19PB-111

In-situ mass measurement of dust particles generated due to interaction between H_2 plasma and graphite wall

水素プラズマとグラファイト壁相互作用により発生したダストのその場測定

Mizuki Tateishi[1], Ryu Katayama[1], Kazunori Koga[1], Daisuke Yamashita[1], Kunihiro Kamataki[2], Hyunwoong Seo[1], Naho Itagaki[1,3], Masaharu Shiratani[1], Naoko Ashikawa[4], Suguru Masuzaki[4], Kiyohiko Nishimura[4], Akio Sagara[4] and the LHD Experimental Group[4]

立石瑞樹[1]，片山龍[1]，古閑一憲[1]，山下大輔[1]，鎌滝晋礼[2]，徐鉉雄[1]，板垣奈穂[1,3]，白谷正治[1]，芦川直子[4]，増崎貴[4]，西村清彦[4]，相良明男[4]，LHD 実験グループ[4]

[1]Faculty of Information Science and Electrical Engineering, Kyushu University, Fukuoka, 819-0395, Japan
[2]Faculty of Arts and Science, Kyushu University, Fukuoka, 819-0395, Japan
[3]PRESTO JST, Tokyo, 102-0075, Japan
[4]National Institute for Fusion Science, Toki, Gifu, 509-5292, Japan

[1]九州大学システム情報科学府 〒819-0395 福岡市西区元岡744
[2]九州大学所基幹教育院 〒819-0395 福岡市西区元岡744
[3]さきがけ 〒102-0075 東京都千代田区五番町7
[4]核融合科学研究所 〒509-5292 土岐市下石町322-6

We have studied wall-bias-voltage dependence of deposition rate of radicals and dust particles on the wall using crystal microbalances (QCMs) equipped with a dust eliminating filter in a divertor simulator. By the method, we have realized real time measurement of deposition rate of radicals and dust particles. The deposition rate due to radicals is nearly constant regardless of bias voltage. The deposition rate due to dust particles together with radicals on area exposed to H_2 plasma increases with increasing bias voltage due to an increase in dust flux and a decrease in etching rate.

1. Introduction

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, DC biased local wall was found to be useful for control of flux of dust particles from 50 to 1000 nm in size to the wall in Large Helical Device (LHD) in National Institute for Fusion Science, Japan and in a divertor simulator in our laboratory [2,3]. In this paper, we report experimental results of wall-bias-voltage dependence of deposition rate of radicals and dust particles measured using crystal microbalances (QCMs) equipped with a dust eliminating filter in a divertor simulator.

2. Experimental

The deposition measurement was conducted with the divertor simulator equipped with QCMs with the dust eliminating filter covered by DC biased stainless steel mesh [3,4]. The bias voltage V_{bias} was 0, ±50, ±70 and +100 V. Dust particles and radicals were generated due to interaction between pulsed H_2 plasmas of 500 W and graphite target. Some of them were transported toward the QCMs. The mass loading Δm and deposition rate *DR* on crystal surface of QCMs were deduced from the resonance frequency shift Δf with the sauerbrey equation given by $\Delta f = -C_f \times (\Delta m/A)$, where C_f is the sensitivity of a QCM sensor and *A* mass loading area of a crystal surface of a QCM [4]. The QCMs were set on the vessel wall at 100 mm below the target. Figure 1 shows the configuration of QCMs. Channel 1 was used to measure *DR* due to dust

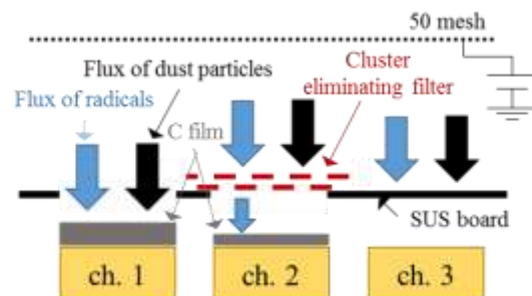

Fig. 1 Configuration of three QCMs.

particles and radicals. Channel 2 was covered by the dust eliminating filter. Almost all of dust particles and some of radicals are eliminated by the filter and we can obtain *DR* due to radicals. Channel 3 was covered by stainless steel plate to monitor effects of pressure and temperature on QCM signals. H_α emission intensity of the plasma was measured by optical emission spectroscopy to check the effect of DC bias voltage applied to the mesh to the H_2 discharge plasma.

3. Results and Discussion

Figure 2 shows time evolution of resonance frequency shift Δf of the three QCMs and H_α emission intensity. H_2 pulse discharges plasma was turned on at t = 0 s. For ch. 1 and 2, Δf's increase after the turning on the discharges due to temperature and/or pressure change, then monotonically decrease due to deposition of radicals for ch. 2 regardless of bias voltage. On the other hand, for ch. 1, Δf increases for V_{bias}= 0, ±50, ±70 V and decreases for V_{bias}= +100 V. Δf increase means decrease of mass load on the sensor crystal of ch. 1. During the measurement, hydrogen plasmas are irradiated to deposits on the crystal surface of ch. 1 so that the deposits might be etched by hydrogen plasmas. Therfore, the frequency shift for ch.1 is changed due to deposition of dust particles and radicals and etching due to hydrogen plasma irradiation.

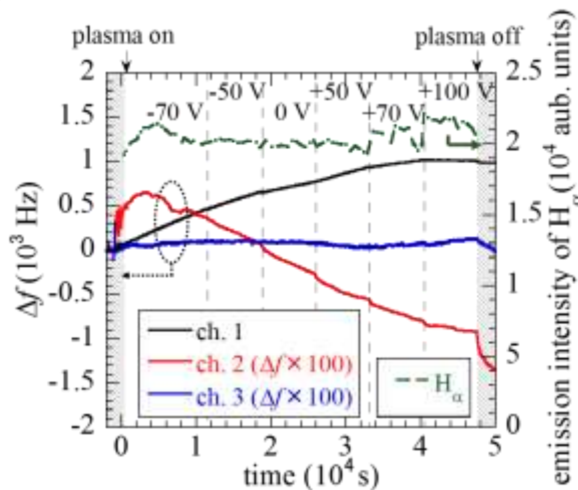

Fig. 2 Time evolution of resonance frequency shift of QCMs and Hα emission intensity.

Figure 3 shows wasll-bias-voltage dependence of deposition rate and H_α emission intensity. The deposition rate of ch. 2 due to radicals is nearly constant for $V_{\rm bias}$ from -70 to +70 V. On the other hand, that of ch. 2 has different value and H_α intensity is higher for $V_{\rm bias}$= +100 V. This result suggests the bias voltage affect the plasma for $V_{\rm bias}$= +100 V. The deposition rate of ch. 1 increases with increasing the bias voltage. The increase of deposition rate of ch. 1 with increasing bias voltage is due to an increase in dust flux and a decrease ib etching rate.

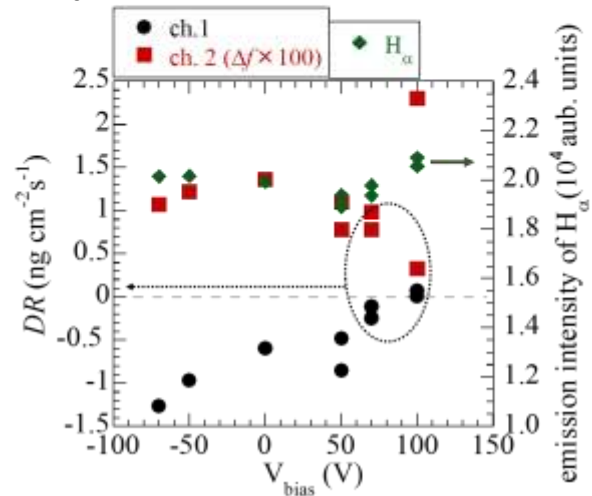

Fig. 3 DC bias voltage dependence of *DR* and emission intensity of H_α

4. Conclusions

We have measured the deposition rate with and without dust particles using three quartz crystal microbalances equipped with the dust eliminating filter covered by DC biased stainless steel mesh. Deposition rate with dust particles and radicals increase with increasing bias voltage due to an increase in dust flux and a decrease in etching rate. This result indicates that mass deposition rate in fusion devices can be controlled by applying the DC bias voltage.

Acknowledgments

This research was supported by JSPS KAKENHI Grant Number 26246036 and General Coordinated Research Grant from the National Institute for Fusion Science Grant Numbers NIFS12KLPF020 and NIFS14KLPF033.

References

[1] S.I. Krasheninnikov, et al.: Plasma Phys. Control. Fusion **50** (2008) 124054.

[2] K. Koga, K. Nishiyama, Y. Morita, G. Uchida, D. Yamashita, K. Kamataki, H. Seo, N. It-agaki, M. Shiratani, N. Ashikawa, S. Masuzaki, K. Nishimura, A. Sagara, the LHD Experimental Group: J. Nucl. Mater. **438** (2013) S727.

[3] K. Koga, M. Tateishi, K. Nishiyama, G.Uchida, K. Kamataki, D. Yamashita, H. Seo, N. It-agaki, M. Shiratani, N. Ashikawa, S. Masuzaki, K. Nishimura, A. Sagara, the LHD Experimental Group: Jpn. J. Appl. Phys. **52** (2013) 11NA08.

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