PLASMA TORCH CLEANING OF CARBON LAYERS FROM DEEP GAPS AT ATMOSPHERIC PRESSURE

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A critical issue for long term operation of fusion machines like Tokamaks is the fuel co-deposition with the eroded wall material, which leads to tritium accumulation in wall. The codeposition is prominent inside castellated tiles with gaps, as those designed for ITER. The problem of cleaning the codeposited layers from the walls was addressed by a number of techniques, including laser ablation, flash-lamp UV radiation exposure, thermal oxidation and glow discharge. These techniques which were proved to be successful for cleaning flat surfaces are less efficient for castellated ones, they having the drawback of limited access in narrow spaces.

The present contribution focuses on the application of a small size, flexible, but still powerful atmospheric pressure plasma torch for carbon cleaning from inside gaps. The plasma torch is based on a capacitively coupled discharge sustained at 13.56 MHz. A plasma jet is obtained by the expansion in the ambient of the radiofrequency discharge through a nozzle [1]. The source has 20 mm diameter, operates with powers in the range 100-500 W, in argon or nitrogen. In a previous paper [2] we have presented extensively the plasma torch working with nitrogen and we have demonstrated its capability of removing the material from the surface of bulk carbon pieces made of graphite or CFC. In the experiments reported here the material used for removal experiments is amorphous hydrogenated carbon deposited by Plasma Assisted Chemical Vapor Deposition. The chosen approach for preparing gaps was to build up castellated surfaces by assembling separate components. The components were coated with carbon layers prior to assembling. Thus, the investigation of the removed material after the cleaning process, by disassembling and individual examination of the components is allowed. Aluminium cubes have been machined as separate parts of castellated surfaces. By assembling the cubes gaps are created in between the lateral faces. The width of the gaps can be varied by displacing the cubes in the range 0.5-2mm, whereas the deepness was 23 mm. Such surfaces were scanned with the nitrogen plasma torch along the castellations, with the plasma jet directed inside the gaps. The surfaces were disassembled after predetermined numbers of scans, and the thickness of the remaining material at various positions with respect to the cubes top face was measured by profilometry. Thus the study of the dependence of the removal rate on gaps width, deepness, and torch position was performed.

Removal of layers from inside gaps was demonstrated for gap widths 0.5-1.5 mm, deepness down to 23 mm. The removal rates are in the range 10^{-4} g/min. The cleaning effect is stronger near the top of gap, where the plasma is stronger and at the gap bottom where the plasma is back-reflected by the gap end. With respect to the torch position the cleaning effect is stronger when the plasma is oriented on the gap side, comparing to the positioning on the gap middle.

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