

## Analyses of Size Distribution and Chemical Composition of In-Vessel Dusts and Metal Droplets in KSTAR after the 1st Campaign

Suk-Ho Hong<sup>1</sup>, Hye-Jin Jung, Hyun-Jung Lee, Woong-Chae Kim, Yeong-Kook Oh

*National Fusion Research Institute, 113 Gwahangno,  
Yusung-Gu, Daejeon, 305-333, Korea*

### Introduction

KSTAR (Korea Superconducting Tokamak Advanced Research) is a superconducting tokamak constructed at the National Fusion Research Institute (NFRI) in Daejeon, Korea. KSTAR has accomplished its 1<sup>st</sup> campaign of about 1000 plasma shots using H<sub>2</sub> with ~100 kA plasma current and duration less than 1 s in 2008 [1]. As shown in Figure 1, the vacuum vessel is made of stainless steel (316LN) with graphite plasma facing components (PFC) that cover small part of the high field side in-board (in-board limiter) and ICRH antenna protection (poloidal limiter). Thus in the 1st campaign, large area of in-vessel was metal surface.

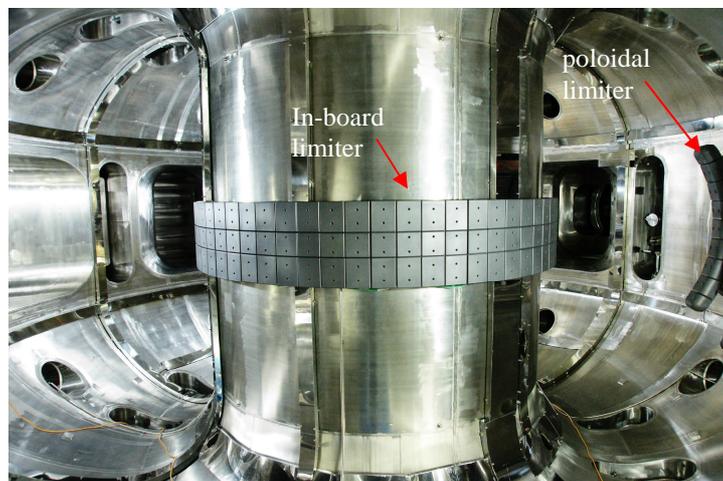


Figure 1. KSTAR vacuum vessel in 1<sup>st</sup> campaign. Small part of in-board was covered by graphite limiter.

PFCs experience plasma-wall interaction during plasma shots, such as ion recycling, capture, reflection, erosion and re-deposition [2]. After the 1<sup>st</sup> campaign, it was found that stainless steel compounds were inhomogeneously deposited on the in-board limiter, poloidal limiter, mirror of the

---

<sup>1</sup> sukhhong@nfri.re.kr

ECE antenna, ICRF antenna protection, and on the glow discharge electrodes. These indicate that the plasma-wall interaction was strong so that stainless steel was eroded, sputtered, transported and deposited. In this paper, we report the plasma-wall interaction occurred during the 1<sup>st</sup> campaign of KSTAR, especially about dust production with metal wall configuration.

### Dusts observed by visible CCD camera in the 1<sup>st</sup> campaign in KSTAR

During the campaign, a large amount of dust creation events (DCEs) were observed by in-vessel CCD camera. Figure 2 shows a KSTAR plasma shot (#1127) with a large amount dusts produced during the shot. The most of dusts in the 1<sup>st</sup> campaign would be produced by arcing on the metal walls and by disruptions: It was the very first plasma operation in KSTAR. Erosion and re-deposition of carbon on the wall was so low that no thick carbon layer is found in the vessel. Thus, flaking of carbon layers was not observed.

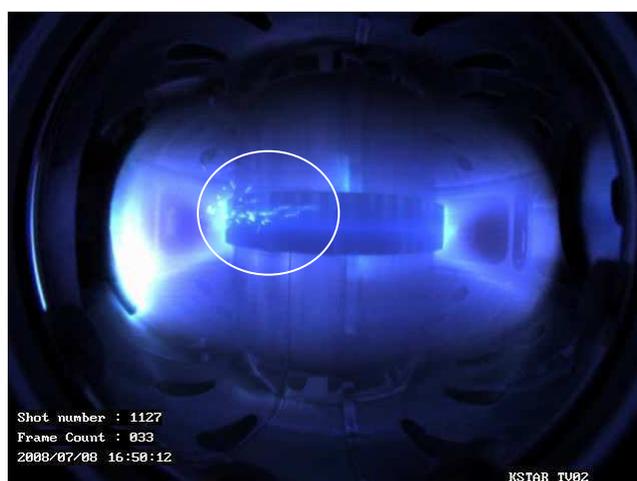


Figure 2. dust creation events in KSTAR vacuum vessel detected by visible CCD camera in 1<sup>st</sup> campaign (in circle).

### Dusts collected after the 1<sup>st</sup> campaign in KSTAR

We have collected KSTAR in-vessel dusts from 10 different in-vessel positions (at each port) by using sticky carbon tapes prepared for SEM measurements. Collected samples were analyzed by SEM to obtain size distribution and by Electron Probe Micro Analysis (EPMA) to identify the chemical composition. Figure 3 shows a SEM picture of in-vessel dusts collected from KSTAR. From the EPMA measurements of the dusts, C, Fe, Cr, Ni, Cl, Au, Ag, Si, and etc were found (data not shown here). Table 1 shows the chemical composition of stainless steel (316 LN) used for vacuum vessel. Comparing the elements with that in the table 1, dusts of several micro-meter-size were made of metal pieces that have almost identical composition as vacuum vessel. Broken pieces of graphite were also observed.

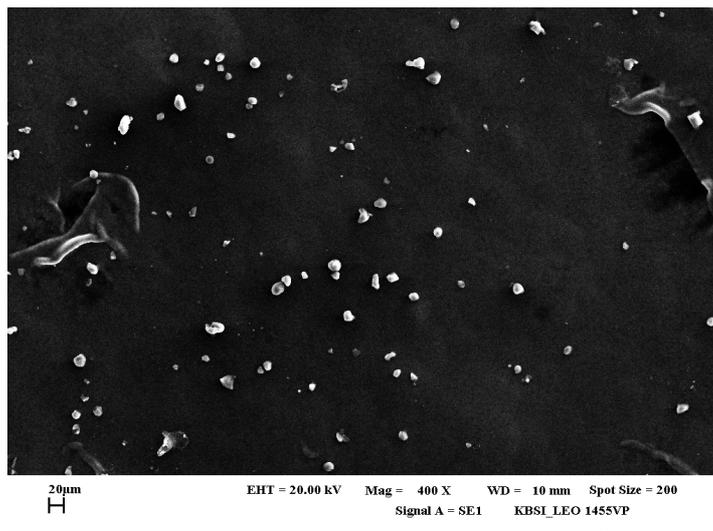


Figure 3. KSTAR in-vessel dusts collected by carbon tape.

component	C	Si	Mn	P	S	Ni	Cr	Mo	N	Co
ASME code	0.03	0.75	2.0	0.045	0.03	10.0	16.0	2.0	0.10	0.25
	max	max	max	max	max	max	max	max	max	max
KBSI requirements	0.02	0.75	2.0	0.03	0.015	10.0	16.0	2.0	0.10	0.25
	max	max	max	max	max	~14.0	~18.0	3.0	~0.16	max

Table 1. Chemical composition of stainless steel (316LN) in weight %

By analyzing the size of the dusts, two different size distributions were identified: one has peak at 100 nm and the other at 2 µm. The results were compared with known dust size distribution database [3].

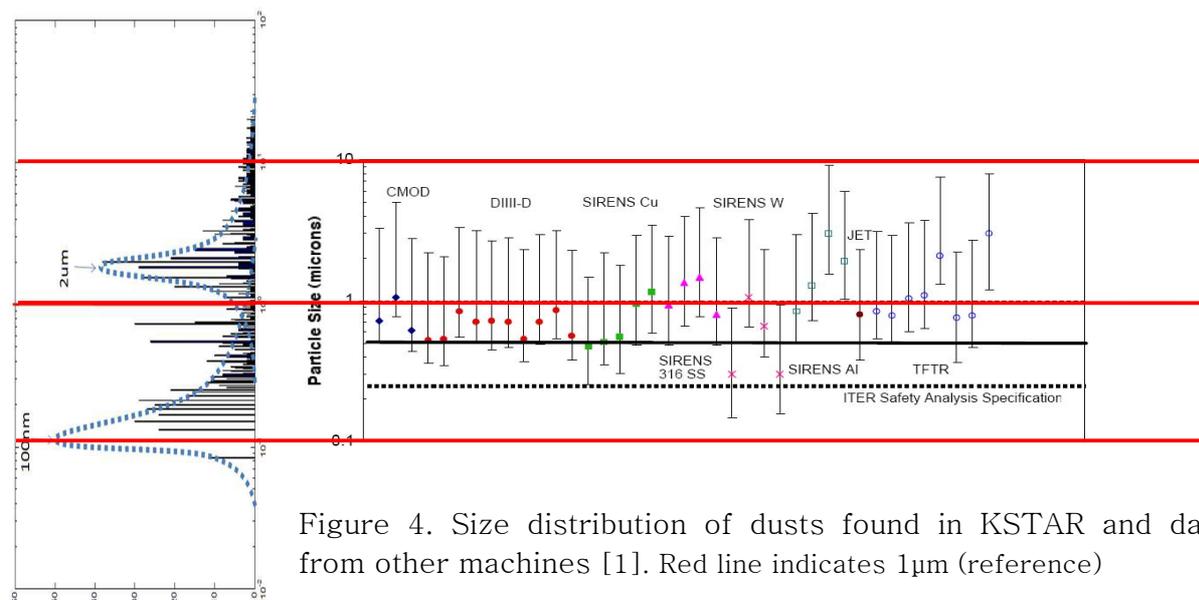


Figure 4. Size distribution of dusts found in KSTAR and data from other machines [1]. Red line indicates 1µm (reference)

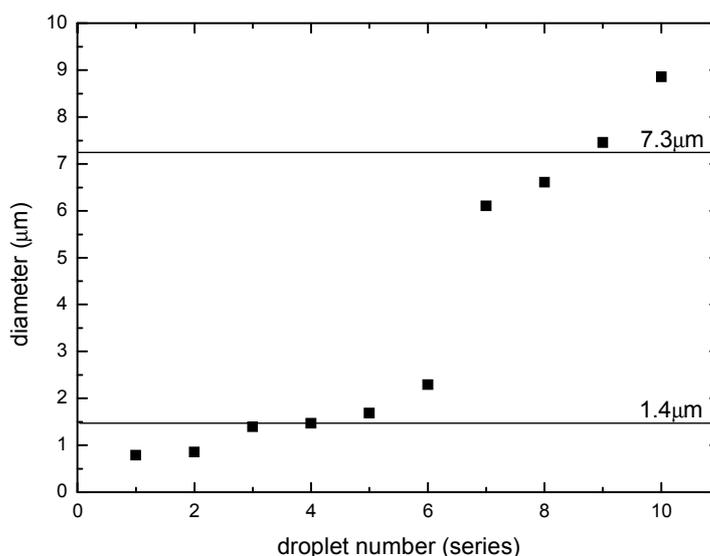


Figure 5. Size distribution of metal droplets found in KSTAR after the 1<sup>st</sup> campaign.

10 metal droplets from different port locations were found by SEM analysis. Two different groups of mean diameters were identified: one at 1.4  $\mu\text{m}$  and the other at 7.3  $\mu\text{m}$ . Metal droplets are in many cases produced by arcing (and probably during disruptions with high heat load on the wall), thus, the size of the metal droplets is connected to the strength of arcs (erosion, thus number of metal molecules in unit volume) and the lifetime (growth). Thus, there would be at least two different types of arcs (or other creation mechanism of metal droplets) in the 1<sup>st</sup> campaign of KSTAR.

### Conclusion

We have reported the statistics on dusts in KSTAR after the very 1<sup>st</sup> campaign. Dusts found were mostly metal, which is due to the strong interaction between plasma and the main vacuum vessel. The statistics on KSTAR in-vessel dusts will have an important meaning because one can build up statistics of temporal evolution of dust size, shape, or chemical composition changes caused by in-vessel components upgrades.

### Acknowledgment

We thank the Korean Basic Science Institute for the use of SEM and EPMA.

### References

- [1] Y.-K. Oh et al., Fusion Engineering and Design, Vol. 84, No 2-6, (2009) 344
- [2] G. Federici et al., "Plasma-material interactions in current tokamaks and their implications for next step fusion reactors", Nuclear Fusion, Vol. 41, No 12R, (2001) 1967
- [3] "Generic Site Safety Report – Volume III – Radiological and Energy source terms – July 2004", G 84 RI 3 R0.2