In-situ assessment of the emissivity of tungsten plasma facing components of the WEST tokamak

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Ensuring adequate protection of plasma facing components (PFCs) from excessive heat loads is required for the safe operation of ITER. To this end, assessing the emissivity of tungsten (W) components, as used for the ITER divertor, is necessary to derive accurate surface temperature from radiation measured by infrared PFC monitoring systems. As a first step, a dedicated setup has been developed at CEA/IRFM to measure the emissivity of W samples representative of the WEST lower divertor, including samples with different damage levels generated by electron gun (micro-cracks and crack network) [1]. The experimental results show that emissivity exhibits dependencies with wavelength, temperature and surface state (roughness, cracks, pollution by impurities). For the same wavelength and temperature, the surface state shows a strong influence with a large increase of the emissivity with the micro crack and cracks network, by a factor up to 4. However, the samples used in this study did not see plasma operation that could have modified the surface state through plasma surface interaction (erosion, deposition and possible damages). This paper reports on the in-situ assessment of the emissivity of the tungsten coated graphite components on the inner and outer strike point areas.

Non-uniform emissivity has strong implication for plasma wall protection and for physical issues when assessing SOL width from infrared measurements for example. A new method is therefore proposed to estimate the emissivity distribution for divertor W-coated PFCs, taking advantage of the WEST tokamak unique settings (mix of diagnosed inertial and actively cooled PFC). The method is based on the recording of the IR radiance, coming from isothermal PFCs at several temperature levels, to be compared with embedded thermal sensors before each pulse. Assuming that in the collected radiance, the reflected contribution is constant (essentially due to the constant temperature of the water cooled surrounding in vessel), the radiance maps can be converted into emissivity maps. The emissivity distribution (poloidal and toroidal) of divertor PFCs is estimated all along the latest experimental campaign (2019) on the outer and inner PFCs. In the strike point area, the emissivity varies from about 0.1 to 0.25 with the minimal value location moving along the PFCs depending on the strike point location of the experiments (evolution through the day). Moreover, the emissivity increases up to 0.7 in the redeposition area especially in the inner side. The variation of the emissivity distribution along the last campaign will be correlated with plasma operation (strike point location, conducted energy in the divertor, boronisation, deuterium or helium plasma …).