Target Plate Conditions During ELM-Suppressed Operation on DIII-D*

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A major concern for operating large fusion power generating tokamaks in the H-mode regime is the presence of edge localized modes (ELMs) that repeatedly send large numbers of energetic plasma particles and heat into the divertor plates. Unacceptable erosion and thermal loading of the divertor plates are predicted for Type 1 ELMing H-mode operation in large tokamaks like ITER. One possible solution, that has been recently demonstrated [1,2] in DIII-D, is operation with resonant magnetic perturbations (RMP) at the boundary. These plasmas exhibit ELM suppression under certain conditions while maintaining high confinement. This magnetically perturbed boundary is produced by a special set of coils (I-coils) that generate small resonant perturbations of the edge magnetic field. The ELM suppression effects exhibit a resonance behavior centered around a particular edge q value ($q_{95} = 3.7$).

At the target plate, the conditions during ELM suppressed operation are observed by a set of radially distributed Langmuir probes for both high and low collisionality. At high collisionality ($\nu*\sim 1$), comparing characteristic values when the perturbation coil is energized to the value between ELMs, the target plate particle flux drops by 30%, the temperature drops by 50%, and the probe floating potential (V_f) goes to approximately zero across the floor. These changes indicate that the plasma is tending toward detachment. Also at high collisionality, small oscillations at about the ELM frequency but with amplitude clamped at a value much smaller than the ELM level are observed in temperature, density, and H_α at the target plate after the ELMs are suppressed. In low collisionality plasmas ($\nu*\sim 0.1$), after the ELMs are suppressed, the core density drops, the target plate particle flux drops by 25% while the electron temperature at the plate increases by about 100%. At low collisionality, we also observe a visible light emission pattern across the divertor floor that may correspond with tile edges. The heat flux during the ELM suppressed phase is about a factor of 2 higher than the heat flux between ELMs during the ELMing phase but the transient heat flux peaks due to ELMs (5X higher than between ELMs) are eliminated. By applying the RMPs, the impulsive heat loading during ELMs has been converted to a more steady-state heat loading which keeps the peak heat flux below the expected ITER ablation limit (5%-10% of W_{ped}).

[1] T.E. Evans, *et al.,* Phys. Rev. Lett. **92** (2004) 235003-1.
[2] T.E. Evans, *et al.,* Nucl. Fusion **45** (2005) 595.

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