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Studies of High Speed Plasma Stream Generated from a Pulsed Plasma Accelerator

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Application of powerful plasma streams has drawn great interest among researchers and investigations under way on different types of plasma accelerators varying in the plasma life, input energy, device size and pulse repetition rate etc. A relatively longer duration (pulse time in the range of ms) pulsed plasma with power density in the range of GW/m^2 is one of the interests for many fields of applications including ITER. This type of pulsed plasma may mimic the damages caused by plasma instabilities like edge-localized mode (ELM) that exist in the millisecond time scale in tokomak reactor. A pulsed plasma accelerator (PPA) is nothing but two coaxial electrodes system that needs power and gas supply for production of plasma stream. The basic design concept for relatively longer duration steady plasma stream production from plasma accelerator is taken from the Morozov's theory [1]. The present PPA is powered by a 200 KJ capacitive pulsed power system (PPS) with a peak discharge current of 100 kA for a time period of 1 ms. The first half time period of the discharge pulse is assumed as the lifetime of the plasma stream from the PPA. The capacitive bank energy of the PPS is transferred to the PPA through ignitron switches. The use of ignitrons in a PPS has been found to be advantageous in some aspects during the development of PPS while it is also observed that ignitron demands maintenance of some critical conditions for smooth operation. The observed performance of the ignitron has also presented in the report. To sustain a plasma stream for the whole duration of millisecond electrical pulse, a continuous supply of gas in between the electrodes is required during the pulsing time. An electromagnetically actuated gas injection valve (GIV) supplies the required gas in the millibar range of filling pressure to sustain the plasma beam during first half time period of the sinusoidal discharge current pulse. The plasma thus produced has been characterized using different diagnostics. The parameters like density and temperature of the plasma beam were measured using Triple Langmuir probe (TLP) for argon and nitrogen plasma. Plasma density is found to be of the order of 10^{21}/m^3 and the electron temperature, of the order of a few eV [2]. The velocities of the plasma beams have also been measured using double plate probe and it is found to be several km/s for argon and nitrogen plasma beams. The heat load associated with the beam has been measured using a thermocouple based calorimeter system and the associated dumped heat energy density of the plasma beam is found to be of the order of a few hundreds of KJ/m^2. As an initial test, the high velocity nitrogen plasma beam, fired at 10 kV discharge voltage, has been allowed to impact on SS304 metal surface for 10 numbers of exposure. The plasma exposure of the SS surface is found to generate great changes to the surface layers like infliction of cracks, melt layer formation and re-solidification in the form globules and cauliflower shapes etc. The above characterization of the plasma beam is significant towards the optimization of device parameters. Further the observed properties of plasma beam shows its potentiality for important results in the field of plasma matter interaction (PMI) relevant to any heat flux research. In this presentation, we report about the development of the high-speed plasma beam producing facility with the characteristic information of the beam obtained from diagnostic studies.

Key words
Pulsed Plasma Accelerator, Pulsed Power System, Plasma Stream

References

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