [3]. During its propagation, the deviation from its original size of 7 mm X 1 mm is experimentally found less than ~23% along the longer side while along the shorter side it is ~20%. The propagated sheet-electron-beam has been characterized using two different diagnostic methods. In the first method, a simple technique has been developed as focusing and defocusing point estimations inside the drift space region while other diagnostic technique based on dielectric charging and the SEM based imaging has also been developed. The later technique is able to provide the exact shape and size estimations of the sheet-electron-beam. The typical image of the generated sheet-electron beam is shown in figure 1. The images of the sheet-electron beam inside the drift space region obtained from experiments have been compared with the particle-in-cell (PIC) simulation results using VSim 6.2 code. A close agreement between the experimental and simulated sheet-beam size occurs which has helped in determining certain useful plasma parameters, such as, ion density at the envelop of the sheet electron beam, space charge neutralization time, and secondary electron temperature, simultaneously, which is a difficult task by experimental means [4]. The generated current density of sheet-electron beam is ~4 times higher than that of the cylindrical electron beam under similar operating conditions [5]. The high current density of the PS generated sheet-electron-beam will be an advantage when exciting very small cavities and planar interaction structures for high frequency vacuum microelectronic devices especially in THz regime.

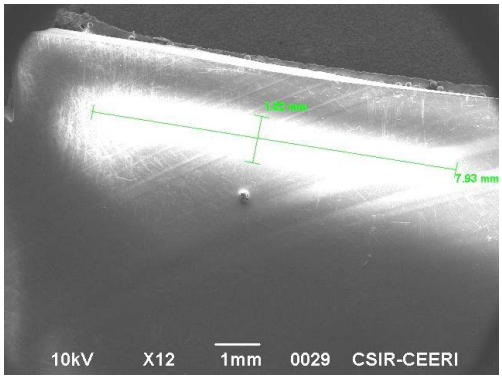

Figure1: Sheet-electron beam image measured experimentally (7.93 mm × 1.02 mm) at V = 17 kV, P = 11 Pa, and Z = 143 mm

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