Electrical characterization of dry etch-induced damages of 4H-SiC reactively ion-etched in SF_6/O_2 plasma

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The plasma-based dry etching techniques are now widely used to fabricate electronic devices. The electrical property of surface is degraded after dry etching process because of the etching induced damages such as surface roughness, residual contaminants and surface defects caused by the energetic ion bombardment and other chemical species. Therefore, it is necessary to understand the formation characteristics of etch-induced damages and to decrease the etching induced damages for the better device performance. There are a few reports about the effects of etching process on the electrical properties of SiC Schottky barrier diodes(SBD's) [1-5]. However, there have been few studies relating the effect of etchant chemistry to the electrical performance of SBD's and also to the damage creation of the SiC surface.

In this study, we investigated the device performance of 4H-SiC Schottky diodes fabricated on the reactive ion etched(RIE) surface under various etching conditions, especially concerning the oxygen amount in the feeding gas chemistry. The chemical species of residues on the etched surface after RIE process was revealed by Auger electron spectroscopy(AES). The surface roughness before and after etching process was evaluated by the atomic force microscopy(AFM). The deep level transient spectroscopy (DLTS) was performed to quantitatively analyze the etching induced damages created during the RIE process.

Fig. 1 shows the I-V characteristics of as-grown Au/Ti Schottky diodes fabricated on the RIE etched surfaces. It is found that the higher oxygen content in the SF_6/O_2 etchant gas mixtures is, the lower the reverse leakage current level is. However, the as-grown diodes on etched surfaces displayed a rather leaky I-V characteristic compared to that on unetched surfaces.

The root-mean-square (RMS) roughness of etched surfaces was reduced from 5.3Å to 3.9Å as oxygen concentration increased from 20% to 80 % in the total gas flow, as shown in Fig. 2.

Table. 1 is the result of AES surface analysis, which shows the variation of surface composition as the increment of oxygen percentage in the input gases.

The DLTS measurements showed that the amount of created defects during etching process was systematically related with the chemical characteristics of input gas mixtures.

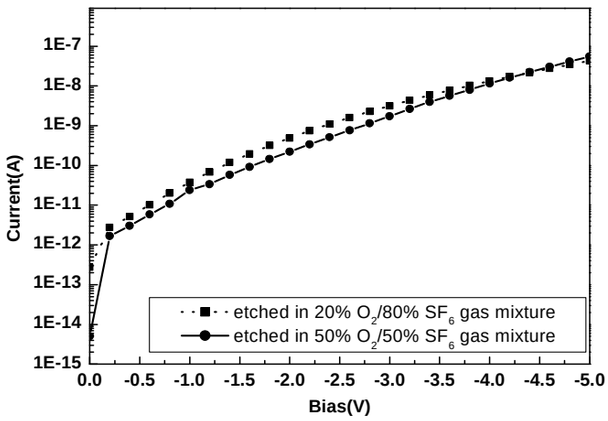

Fig. 1 Reverse I-V characteristics Au/Ti/4H-SiC Schottky diodes fabricated on the etched surfaces with 20% and 50% oxygen addition into etchant gas chemistry

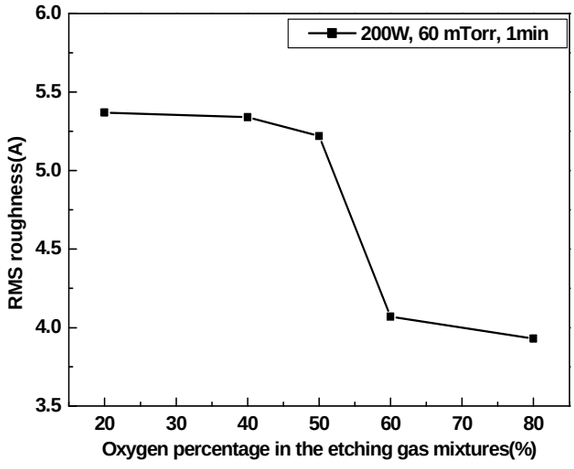

Fig. 2 The RMS roughness as a function of oxygen contents in the feeding gases

O_2:SF_6 ratio	C1	N1	O1	F1	Si2	S1
2 : 8	27.47	-	6.59	0.95	62.81	2.18
4 : 6	29.25	-	7.56	-	61.29	1.78
5 : 5	29.63	-	7.56	0.94	59.39	2.38
6 : 4	30.28	2.45	7.68	0.93	55.72	2.94
8 : 2	3.18	-	56.79	-	40.03	-

Table. 1 The surface composition of 4H-SiC etched in the SF_6/O_2 plasma with a variation of oxygen flow rate

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