§4. In-situ Measurements of Dust Deposition in LHD Using a Quartz Crystal Microbalance Method

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Accumulation of dust particles in fusion devices poses two potential problems, operational issues and safety hazard, such as deterioration of plasma confinement and accumulation of tritium in fusion deices [1]. Development of a real time dust monitoring method and reduction of dust accumulation in fusion devices are important for the realization of safe, long-term operation. So far we have developed an in-situ method for measuring deposition rate of radicals and dust particles using quartz crystal microbalances (QCMs) equipped with a dust eliminating filter. We have confirmed detection of the dust particles in a divertor simulator [1]. Here we report results of preliminary QCMs measurements during the main discharge of Large Helical Device (LHD) 18th campaign on November 11, 2014.

The QCMs have three channels of quartz crystals [1, 2]. Channel 1 was used to measure deposition rate correlated to radicals and dust particles. Channel 2 was covered by a dust eliminating filter which eliminates 94.2% of dust particles [1], giving information of the deposition rate of radicals. Channel 3 was covered by a stainless-steel plate to monitor effects of pressure and temperature on signals of QCMs, because the resonance frequency also depends on ambient temperature and pressure. The QCMs have been installed at 2190 mm far from the first wall position inside the port 8.5 U in the LHD.

Figure 1 shows typical time evolution of frequency shift from resonance frequency at the beginning of the measurement. Abrupt frequency changes in Fig. 1 show discharge periods. Most of the abrupt frequency changes for channel 1 are positive spikes whereas those for channels 2 and 3 are negative ones. Mechanism of the frequency spikes

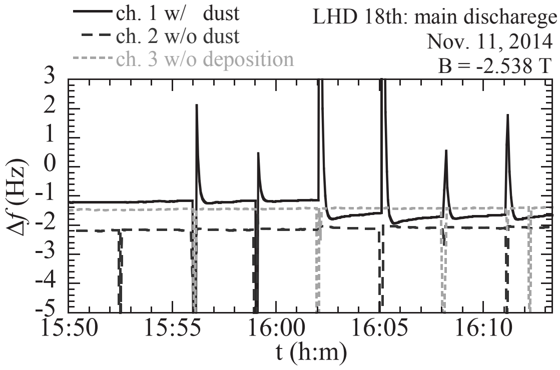

Fig. 1. Time evolution of resonance frequency shift of QCMs in LHD. The spikes occurred during the discharges.

is unclear but thermal load from plasmas toward the quartz crystals is one possible origin. The results indicate that measurements of the deposition rate during the discharges are difficult in this experiment. However, we can obtain the total mass changes on the quartz crystals from the frequency difference between the frequency before and after each discharge. Figure 2 shows the frequency difference for each discharge in the experiments for magnitude of magnetic field B= -2.538 T. The frequency difference for channel 1 changes from 0.1 Hz (etching) to -0.5 Hz (deposition) while those for channels 2 and 3 is in a range of ± 0.1 Hz and ± 0.05 Hz, respectively. In this experiment, the QCMs are covered with a grounded stainless steel mesh for which a few charged particles such as ions and electrons impinge to the QCMs. Therefore neutral radicals and dust particles are responsible to the frequency difference.

These results indicate that the QCMs method is promising to obtain information of deposition rate correlated to neutral radicals and dust particles in fusion devices.

[1] Tateishi, M., Koga, K., Katayama, R., Yamashita, D., Kamataki, K., Seo, H., Itagaki, N., Shiratani, M., Ashikawa, N., Masuzaki, S., Nishimura, K., Sagara, A., and the LHD Experimental Group: J. Nucl. Mater. (2015) in press.
[2] Kim, Y., Hatozaki, K., Hashimoto, Y., Uchida, G., Seo, H., Kamataki, K., Itagaki, N., Seo, H., Koga, and Shiratani, M.: Jpn. J. Appl. Phys. 52 (2013) 01AD01.

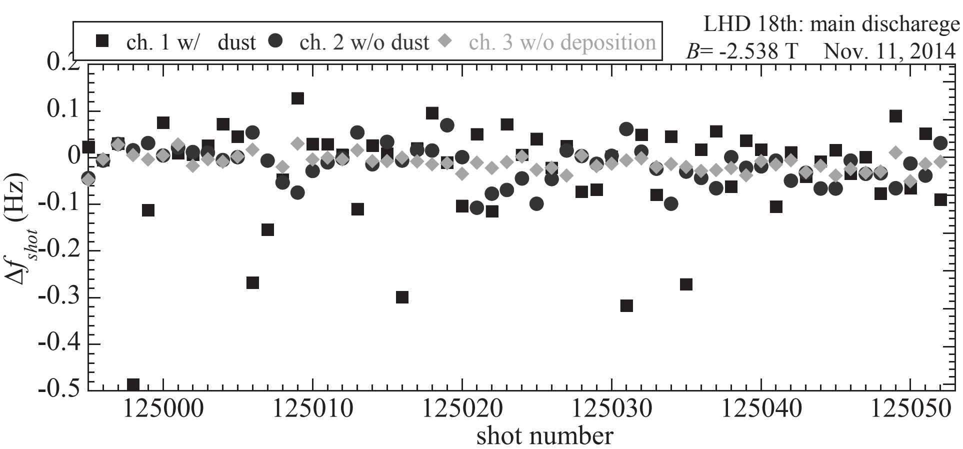

Fig. 2. Resonance frequency difference between before and after each discharge.