Initial Experimental Results on Boron and Boron Nitride Powder Injection into KSTAR Discharges

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A series of initial experiments were carried out using an Impurity Powder Dropper (IPD) to introduce small, precise, controllable amounts of boron and boron nitride into ELMy H-Mode KSTAR discharges. The results show the mitigation of ELMs and reduced recycling when 150 micron diameter boron powder is dropped. ELMs are stabilized and edge fluctuations are altered when 60 micron diameter boron nitride is dropped. The promising results suggest that the IPD may be used for intra- shot wall conditioning and ELM control, and they provide the motivation for follow-on experiments in the coming campaign that drop powders into high-power, long-pulse plasmas to improve plasma performance and lifetime.

IPDs have been used for experiments on ASDEX-Upgrade [1], EAST [2], and DIII-D [3], and one will be installed on LHD in 2019. The IPD consists of four reservoirs that can each hold a separate material. Powders fall from the reservoirs onto troughs that, when vibrated by piezoelectric actuators, drop the powder into a common drop tube and into the plasma. The orientation and mechanical resonant frequency of each of the four sub-systems is set to minimize incidental dropping of unwanted powders. The dropped powders pass through an optical flow meter in order to monitor the flow rate, and a photodiode mounted at the top points down the length of the drop tube to watch for light emission from the plasma when powders reach the plasma periphery. The powders fall a total distance of approximately three meters.

In the recent KSTAR experiments, powders were dropped into 10 s – 20 s duration, 1.5 MW, 500 kA plasmas. The photodiode signal and real-color fast camera images show the powders entering the plasma. A 10 mg dose of boron caused a disruption, but had the effect of allowing ELM-free phases in several subsequent shots, likely due to a wall-conditioning effect. Several 2.5 mg doses of boron during a single discharge reduced recycling as evidenced by the reduced baseline D-alpha level during the following shot. A series of 2.5 mg doses of boron nitride, delivered in 0.1 bursts, was observed to transiently eliminate ELMs for up to 5 s, without changing the stored energy or plasma density (Fig. 1b). Analysis of the BES data during the ELM-free phase showed increased coherent mode activity near 180 Hz, corroborated by magnetics data. A continuous boron nitride dose of 2.5 mg/s for ten seconds reduced the ELM amplitude (Fig. 1d).

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References

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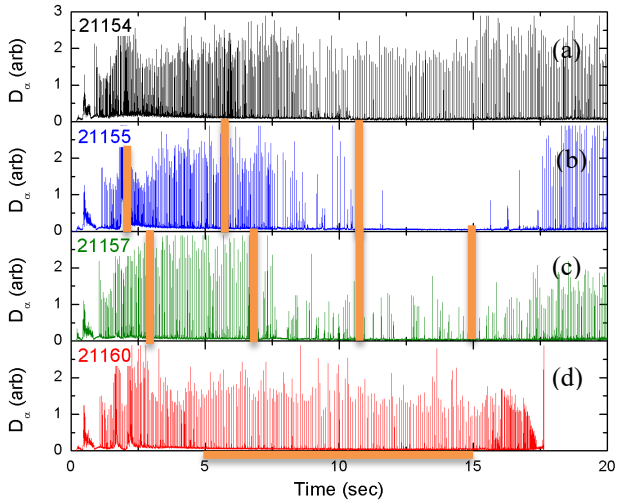

Figure 1: Reference shot (21154) and three shots with boron nitride injected in three 0.1 s bursts at 25 mg/s (21155), four 0.1 s bursts at 12.5 mg/s (21157) and continuously for 10 s at 2.5 mg/s. ELM suppression is observed in shot 21155 and ELM mitigation in shots 21157 and 21160.