UPGRADED IR-IECF DEVICE AS A PROMISING COMPACT SOURCE FOR THE FUTURE NUCLEAR FUSION RESEARCH

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The compact fusion sources are mostly considerable because their high efficiency in producing high energy particles and rays. Inertial Electrostatic Confinement Fusion (IECF) device is one of the tabletop fusion sources capable of producing neutrons, X-rays, protons, etc [1]. Therefore, the portable sources based on the IECF concept provide a wide dimension of fusion-based applications. Some of promising applications of these sources are medical isotope production, x-ray and neutron radiography [2], boron neutron capture therapy (BNCT) [3], neutron activation analysis (NAA) [4], explosive detection, plasma propulsion system and security screening.
In IECF, basically, the fuel ions are trapped and accelerated for reaching the fusion reactions into the cylindrical or spherical electrodes due to the converging electrostatic field inside the electrodes which is produced by applying a high voltage to the electrodes. Iranian Inertial Electrostatic Confinement Fusion (IR-IECF) device is a compact IEC-based source for plasma confinement and fusion research [5-6]. In this device the nuclear fusion reactions then takes place due to the high temperature and frequent collision of ions and the bombardments of the ions and background atoms by the accelerated ions.
In this synopsis the upgraded Iranian Inertial Electrostatic Confinement Fusion (IR-IECF) device as a tabletop fusion source is introduced. In upgraded IR-IECF device, a gird with new geometry was designed and also to prevent overheating of the central electrode, a cathode electrode with cooling capability along with a new connected high voltage feedthrough was installed in the device which prevents the melting of the inner electrode at high powers. Moreover, to investigate the properties of the plasma formed in the upgraded IR-IECF device, a Langmuir probe diagnostic system was constructed and installed on device to measure the plasma parameters.

1. UPGRADED IR-IECF DEVICE

1.1. Electrodes with new geometric and cooling system

A new spherical grid and also a cylindrical grid have been designed and constructed in upgraded IR-IECF. In Fig.1, the upgraded IR-IECF device and constructed cylindrical grids have been shown. In this device, the cathode as the central electrode is negatively high-voltage-biased and the anode as the outward electrode is grounded. The strong electric field between electrodes causes the filling gas to ionize and then accelerate the glow discharged-generated ions toward the center resulting in formation the hot and dense plasma in the center of the device. The created ions are confined in the electrostatic potential well formed between the electrodes. The nuclear fusion reactions occur due to the collisions of the ions and bombardments of the ions and background atoms by the accelerated ions.

Fig.1. (a) upgraded IR-IECF device and (b) the electrodes in cylindrical geometry

As in this configuration the central electrode is exposed to high energy ions, it suffers from high temperature and may get melted. This causes the stable operation of device to being not possible for long term particularly at high powers. Therefore, a new actively cooled cathode with a new high voltage feedthrough has been designed and constructed. For cooling of the electrode the deionized water is used to prevent high voltage breakdown. This new electrode leads to the excellent heat removal at high powers and also to improvement of the effective operation time of the device.

1.2. Plasma diagnostic

A Langmuir probe diagnostic system was designed and constructed to measure the plasma parameters in upgraded IR IECF device. The probe was installed on device so that its electrode was in direct contact with the plasma formed in the upgraded IR-IECF device. By applying voltage to the probe electrode, the current drawn from the probe is measured. Then, by interpreting the extracted current-voltage (I-V) characteristic curve, the plasma parameters such as electron temperature, electron and ion density and plasma potential were determined in different conditions of discharge voltage and current. Fig. 2(a) and 2(b) indicates the variation of electron temperature versus the discharge voltage and the plasma potential versus the discharge current in upgraded IR-IECF device, respectively.

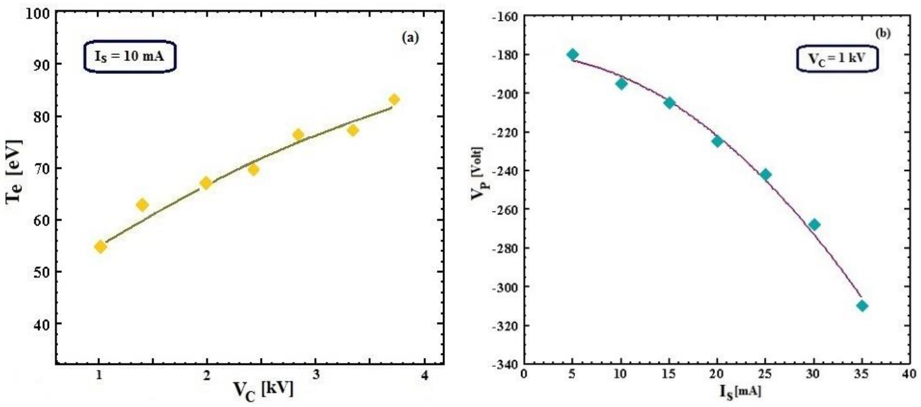

Fig.2. (a) electron temperature versus the discharge voltage and (b) the plasma potential versus the discharge current.

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