NO2を用いたSi系材料の低速ケミカルドライエッチング中の表面反応
Surface etching during the slow Si etching using F2 and NO2

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【Introduction】We have been investigating Si chemical dry etching using the F generated from the reaction of F2 + NO2 → F + FNO2 to remove the plasma-induced damaged layer around the gate electrode [1-3]. Previously we evaluated the gas phase reaction of F2 and NOx (X = 1, 2) using the density functional theory and found that generation of F was significantly low when NO2 was used instead of NO due to the restriction of the reaction space by the presence of two oxygen[3]. Furthermore, the reproducible Si etching by F2 + NO2 is challenging since the NO2 tend to be lost by the reaction of 2NO2 ↔ N2O4. [4] Our preliminary results show that maintaining the gas line and the chamber wall temperature is much critical when Si etching was performed using NO2 instead of using NO. In this study, we varied the chamber wall and the substrate temperature separately and evaluated the change in etch rate and the surface reaction to obtain the reproducible ~nm/min slow etching.

【Experimental】p-type and non-doped Si(100) 10 x 10 mm2 samples were prepared and placed in the Pyrex tube etching apparatus. The total of 107 sccm of Ar/10%F2 + NOx were introduced to the etching apparatus and the pressure was maintained at 600 Pa during the process time of 30 ~ 60 min. The chamber was heated at 80 °C while the substrate temperature was varied from 150 ~ 350 °C. The vertical etch rate, E, was measured by scanning electron microscopy (SEM) and the surface chemical bonding structure was measured by Fourier transform infrared spectroscopy (FTIR).

【Results & Discussion】Figure 1(a) shows the preliminary results of the E vs with respect to the substrate temperature. The E obtained from the Si that was exposed to F2 and NO2 was in the range of 10 nm/min to 200 nm/min when the substrate temperature was varied from 150 °C to 350 °C. This E value was one to two order of magnitude smaller than the E obtained from the Si exposed to F2 + NO. Figure 1(b) shows the FTIR spectra measured from the non-doped Si samples exposed in F2 + NOx. Si-F stretching peak was not observed but Si-O stretching peak position shifted to the low wavenumber and the peak width became broad when Si was exposed in F2 and NO2, indicating that the possible formation of Si-NO bond at the surface. Further investigation of the molecules present at the Si surface exposed in F2 + NO2 are in progress.


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