Overview of power exhaust experiments in the COMPASS divertor with liquid metals

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Conventional high-Z solid metals, which are foreseen as plasma-facing components (PFC) for ITER and next generation devices, have shown their limits in terms of power handling, such as melting of leading edges, cracking, morphology and heat capacity deteriorations subsequent to neutron irradiation or recrystallization. A possible solution to overcome these issues is to use liquid metals as PFC. One candidate technology is the capillary porous system (CPS) where the liquid metal is impregnated in a metallic mesh and confined against MHD effects by capillary forces [1]. The power exhaust capabilities of such CPS-based liquid metals have been tackled experimentally in linear devices [2] as well as in tokamaks [3,4], where they were exposed to heat loads up to 20 MW/m^2. As a result, a heat flux reduction and no damage of the exposed surface/mesh were observed. However, this potential solution comes with new issues such as resilience to transients, tritium retention, evaporation, etc. Most of these issues were investigated experimentally for the first time in ELMy H-mode plasmas in the COMPASS tokamak for liquid Li and liquid LiSn alloy.

This contribution presents an overview of the international efforts to study the power handling capabilities of liquid metals (Li & LiSn) in a unique experiment in COMPASS. The effects on core performance and SOL profiles modification are also characterized. A specially designed CPS module with pore radius 75 µm was installed in the COMPASS divertor and exposed to powerful ($q_{//} \sim 30$ MW/m^2), short (200 ms flat-top) deuterium plasmas. The module was in direct view of a high resolution infra-red camera (0.6 mm/pixel & 4 kfps) and of a 8-channel spectroscopic system to monitor Li spectral lines. Two high speed visible, color cameras (5 kfps) allow the tracking and visualization of evaporated and ionized metal plumes. The local heat loads is measured by means of two divertor probes arrays surrounding the target and two reciprocating probes measure the SOL profiles. Both in L- and H-mode plasmas, a good power exhaust capability has been observed up to $q_{dep} \sim 15$ MW/m^2 with no droplet ejection from the CPS mesh surface, even in the presence of ELM with energy in the range of 1 MJ.m^{-2}.s$^{-1/2}$. However, some droplets were observed to moved crosswise on the CPS mesh by JxB forces towards the edge of the module. Most of them remained attached to the mesh by capillary forces but in some cases (strong MHD effects or strike-point movement) they were pushed away from the side of the module. Radiated power in the core plasma is measured by fast AXUV diodes. A post-mortem TDS analysis was performed to quantify the amount of D trapped in the target. The elemental depth profile analysis (LIBS) of 14 stainless-steel samples located around the vacuum vessel provides information about the migration of evaporated/redeposited liquid elements during these experiments [5].

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