

## Novel in-situ measurement of dust quantities by a solar cell in Transport and Removal experiments of Dust (TReD) device.

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### Abstract

A dust detector is developed for monitoring quantities of dust particles in acting fusion devices. It uses a silicon solar cell and is applied to measure the amounts dusts in Transport and Removal experiment of Dust (TReD) device. We acquired the voltage signals of the solar cell in designated time sections according to the accumulated  $\text{Al}_2\text{O}_3$  dust particles which were levitated in the sheath potential and transported on collection tray with a slide glass in the TReD device. Dust quantities were deduced from the relation between the amounts of the dusts within each time period and the slope of the output signal.

### 1. Introduction

In tokamaks, dust particles are produced by plasma-surface interaction such as erosion, cracking, redeposition, flake arcing, disruptions and Edge localized Modes (ELMs) [1-5]. These results have been at issue recently in operating tokamaks devices such as the Korea Superconducting Tokamak Advanced Research (KSTAR) device and the International Thermonuclear Experimental Reactor (ITER) devices. ITER wall and devices will be consist of various materials such as Tungsten, Copper, Beryllium and Carbon fiber composition [1-4]. However these materials produce

many dust particles which can cause disadvantages of operating tokamaks and safety limitations. The produced dust particles affect the lifetime of tokamak walls and various devices, they are also included radioactive and toxic materials such as beryllium [1-4, 6-8], which are a potential hazard at operating ITER in the air and/or steam in the case of accidental water leak. It is important to know the removal timing of dust particles, and their production should be monitored in real time. For these purposes, various methods and devices which use laser scattering, grid type device

and capacitive diaphragm have been developed [9-12].

We developed solar cell system to measure quantities of accumulated dust particles in real time, the system has good sensitivity and reproducibility. It also does not directly effect other systems or devices. Because it is installed on the outside of plasma generation system. The system was equipped in a vacuum vessel device called Transport and Removal experiments of Dust (TReD) for transporting and removing dust particles. The solar cell system measured the quantities of the accumulated dust particles on the slide glass per specific time. In order to map the change of the signals to the accumulated dust weights, we measured both the signals of the system and the weights of the accumulated dust particles each time. We calculated the slope based on these results, we also inversely calculated quantities of dust particles by each slopes in total time scale of the solar cell amplitudes.

## 2. Experiment Set-up.

TReD is a device to realize the practical removal of dusts in acting fusion devices. It has the dimension of  $50 \times 50 \times 120 \text{ cm}^3$  in rectangular shape as shown in the figure 1. It has three view ports of square shape to observe dust particles behaviors.

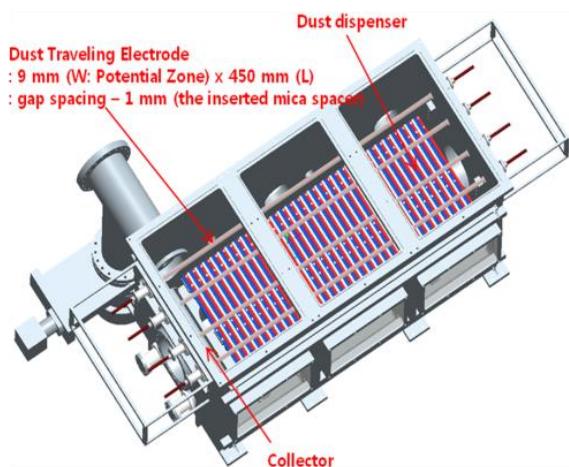


Figure 1. Schematic drawing of a TReD device.

Helium plasma is produced by applying low RF power of 13.56 MHz to four linear antennas located at the upper part of the rectangular chamber. The operating pressure of the experiments was in the range of 2.4 to  $2.6 \times 10^{-1}$  Torr and the injected gas flow was 30 sccm. The dust particles and balls were shaken and dispersed by the vibration of the dispenser and the dust particles were got into the plasmas as shown in Figure 2. A solar cell of dimensions ( $31 \times 24 \text{ mm}$ ) [13] was installed under the 6 inch view port. In order to prevent deviating dust particles from the side of the electrodes, we installed three glass guide lines located on three sides of the electrodes in a ladder shape as shown in Figure 2 (b).  $\text{Al}_2\text{O}_3$  dust particles were transported by plasmas and accumulated on the dust tray with a slide glass whose weight was measured using an electronic scale whose observable range was 220 g to  $10^{-5}$  g.

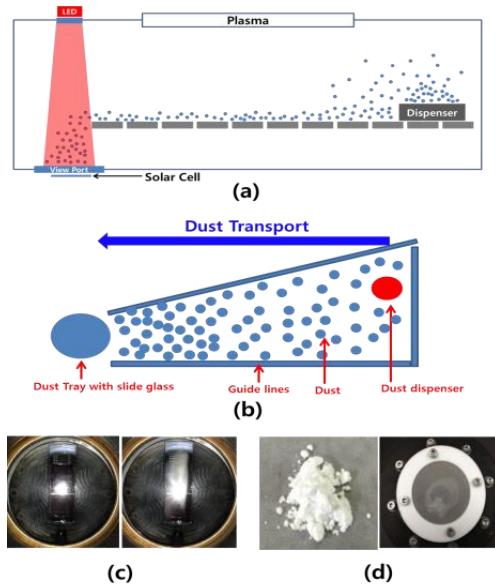


Figure 2 show dust detecting system using solar cell. Figure 2 (a) Schematic vertically drawing of the system in TReD device. (b) shows horizontally drawing of the system. (c) shows a tray with slide glass. Left side shows only a slide glass and right side is shows a slide glass with accumulated dust particles. (d) shows Al<sub>2</sub>O<sub>3</sub> dust particles and location in dust dispenser.

### 3. Results and discussion.

In order to check the relations between the dust particles weight and the change of the solar cell amplitude for each time section, we repeated the experiments whose operating time were increased by 30 minutes per each experiments until 240 min. We measured the dust weight accumulated on the slide glass in the tray using an electronic scale for each experiments. Figure 3 (a) shows the output signal of the solar cell according to each operating times. The characteristics of the output signals are totally similar until 90 minutes and the characteristics become different as time goes on. The bars of figure 3 (b) shows the dust weight on the slide glass of each section time. We assume the linear relation between

the weight of the accumulated dust particles and the change of the output signal in each given time section as 30 min.

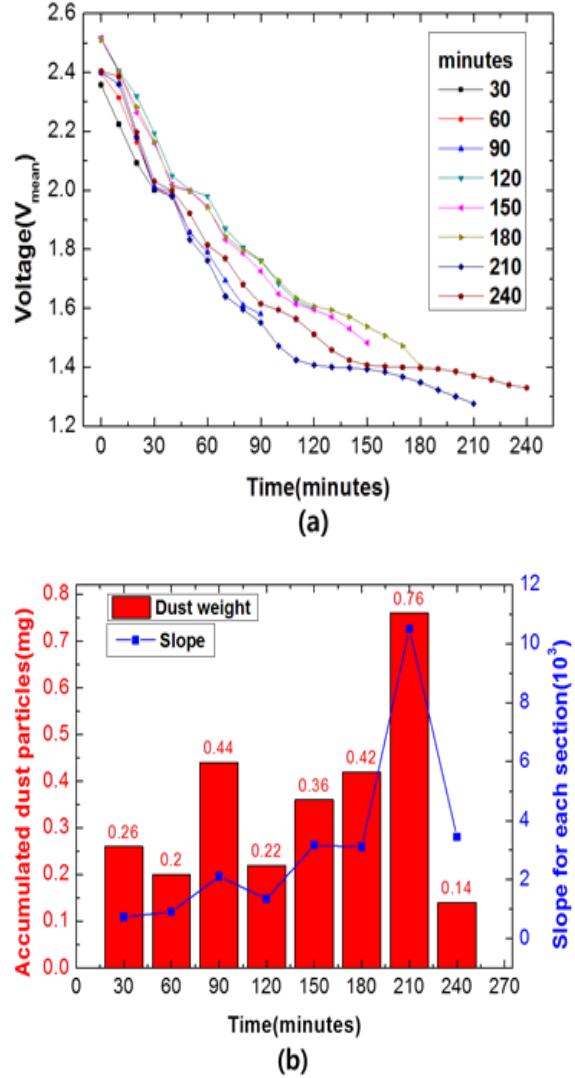
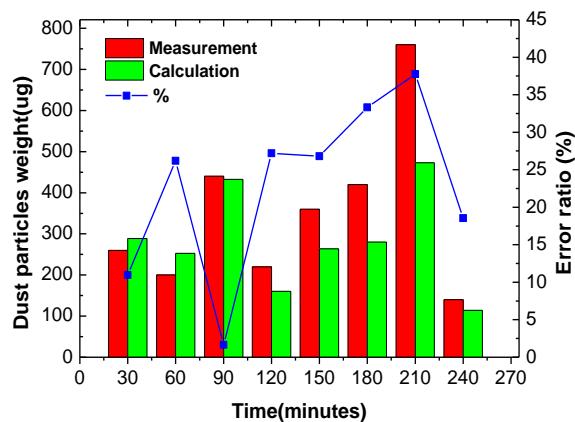


Figure 3 (a) shows the signal of the solar cell that operating and measuring times were increasing per 30 minutes until 240 minutes. (b) shows the practically measured dust particles and calculated slope value.

Figure 4 shows measured and calculated dust quantities values. The red bars are the measured values of each experiment, and the green bars are the calculated values as shown in figure 4 in respectively. The blue dots are error ratio. We checked to estimate the dust weight by two thechniques

measurement and calculation. The results were similar until 90 minutes when the weight of the dust particles is practically 900  $\mu\text{g}$ . Then the error ratio become larger after 90 minutes. This larger errors might be due to the increasing values of slope. The difference in the solar cell voltage changed slightly, although the dust particles largely accumulated with time.



**Figure 4** shows comparasion between practically measured dust particles and calcurated dust particles, and error ratio.

#### 4. Conclusions

We developed an in-situ dust detector using a solar cell for monitoring the accumulated dust particles in TReD device, aiming for application to the measurement of dust particles in acting tokamaks. Dust particles were transported and collected in the TReD device, and we measured the weight of the dust from the output voltage of the solar cell by using the relation of the slope and compared the calculated weight to the practical measured weight.

The dust detector using solar cell is to measure the precious weight of the dust

particles with advantages are good sensitivity, reproducibility, reliability and detection of a wide area. Besides, the system seems to be robust and does not affect plasma and vacuum due to its installation outside of the plasma and vacuum conditions.

#### 5. References

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