Impurity Powder Driven Plasma Modifications on the Large Helical Device

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An extended series of Impurity Powder Dropper(IPD) experiments were executed over the 21st and 22nd LHD experimental campaigns. These experiments encompassed boron, boron nitride, boron carbide and carbon powders introduced at variable mass rates into plasmas of multiple magnetic geometries across a range of densities and heating schemes. Discharges within this set have been observed to display both evidence of real time particulate wall conditioning as well as access to a turbulence suppressed enhanced confinement regime. The primary application of the IPD is envisioned as a instrument capable of supplementing and maintaining the depositional coatings utilized to provide premium wall conditions. For these experiments, a reduction in wall recycling and native impurity content is noted over the course of several discharges and a prompt reduction of plasma density is provided through a combination of main ion co-deposition at plasma facing surfaces and gettering by the newly applied impurity layer. In addition active density control through powder injection has been observed during long pulse discharges whereby the largest injection levels drive decreases in plasma density which persist at reduced levels even after the injection is concluded. Also observed were extended multi-discharge periods of intrinsic impurity suppression similar to a standard boronization and evidence of a depositional coating layer is confirmed by ex-situ analysis of a materials sample probe. This ability to demonstrate active control in steady state scenarios is an important initial step in the development of this technique as a method to apply real time boronization and provide additional regulation for long term plasma control. In addition, enhancement of electron and ion temperatures as well as plasma stored energy was observed during periods of powder injection. This powder induced novel confinement regime is exemplified by broad radial turbulence suppression. The corresponding reduction in anomalous transport leads to ion temperature enhancement on the order of 25%, but up to ~50% in some cases. While a final conclusion as to the nascent cause of the turbulence suppression has yet to be reached, present supposition advocates a combination of effects due to superposition of both the increased radial density gradient, as caused by the increased electron burden compounding the nominal LHD hollow density profile in conjunction with the turbulence suppression effects of the increased effective charge Z_{eff}, all of which have been reported to provide a stabilizing effect upon ion temperature gradient type turbulence. The deconvolution of these is planned through further experiment and gyrokinetic simulation.