# ICRF Performance with Metallic Plasma Facing Components in Alcator C-Mod

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Ion cyclotron range of frequency (ICRF) heating is expected to be an important auxiliary heating source for ITER and future fusion reactors where high Z metallic plasma facing components (PFCs) are envisioned. High power ICRF injection into plasmas with metallic PFCs present significant challenges. One of the more restrictive is the acceptable fractional concentration of high Z material in the plasma, tungsten ~$10^{-5}$ and molybdenum ~$10^{-4}$, is significantly reduced compared to low Z material, carbon ~0.1.[1] Another issue is the erosion of low Z coatings, ie. boronization, used to control plasma radiation that has been shown to be very important for high performance H-modes, particularly in devices with high Z PFCs.[2] In Alcator C-Mod, we have investigated the compatibility of high power ICRF heating with high performance plasmas and high-Z PFCs with and without boronization. In discharges performed with uncoated metallic PFCs, the H-mode performance, as measured by ITER89 H-factor, was typically ≤1.2 and had generally higher radiated power fraction. Additional experiments indicated that excess radiation particularly from Mo, a strong edge radiator, resulted in lower H-factors.[2] Upon boronization, record C-Mod stored energy and world record plasma pressures were achieved concurrent with a large drop in Mo radiation. Control of the impurity influx through boronization is temporary. In C-Mod, we find that after ~ 20 ICRF-heated discharges, corresponding to ~50 MJ injected ICRF energy, the Mo levels have risen and the confinement degrades.[2] Furthermore for Ohmic H-mode discharges with similar input energy (discharge integrated), the plasma performance degradation occurs at a rate 3-4 times slower than RF heated discharges. Experimental evidence suggests that RF-enhanced sheaths on open field lines passing near the antennas terminating on top of the outer divertor are the most likely erosion/impurity mechanism. The antenna limiters were eliminated as the primary Mo source by experiments where insulating limiters, used to eliminate RF enhanced sheaths on the antennas, failed to control the core molybdenum despite reduction of the local antenna molybdenum source. The antenna Faraday screens were ruled out because the rods are coated with TiCN and the dominant impurity is molybdenum. The outer divertor location corresponds to the radial region where localized boronization was most effective and we demonstrated that the erosion location was linked to the active antenna. Using recently installed marker tiles, we will present additional data on a more direct test this hypothesis. Furthermore, we observed that erosion rate associated with ICRF heating was unaffected by the heating scenario's single pass absorption. We will also present results from experiments investigating why the outer divertor location appears to be the primary impurity source.

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[1] R.V. Jensen et al., Nucl. Science Eng. **65** (1978) 282.
[2] B. Lipschultz et al., Phys. Plasmas **13** (2006) 056117.