Deposition and dust studies in NSTX

C.H. Skinner [1], J. Hogan[2], H.W. Kugel [1] , A. L. Roquemore[1], W. R. Wampler[3], C. V. Parker[4], C. Voinier[5].
(email: cskinner@pppl.gov)

[1]*Princeton Plasma Physics Laboratory, P. O. Box 451, Princeton, NJ 08543 USA*
[2]*Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA*
[3]*Sandia National Laboratory Albuquerque, NM 87185*
[4]*Harvey Mudd College, Claremont, CA, 91711*
[5]*The College of New Jersey, Ewing, NJ, 08628 USA*

Tritium retention, dust and deposition on diagnostic mirrors will impact the operation of next-step devices such as ITER. Hence, measurements in contemporary tokamaks are important to gain a predictive understanding that can help to mitigate the associated risk. Quartz crystal microbalances (qmb) have been deployed in NSTX to measure pulse-by-pulse deposition and erosion at the upper & lower divertor and outboard midplane and the deposited layer thickness was recorded continuously throughout the 2005 campaign. Typically ~1 nm of deposition is observed on the first discharge of the day followed by a complex pattern of erosion or deposition on subsequent discharges. The scale of the interaction increases with the proximity of the plasma to the qmb's. Fig. 1 shows a transition from deposition for short duration ohmic discharges to erosion from longer duration higher stored energy discharges. Other correlations between erosion / deposition and other diagnostic signals are being investigated. Nuclear reaction analysis showed the average atomic composition of the deposited material remaining on the qmb's after the campaign to be ~58% carbon, ~27% deuterium and ~15% boron. Wall conditioning using a glow discharge of trimethyl boron and helium was a major contributor, especially at the midplane, near the glow discharge electrodes.

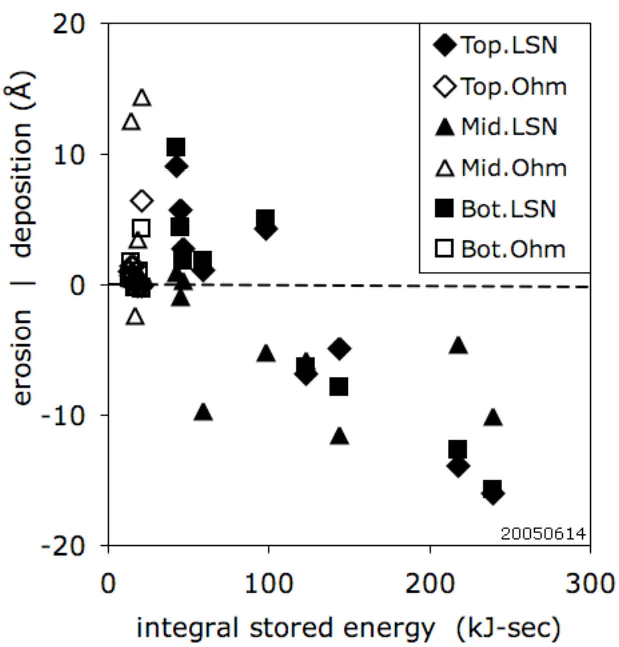

Fig. 1 Change in deposited layer thickness at various locations after a high performance LSN or ohmic discharges plotted vs. the integral of the stored energy.

Monte Carlo modeling of C transport in the near-divertor region in NSTX, using an axisymmetric version of the 3D BBQ guiding center code, has been used to quantify the spatial dependence of the C migration for comparison with qmb measurements. Previous modeling showed that quiescent cross-field transport of impurities generated at the divertor strike points was unlikely to account for mid-plane deposition, indicating that intermittent low field side far-SOL transport and/or ELMs were more likely to be responsible[1]. In addition, the modeling addresses the relative contributions of physical, self- and chemical sputtering; and the degree of suppression of chemical erosion processes in the NSTX divertor region at high incident D+ flux.

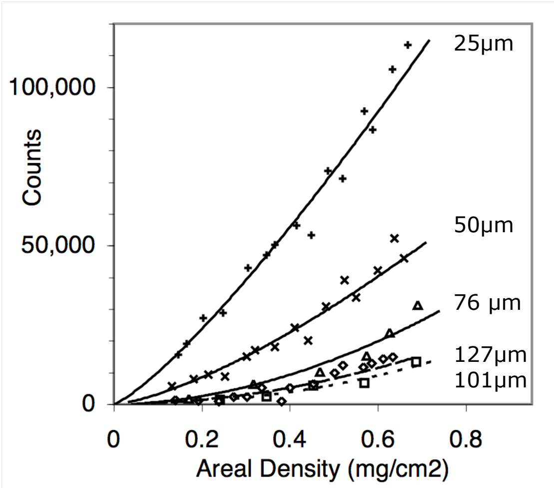

Fig.2 Response of dust detector showing a increase in counts with finer grid size (listed on the right) by more than one order-of-magnitude. The lines are a second order polynomial fit to the data (reproduced with permission from Ref. 3).

Dust particles are ubiquitous on the interior surfaces of current tokamaks and the more intense plasma surface interactions and longer pulse duration in next-step devices such as ITER is expected to lead to much higher accumulations of dust. These dust particles will be radioactive from tritium or activated metals, toxic and/or chemically active with steam or air and the inventory of dust will be strictly limited to avoid adverse safety consequences. Methods to measure the inventory of dust particles and to remove dust if it approaches safety limits will be required. A novel electrostatic dust detector, based on fine grids of interlocking circuit traces, biased to 30 or 50 v, has been developed for the detection of dust on remote surfaces in air and vacuum environments[2,3]. Laboratory experiments showed that impinging dust particles from carbon tiles create a short circuit. The resulting current pulse is analyzed by nuclear counting electronics and the number of counts is correlated with the mass of dust landing on the grid. Fig. 2 shows an increase of sensitivity of more than an order of magnitude with 25 µm grid spacings that approached the count median diameter of the dust particles. The short circuit events are transient as heating by the current pulse caused up to 90% of the particles to be ejected from the grid or vaporized.

The detection threshold of the present device for fine carbon particles is ~ 1 µg/cm^2. This is appropriate for measurements of dust in ITER where the present strategy suggests an administrative safety limit of 5-25 mg/cm^2. Time-resolved dust measurements in existing plasma devices are desirable to identify mechanisms of dust production and benchmark models, however measurements of the dust collected on a glass slide in NSTX after 1249 discharges showed dust levels of 5 ng/cm^2/discharge which is below the sensitivity of the current detector. We will discuss potential strategies to increase the sensitivity of the dust detector.

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