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Confinement Improvement through Impurity Induced Profile Modification on W7-X.

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Pulsed injection of boron carbide granules into W7-X discharges transiently increase the plasma stored energy and core ion temperature above standard W7-X operation by up to 30%. In a series of 4MW ECRH heated experiments, the PPPL Probe Mounted Powder Injector provided 50 ms bursts of 100 micron granules every 350 ms at quantities ranging from <1mg/pulse to 30 mg/pulse. For quantities up to 10 mg/pulse, the impurities are flushed from the plasma between pulses and the effect on the overall plasma is modest. For quantities above 10 mg/pulse the impurities are partially flushed, and Zeff increased from 1.3 to 3.2 over the series of pulses. For each injection, the stored energy initially drops, the radiated power transiently increases, and the radial density profile flattens on the edge as the material is assimilated. After the injected boron has been fully absorbed and the radiated power recovers, the stored energy increases above the previous baseline level by an amount linearly correlated with the injection quantity. The peak core ion temperature increases from 1.7 keV to a maximum of 2.9 keV for the largest injection amounts. During the injections, the ion temperature gradient steepens and a central plateau develops out to a minor radius of 0.2m, resulting in a decrease in the gradient scale length. This is accompanied by a reversal of the electric field at r >0.4m, indicating the transport has switched to the ion root. The impurity confinement time increased by roughly a factor of 2. These observations are suggestive of a transient stabilization of ITG turbulence, similar to the enhanced confinement after cryogenic pellet injection. This provides further evidence that externally induced profile modification is a possible path to elevated W7-X performance metrics.