CHARACTERISTICS OF ELECTRONS IN THE BEAM GENERATED IN DENSE PLASMA FOCUS DEVICE

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Abstract

The characteristics of electron beam produced by Dense Plasma Focus (DPF) device have been investigated with the help of Faraday cup. The electron signals have been analyzed to estimate time resolved electron energy and electron number density.

1. Introduction

The Dense Plasma Focus (DPF) is a pulsed plasma producing device that produces a high temperature and high density plasma for short duration. Besides, being a source of high fluence neutrons and X-rays, it is an efficient accelerator of ions and electrons with ion energies upto several hundred keV and above. Fast ion beams [1-3] and electron current signals [2,4,5] emitted from DPF have been investigated in the past by using different diagnostic techniques. In the present paper we have obtained the electron current signals by using Faraday cup technique. The electron energy and electron number density have been estimated from these signals.

2. Experimental setup and method

The DPF device at our laboratory is a 3.3 kJ Mather type focus (Fig 1). Essentially it comprises of an electrode assembly consisting of a central hollow copper anode surrounded by six axially symmetric copper cathode rods, a capacitor bank, a high voltage charger and a triggering electronic system. Details regarding the device are reported elsewhere [6,7]. This device is powered by a single 30 μF, 15 kV fast discharging energy storage capacitor. The gas breakdown occurs initially across the surface of insulator. The resulting plasma sheath accelerates towards the top of the anode by $j_r B_\theta$ force. Upon reaching the open end of the anode, the sheath pinches radially because of the $j_z B_\theta$ force. Subsequently the enhanced electric field due to the onset of m=0 instability during the focus phase, accelerates the electrons towards the anode in the downward direction and ions in the opposite direction towards the top of the DPF chamber. The device is operated at the pressure of 80 Pa of argon and at 14 kV of charging of the capacitor. The electrons are collected at the bottom of the

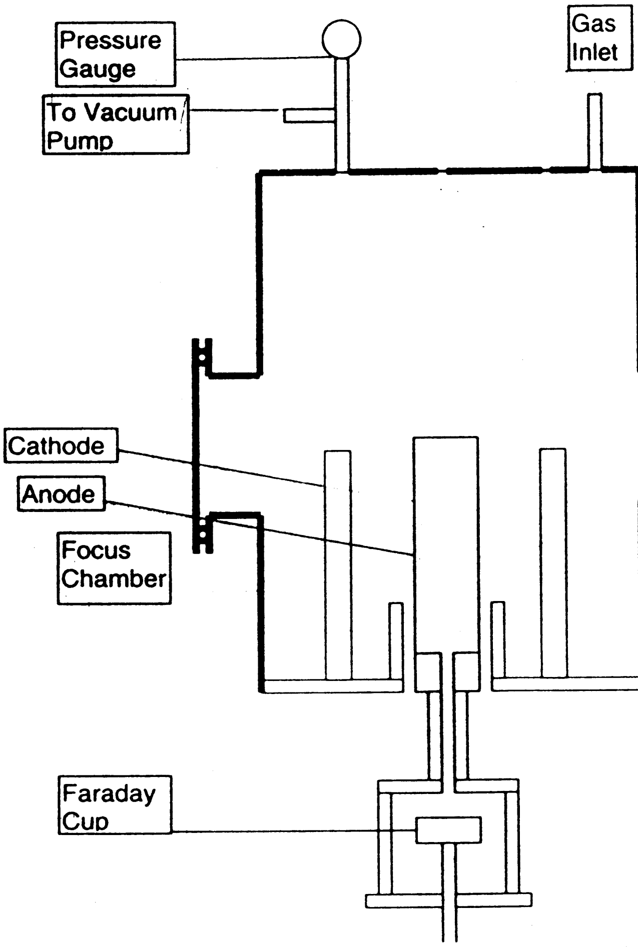

Figure 1: Schematic of experimental setup

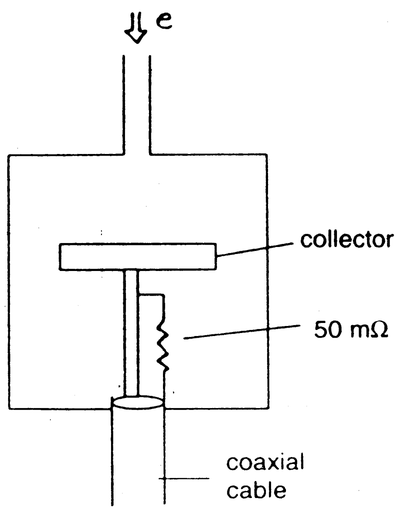

Figure 2: Schematic of faraday cup

anode through the hole in the anode. The electron collector which we have used for current measurement is shown in Figure 2. The electron collector consists of a copper disc of 3.0 cm diameter which is connected to the ground through a 50 mΩ resistor. The voltage develop across this resistor is fed to TDS 784 digitizing oscilloscope to record the electron current signals. One of these signals is shown in Figure 3.

3. Results and Discussion

Electron signals that are obtained on the oscilloscope have been found to always have four to five dominant spikes. The magnitude of the first peak of electron pulse is always smaller than the next electron peak. It has also been seen that the second or the third peak of electron pulse is of highest magnitude. It is also observed that in the tail region, there occurs a periodic structure. The first spike of electron current signal appears after about 40 ns from the start of

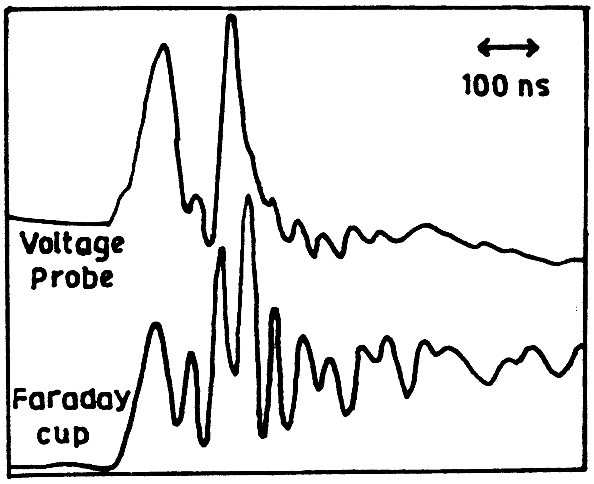

Fig. 3. Oscilloscopic trace of typical electron current signal

spike in the voltage probe signal. It can be explained in the following manner. Beginning of radial collapse phase, when the plasma reaches the top of the anode, the anode being at positive potential attracts electrons towards itself and ions in the opposite direction. The electrons are collected by the collector which is placed at the bottom end of the anode which is about 32.5 cm from the top of the anode.

Number density of electrons n, having velocity v and charge e, has been estimated at different instants using relation n=V/(RevA). Where V is the voltage developed across resistor R (50 mΩ) at different time instants. The velocity v of the electrons, at different time instants, has been calculated using time of flight of electrons to from the top of the anode to the electron collector which is estimated from voltage probe and faraday cup signals. The time history of electrons kinetic

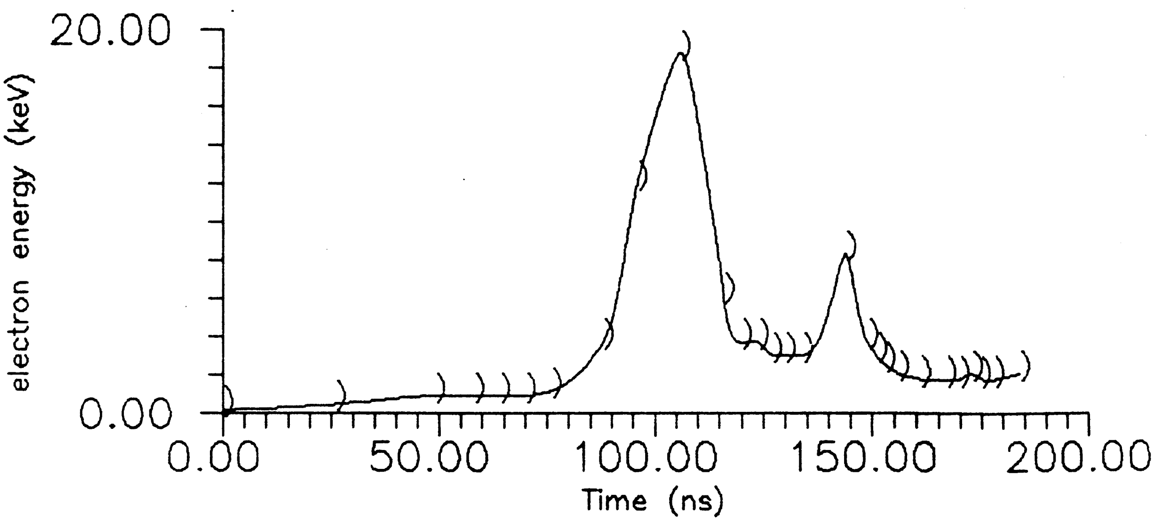

Fig. 4. *Characteristic curve of time resolved electron energy*

energies and electron number densities are given in Figure 4 and 5 respectively. In both the figures the time instant t=0 refers to the time of starting of the first voltage spike on the voltage probe signal. The estimation of electron energies and number densities are provided only for the first two spikes on the voltage probe signal. The peak electron energy is about 18.8 keV which occurs at the timing instant of first peak on voltage probe signal i.e. about

112 ns after t=0. The peak number density of electrons has been estimated to be approximately 1.4×10^{17} m^3 which occurs about 76 ns after t=0.

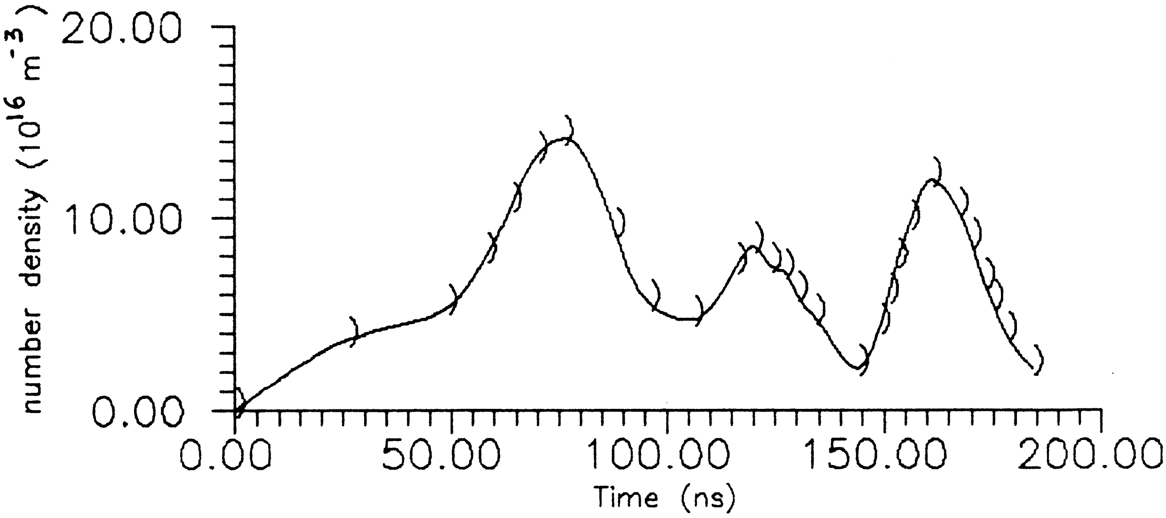

Fig. 5. *Characteristic curve of time resolved electron number density*

5. Conclusion

The electron current signals have been obtained with the help of faraday cup. These signals are then used to provide the time resolved estimates of the electron energies and number densities.

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References

[1] R.L. Gullikson and H.L. Sahlin: J. Appl. Phys. **49**, 1099 (1978).

[2] W. Stygar, G. Gerdin, F. Venneri and J. Mandrekas: Nucl. Fus. **22**, 1161 (1982).

[3] R.S. Rawat and M.P. Srivastava: *Seventh Int. Conf. on Emerging Nuclear Energy Systems*, ed. Hideshi Yasuda, World Scientific Pub. Co., Singapore, 248 (1993).

[4] J.R. Smith, C.M. Luo, M.J. Rhee and R.F. Schneider: Phys. Fluids **28,** 2305 (1985).

[5] P. Choi, C. Deeney and C.S. Wong: Phys. Lett. A **128**, 80 (1988).

[6] J.W. Mather: Phys. Fluids **7**, 5 (1964).

[7] S. Lee, T.Y. Tou, S.P. Moo, M.A. Eissa, A.V. Gholap, K.H. Kwek, S. Mulyodrono, A.J. Smith, W. Usada and M. Zakaullah: Am. J. Phys. **56**, 62 (1988).