Pellet injection and internal diffusion barrier formation in LHD plasmas

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An experimental study is performed to explore the operational space of a super dense core plasmas due to an internal diffusion barrier in Large Helical Device (LHD). An internal diffusion barrier with steep gradient has been produced at an intrinsic helical divertor configuration in LHD by optimizing the pellet fueling and magnetic configuration. Core fueling by multiple pellet injections is essential to the internal diffusion barrier formation. Nine-barrels in-situ pneumatic pipe-gun was employed to inject solid hydrogen pellets, which contain 1.5 - 2.0×10^{21} hydrogen atoms, at a velocity of ~ 1100 m/s every several 10 ms. The internal diffusion barrier easily appears in the outer shifted magnetic configuration in which magneto-hydrodynamic stability properties are considered to be favorable and yields a super dense core plasma with steep density gradient. Attainable central plasma density becomes higher as the magnetic axis shifts outward. Maximum central density reaches 1×10^{21} m^{-3}. Since the internal diffusion barrier can lead to high density regime while keeping temperature, a central pressure of the super dense core plasma increase with density and the central pressure exceeds 1.3 times atmospheric pressure (~ 130 kPa). The super dense core plasma is, therefore, characterized by very large Shafranov shift (Δ/a_{eff} ~ 1/2), even at high magnetic field (B_t> 2.54 T). The maximum central pressure is limited by an core density collapse event which may be caused by MHD equilibrium. The core density collapse event can be suppressed by controlling ellipticity of the magnetic configuration.