§44. High Sensitive In-situ Measurements of Dust Deposition on the Wall of LHD using QCMs

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Dust in a fusion device has negative effects on the operation such as accumulation of tritium and deterioration of plasma confinement.[1] To overcome the thorny problem, development of a dust monitoring method is particular significant for realization of safe, long-term operation. So far we have developed a real-time dust monitoring method, the QCM method, which can obtain information of deposition of dust particles and radicals respectively by using quartz crystal microbalances (QCMs) equipped with a dust eliminating filter.[2, 3] Here we report the results of measurement of dust deposition in Large Helical Device (LHD) and comparison with an incident energy from the plasma to the wall of LHD.

The QCM measures a deposition on the quartz crystal by the shift of resonance frequency. We used 3 channels of QCMs. Channel 1 (Ch. 1) was used to measure total deposition of dust particles and radicals. Channel 2 (Ch. 2) was covered by the dust eliminating filter which eliminates 94.2 % of dust particles,[2] in order to obtain data of deposition due to radicals only. The deposition of dust particles can be calculated with comparison Ch. 1 and Ch. 2. A stainless-steel plate was set above channel 3 (Ch. 3) to acquire the information of effects of ambient temperature and pressure on QCMs and compensate their influences on resonance frequency of QCMs. Using this QCM method, we measured the dust deposition rate during the main discharge of LHD 18th campaign on November 11th, 2014. The shot numbers were #124996 - #125052. Each discharge duration was from 0 to 6 seconds. The magnetic flux density was -2.538T. The incident energy on the wall (W_{wall}) was calculated by

$$W_{wall} = \int (P_{heat} - P_{rad} - \frac{\mathrm{d}W_p}{\mathrm{d}t})\,\mathrm{d}t \qquad (1)$$

where W_p is a plasma stored energy, P_{heat} is a power of heating to the plasma, P_{rad} is a power of radiation from the plasma.

We measured the time evolution of the resonance frequency of QCMs. Accompanied with each discharge ignition, resonance frequency significantly changed. One possible origin might be thermal load by plasma radiation. To eliminate them, we obtain the change of resonance frequency during every discharge time (Δf_{shot}) by comparing the frequency before and after each discharge. Deposition on QCMs was measured in 0.1 ng/cm^2 order successfully. Figure 1 shows W_{wall} dependence of resonance frequency in each channel. In Ch. 1, with the W_{wall} increasing, change of deposition mass (Δm_{shot}) raises linearly from -1.5 ng/cm^2 to 7.3 ng/cm^2. It shows deposition mass due to dust particles and radicals per unit W_{wall} is 1.0×10^{-7} ng/cm^{2}J. In Ch. 2, Δm_{shot} diminishes at a speed of -1.7×10^{-8} ng/cm^{2}J with the increase of W_{wall}. It suggests that deposition rate due to radicals is little. In Ch. 3, Δm_{shot} changed randomly in a range from -0.5 ng/cm^2 to 0.9 ng/cm^2. It shows that effects of ambient temperature and pressure can be ignored. These results suggest that deposition mass of dust particles increases with W_{wall}.

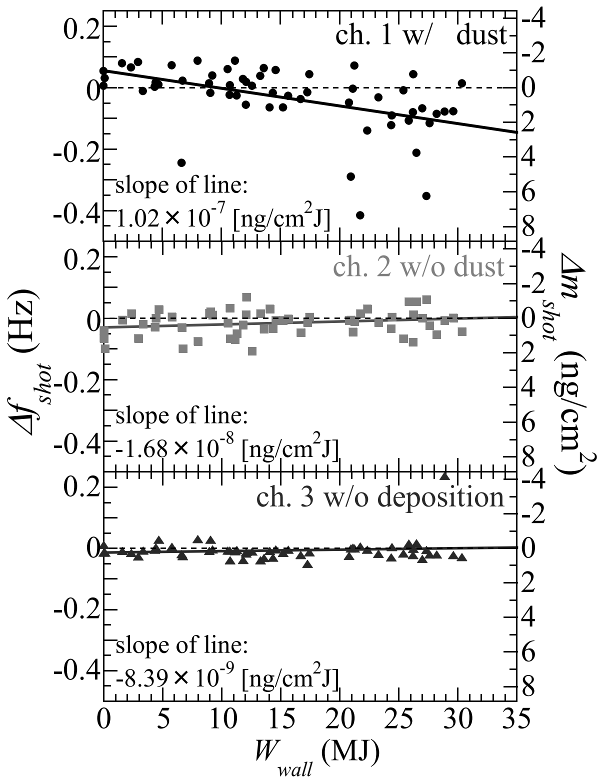

Fig. 1. Incident energy on the wall dependence of resonance frequency differences for each discharge.

From this study, the QCM method is promising to get real-time information of deposition rate due to dust particles and radicals, and to compare with plasma parameter.

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3) Kim, Y., Hatozaki, K., Hashimoto, Y., Uchida, G., Kamataki, K., Itagaki, N., Seo, H., Koga, K., and Shiratani, M.: Jpn. J. Appl. Phys. **52** (2013) 01AD01.