REMOVAL OF IN VESSEL TOKAMAK DUST BY LASER TECHNIQUES.

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During the ITER operation, dust will be inevitably produced. Due to safety risk, the in vessel dust quantity must be controlled. Particle removal from surface required two steps: a mobilization one to overcome the adhesion forces and detach particles from surfaces followed by collection step to catch the dusts and transport them out of the vessel. Many techniques have been suggested and evaluated as cleaning process for Tokamak. However, none of them appears fully satisfactory to efficiently clean the ITER reactor walls.

In this paper, lasers techniques will be described and assessed. Laser cleaning processes are used in many industrial fields. They can work under a wide range of pressure condition from vacuum to atmospheric pressure and they do not require an optical setup close to the surface to be treated. They appear to be a promising tool to be used in the ITER complicated topology.

In order to develop an efficient mobilization tool, it is necessary to study in detail the physical mechanisms inducing particle removal. The right laser source must be selected taking into account the material properties of the particle to be removed in defined ambient conditions. The ejection mechanisms and the particle dynamics must be assessed as well.

Two laser techniques have been investigated. First, a direct irradiation of the substrate usually named Dry Laser Cleaning (DLC) and then Laser-induced Shockwave Cleaning (LSC) technique based on the generation of shockwave to blow the particles.

In DLC system, the laser irradiation leads to the ejection of the particles, and ablated products, perpendicularly to the surface. Laser-induced removal of carbon aggregates, tungsten and aluminum droplets and tungsten nanoparticles that are comparable of dust collected in Tokamak have been carefully studied. The particle removal efficiencies have been measured for a wide range of laser irradiation conditions. Laser carbon mobilisation is very efficient independently of the laser source characteristics, but the ejection of tungsten only occurs for short wavelength (UV) or ultrashort pulse duration (ps, fs). Moreover, carbon aggregates are ablated via thermal processes, whereas intact tungsten droplets or nanoparticles are ejected without ablation. For this metallic dust, the electrostatic force, induced by a cloud of electrons formed above the dust, is proposed as a new mechanism to explain the ejection process.

In LSC process, the focalisation of laser beam in gas onto of a surface induces the fast heating of a small volume of gas and then the generation of a shockwave. Its fast expansion allows blowing the dusts. Laser induced schock wave has been used to clean castellation filled by carbon dust. Particle motion is clearly induced by the shock wave since there is no direct interaction of the laser beam with dust. This technique appears very efficient in this configuration to push dust towards colder areas where they can be accumulated and collected at a later time.

Results obtained in the frame of this study provide a clear view of the ability of laser process to remove ITER-like dust from hot surfaces. The extrapolation of these outcomes will be used in order to propose a reliable ITER removal system.