Low-Z Shell Pellet Experiments on DIII-D*

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Abstract. Wall damage resulting from a disruption is a major concern for future reactor-size tokamaks like ITER. Research is underway to evaluate fast shutdown methods for terminating tokamak discharges safely in the event of an unavoidable disruption. The most widely studied tokamak fast shutdown method is massive gas injection (MGI), which involves injection of radiating gas, typically neon or argon, into the plasma edge. Injection of shell pellets is a potentially attractive alternate to MGI. Shell pellets consist of a thin outer shell surrounding a dispersive payload, such as powder or pressurized gas. Ideally, the shell should consist of a low-Z material to avoid collapsing the plasma current channel and initiating global magneto-hydrodynamic (MHD) modes, while the payload should consist of higher-Z material to efficiently radiate away the core plasma thermal energy. Ascertaining the usefulness of the shell pellet concept for fast shutdown of tokamaks requires the ability to predict shell ablation rates, dispersion of the core material, and the reaction of the plasma core and edge to the introduced impurities. Tokamak shell pellet experiments have been performed by firing OD = 2 mm, v = 300 m/s polystyrene shell pellets filled with either boron powder or 10 atm Ar gas into DIII-D plasmas. The polystyrene shells successfully penetrated past the plasma edge without initiating global MHD modes and deposited the payload material rapidly (~0.2 ms) into the plasma core. The deposition of the core material appears to be quite local (<2 cm), but the resulting impurity ions appear to mix rapidly (<15 ms) throughout the plasma core. The measured burn-up rate of the polystyrene shell appears to be well explained by ablation rate modeling; however, the observed slowing of the pellet velocity from 300 m/s down to 50 m/s prior to burn-up is not fully understood at present.

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