Contribution ID: **98** Type: **Contributed Poster**

Heat loading of Pulsed Hydrogen Plasma Stream on Tungsten Substrate

Tuesday 3 September 2024 13:55 (1 hour)

A pulsed hydrogen plasma stream is produced from a pulsed plasma accelerator (PPA) powered by 200 KJ Pulsed Power System (PPS). The PPS, which consists of two modules capacitor banks, is charged up to 15 kV to generates a peak discharge current of 100 kA for a half time period of 500 μs. The high voltage from the capacitor banks thus applied in between two coaxially positioned electrodes to break down the gaseous medium and consequently plasma sheets are formed in between the electrodes. The plasma sheets are driven by the JxB force towards the open end of the electrodes to form a high-density(⊠ 1020/m3) plasma stream. A gas injection valve is used to supply the requisite gas during the application of high voltage discharge pulse in between the two electrodes so that the plasma stream can be sustained during the pulse time. To study the heat loading effect on tungsten material, 10 mm diameter tungsten metal samples were placed at 10 cm distance from the electrodes'end. The measured heat energy density of the Hydrogen plasma stream at this position is 0.205 MJ/m2 while it increases up to 0.224 MJ/m2 under an influence of an external magnetic field with a strength around 0.1 Tesla strength. The effect of heat energy dumped by the pulsed hydrogen plasma stream on the tungsten material creates formation of blister on the surface of Tungsten material for single exposure and it is observed in the micrograph of scanning electron microscope (SEM). However minor and major cracks, displacement of cracked surface, dust formation, re-deposition are more prominent in SEM micrograph for surface exposed for 15 times to the same plasma stream in the same position with and without external magnetic field. Although, the EDX data from the exposed samples as well as emission spectra from the plasma stream shows that carbon impurities, found in the plasma beam, decreases under the influence of external magnetic field. The interaction due to the heat energy density of plasma stream on Tungsten material in this work resembles either a mitigated or lower energy type-I Edge Localized Mode (ELM) [1] and the reported results are highly relevant for fusion reactor.

Reference:
[1] G. Sinclair, et. al., Scientific Reports7, 1, (2017)

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Session Classification: Posters

Track Classification: Consequences