

**ENHANCEMENT OF THE ION BEAM EMISSION IN A  
LOW ENERGY PLASMA FOCUS**

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**FACULTY OF SCIENCE  
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**ENHANCEMENT OF THE ION BEAM EMISSION IN A  
LOW ENERGY PLASMA FOCUS**

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## ABSTRACT

The characteristic of the plasma focus device as efficient source of ion beam generation as well as X-ray source is particularly an appealing subject of study. In this work, we optimized a plasma focus to work at low pressure as an ion beam source. The plasma focus used is of Mather type which is powered by a low inductance capacitor (15 kV, 30  $\mu F$ ). At the discharge voltage of 15 kV, maximum energy supplied to the system is 3.3 kJ.

The primary objective of the current project is to find an optimum condition for ion beam production in deuterium filling. The geometry of the electrodes employed is meant for low pressure operation. Experiments are conducted with deuterium as the working gas at pressure of less than 1 mbar. Operation at this low pressure regime is found to produce much more significant ion beam than at normal pressure of several mbar. The axial current sheath velocity of up to 10 cm/ $\mu s$  is achieved, which is near to the speed limit recommended for good focusing discharge. Intense focusing discharge with good reproducibility has been obtained at operating pressure in the range of 0.05 – 0.5 mbar.

The energy of the ion beam has been determined using time of flight technique by employing three biased ion collectors installed at the end on direction. Intense ion beam emissions with good reproducibility have been obtained. Optimum operating pressure for the ion beam production is around 0.1 mbar, where the average ion beam energy registered was 80 keV. The average total deuteron flux per shot is estimated to be  $2.1 \times 10^{18} \text{ cm}^{-2}$  at 0.1 mbar. The deuteron beam with average energy for the pressure of 0.05 – 0.5 mbar was determined to be in the range of 25 – 80 keV. Correlation of ion

beam and X-ray emission as well as other discharge parameters with operating pressures has been investigated.

X-ray emission was measured by a filtered 5-channel windowless BPX-65 photodiode array. Soft X-ray production from the plasma focus was also found to be pressure dependent and exhibit similar trend to the ion beam emission. The highest X-ray emission is also observed at pressure of 0.1 *mbar* which implies that high temperature plasma column has been formed. A reliable plasma focus device with consistent high production of ion beam or X-ray emission could be used as ion beam source or light source in various technological fields.

## ABSTRAK

Ciri-ciri peranti plasma fokus untuk digunakan sebagai sumber alur ion atau sinar-X merupakan subjek penyelidikan yang menarik. Dalam projek ini, plasma fokus dioptimumkan untuk beroperasi pada tekanan rendah sebagai sumber aruh ion. Peranti plasma fokus jenis-Mather dicaskan dengan menggunakan satu kapasitor (15 *kV*, 30  $\mu F$ ) yang beraruhan rendah. Nyahcas pada voltan 15 *kV*, membekalkan tenaga maksimum sistem sebanyak 3.3 *kJ*.

Objektif utama projek ini adalah untuk menentukan keadaan optimum untuk pengeluaran aruh ion bagi deuterium gas. Geometri elektrod yang digunakan bertujuan untuk operasi pada tekanan rendah. Eksperimen dijalankan dengan menggunakan deuterium gas pada tekanan kurang dari 1 *mbar*. Operasi pada tekanan yang rendah menghasilkan aruh ion yang lebih ketara berbanding dengan tekanan biasa pada beberapa mbar. Halaju paksi arus keratan sehingga 10 *cm/μs* boleh dicapai dimana masih di dalam lingkungan had laju lebih tinggi untuk nyahcas fokus yang baik. Nyahcas fokus yang amat kuat dan boleh berulang telah diperolehi pada tekanan operasi dalam julat 0.05 - 0.5 *mbar*.

Tenaga aruh ion ditentukan dengan menggunakan teknik masa penerbangan yang dikesan oleh tiga pengesan ion dipincang yang diletakan pada hala tuju hujung. Pengeluaran aruh ion yang beramat dengan kebolehulangan semula yang baik telah diperolehi. Tekanan operasi yang optimum untuk penghasilan aruh ion didapati pada 0.1 *mbar* di mana tenaga purata aruh ion yang diperolehi ialah 80 *keV*. Jumlah purata fluks deutron per nyahcas yang dianggarkan adalah  $2.1 \times 10^{18} \text{ cm}^{-2}$  pada 0.1 *mbar*. Tenaga purata aruh ion pada tekanan antara 0.05 – 0.5 *mbar* telah dianggarkan dalam

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Pancaran sinar-X telah dikaji-selidik dengan menggunakan 5 saluran fotodiod BPX-65 bertapis. Pengeluaran sinar-X lembut juga didapati bergantung kepada tekanan dan menunjukkan aliran yang serupa dengan pengeluaran aruh ion. Pengeluaran pancaran sinar-X tertinggi juga diperhatikan pada tekanan 0.1 *mbar* menandakan suhu plasma yang tinggi telah dicapai. Peranti plasma fokus yang boleh menghasilkan aruh ion dan sinar-X yang tinggi dan tekal dipercayai boleh digunakan sebagai sumber aruh ion atau sumber cahaya dalam pelbagai bidang teknologi.

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