Investigation of D2 Ion Incident Angle Effect on W Blister and Dust Generation

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The Deuterium flux entering the entire ITER diverter area is more than $10^{20}m^{-2}s^{-1}$, thus blister generation is expected within minutes of fluences exceeding $10^{23}m^{-2}s^{-1}$ in all diverter areas except for the strike point where the surface temperature rises very high.(> 1000K)[1] In particular, small blisters having a diameter of less than 1 μ m are easily broken by sputtering and generate dust particles.[2][3] Dust particles become toxic substances including tritium or cause radiation to cause core plasma to collapse.[4] Dust particles caused by blister destruction are generated at low hydrogen dose, low temperature tungsten condition so the entire area of the diverter may be a region vulnerable to dust particle generation. Previous studies have reported that small blisters only occur in grain with (111) plane orientation.[2][5] These results dealt with when hydrogen ions were incident perpendicularly to tungsten, but ion flux is tilted to the diverter by a strong magnetic field. This study showed a grain orientation change in which small blisters are generated and directionality of blister destruction when the incident angle of ions is tilted by a magnetic field. ECR deuterium plasma was used as the magnetized ion source and ion energy was set as 100eV by applying DC bias voltage to the tungsten target. The incident angle of the ions was calculated by the Ahedo's magnetic sheath model, which consider the ion-neutral collision term. Small blisters were produced at (111) and (212) grain orientations when deuterium ions were incident at a 17-degree incident angle. Since the (212) grain is rotated about 16 degrees from the (111) grain, it appears as (111) in terms of ions with an incident angle of 17 degrees. In the tungsten BCC crystal structure, it is interpreted that a small blister is produced on the (212) grain with the lowest surface density and a high ion permeability with channeling [6] in the direction of incident ions. Deuterium adsorbed on the surface on (111) grains migrate toward the tungsten bulk.[7] It will be demonstrated that blisters are generated on (111) grain regardless of the incident angle of ions by using single crystal tungsten. Blister destruction was observed with increasing ion fluence. Unlike the vertical incidence condition where the blister breaks in a random direction[2], directionality occurs under the tilted ion incidence condition. The directions of destruction are ion-facing side and ion-backed side. The difference in the sputtering yield due to the difference in the incident angle causes asymmetry in the location and size of the fracture of the ion-facing side and the ion backed side. In conclusion, the area in which small blisters can be produced and the direction of destruction are determined by the incident angle of the ions. Therefore, in order to know the amount of blister and dust particles generated on the diverter, the incident angle of the deuterium ions formed in the magnetization sheath should be considered. For the quantitative analysis of dust particle, the study will be conducted on the magnetic sheath model and the distribution of dust particle size generated by blister destruction.

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