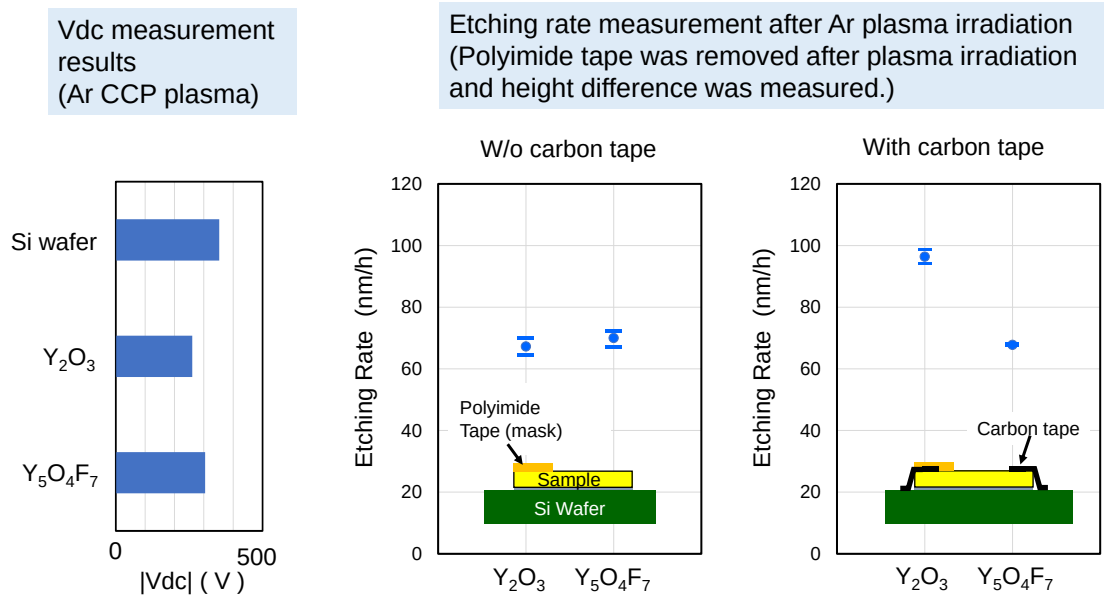
On the Self-bias Voltages at Sintered Yttrium Oxyfluoride (Y-O-F) and Y_2O_3 During Plasma Irradiation and Their Etching Rates due to Ion Bombardment

Tetsuya Goto, Tohoku University, Japan.
Yoshinobu Shiba, Tohoku University, Japan.
Akinobu Teramoto, Hiroshima University, Japan.
Yukio Kishi, Nippon Yttrium Co., Ltd, Japan.
Shigetoshi Sugawa, Tohoku University.



Abstract

Yttrium oxyfluoride (Y-O-F) has been received much attention as the bulk and/or coating materials for functional components used in the plasma process chamber in semiconductor manufacturing, because chemical component stability of Y-O-F against various corrosive plasmas is better than that of widely used Y_2O_3 [1-3]. In addition to the chemical component stability, etching rate of these materials is also an important issue when particle problem and lifetime of the components are considered in industry. Previous report has shown that the etching rate of Y-O-F and Y_2O_3 due to plasma irradiation is almost the same level [2]. On the other hand, we reported that, the etching rates of the sintered Y-O-F due to the Ar ion beam irradiation (without plasma) was clearly smaller than that of Y_2O_3 [3]. We speculated that such tendency was caused by higher atomic number density of Y-O-F than that of Y_2O_3. Thus, the etching behavior of Y-O-F and Y_2O_3 was different between the cases of the ion beam irradiation and the plasma irradiation.

In this report, to understand the observed difference in more detail, we measured self-bias voltage

V_{dc} of surfaces of Y-O-F and Y_2O_3 samples set on Si wafer in 13.56-MHz excited capacitive coupling Ar plasma. Here, V_{dc}, which is approximately an acceleration voltage of ions, is a good parameter to estimate ion bombardment energy at the sample surface. It was found that $|V_{dc}|$ of Y_2O_3 was smaller than that of Y-O-F, suggesting that surface voltage condition was different under the normal setup of the samples for the plasma irradiation test. In this setup, etching rates of Y-O-F and Y_2O_3 due to Ar plasma irradiation were found to be almost the same.

Next, to equalize the surface voltages of Y_2O_3 and Y-O-F during the plasma irradiation as far as possible, we connected the sample surface and the Si wafer surface using electrically-conductive carbon tape. In this case, it was found that the etching rate of Y-O-F was smaller than that of Y_2O_3, showing the same behavior to the Ar ion beam etching experiment.

The results suggested that the intrinsic etching resistance of Y-O-F due to the ion bombardment is better than that of Y_2O_3. Also, the results showed the importance of how the sample was set in the plasma irradiation test to accurately estimate plasma resistance. Furthermore, it is considered that, in the actual plasma equipment, plasma resistance depends strongly on how the protect material was set or coated.

1. Y. Shiba et al, J. Vac. Sci. Technol. A, 35 (2017) 021405.
2. H. Ashizawa and K. Yoshida, Int J Appl Ceram Technol. (2021) 1.
3. T. Goto et al., J. Vac. Sci. Technol. A, 38 (2020) 043003.