APPLICATION OF CF_4 PLASMA ETCHING TO $Ta_{0.5}Al_{0.5}$ ALLOY THIN FILM

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ABSTRACT

Reactive ion etching(RIE) of Ta-Al alloy thin film with a thickness of 1000 Å was studied. It was confirmed that CF_4 gas could be used effectively to etch the Ta-Al alloy thin film. The etching rate of the thin film at a Ta content of 50 mol% was about 67 Å/min. No selectivity between the Ta-Al alloy thin film and SiO_2 thin films was observed during the etching with the CF_4 gas and the etching rate of the SiO_2 layer was 12 times faster than that of the Ta-Al alloy thin film. In addition, it was observed that photoresist of AZ5214 was more useful than Shiepley 1400-27 in RIE with the CF_4 gas.

INTRODUCTION

Ta-Al metal alloy forms the basis for imaging system. Ta-Al metal alloy, which composition is 1:1, is stable chemically. The alloy also keeps a constant resistance while AlSi(1%) metal alloy shows a linear variation with temperature increasing. The phenomenon is not proved distinctly yet. We considered it not because the alloy represent only characteristics of one element but because the refractoriness of Ta and high conductivity of Al interact.

When Ta-Al metal alloy is applied to display device, the alloy has to be patterned with micro-dimensions and etching process is typical. Etching process is the process to form a micro pattern. There are two types of etching; one is wet etching and the other is dry etching. If wet etching is applied to etch Ta-Al metal alloy, there are many difficulties because the etch rates between Ta and Al are different and the etching solution of each is also different. Dry etching, therefore, is used as a method to form a micro-pattern on Ta-Al metal alloy. Figure 1 shows the schematic diagram of primary processes in plasma etching.

There are many methods in plasma etching - for example, sputtering, Reactive ion etching, Ion beam etching(IBE), etc. Especially, Reactive ion etching(RIE), which has high etch rate and superior selectivity as compared with sputtering and IBE, is a significant method and selection of gas is the most important. In case of etching alloy - especially, the composition is 1:1, the characteristics of the alloy are very different from the state before alloying, selection of etching gas is restricted.

In this study, we use CF_4 gas which is a etching gas of refractory metal as we notice that Ta give a chemical stability in Ta-Al metal alloy. We also observe the etching trend of CF_4 gas on Ta-Al metal alloy thin films.

EXPERIMENTALS

Ta-Al metal alloy thin film (thickness = 1000 Å) was deposited on SiO_2 layer (1.6 ㎛) ,which was grown on semi-insulating Si substrates by thermal chemical vapor deposition, by RF sputtering method. Wafers were lithographically patterned with Shiepley 1400-27 and AZ5214 photoresist to produce features with dimensions between 5 ~ 40 ㎛. The etching was performed in a NE500c system.

Etch rates were measured by α-step of the largest features after removal of the resist in ALEG 355 PR stripper. Scanning electron microscopy (SEM) and α-step were used to examine the surface morphology and etching depth of the etched samples.

RESULTS AND DISCUSSION

Resulted from etching by Table 1, Figure 2 shows the SEM micrographs of tilted cross-sectional features etched into CF_4 with 30 mTorr. Fig. 2(a), 2(b) and 2(c) shows that etching is not ended while Fig. 2(e) shows overetching. Fig. 2(d) shows that etching depth is 1000 Å. In each figure, the etching depth was measured by scale method and the etch rate was calculated with the measured etching depth. By this way, the calculated etch rate of Ta-Al metal alloy thin film with a thickness of 1000 Å is about 67 Å/min. When the etch rate of SiO_2 layer was calculated, 15 min was taken as a starting point and 20 min as a end point. That is the total time in etching SiO_2 layer is 5 min and measured etching depth is 4000 Å. The etch rate of SiO_2 layer, therefore, is calculated about 800 Å/min. From these results, the etch rate of SiO_2 is 12 times faster than that of Ta-Al metal alloy thin film.

Fig. 3 shows the variation of etch rate as a function of time. The etch rate is decreasing with time increasing. The etch rate, however, is increasing after 13 min. In this fact, we consider that the chemical etching acts mainly from critical point after 13 min. In RIE, there are both physical etching and chemical etching. In beginning of etching, the physical etching acts mainly. However, the more etching, the more chemical etching acts mainly. The etching trend by time, therefo re, shows like Figure 3.

Fig. 4 shows the photographs after photoresist stripping. ALEG 355 PR stripper is used with no rubbing, no ultrasonic. Shiepley 1400-27 (a) is not stripped while AZ5214 (b) is stripped clearly as seen in Figure. The coating thickness of Shiepley 1400-27 is 1.3 ㎛ and that of AZ5214 is 1.2 ㎛. The stripping is performed in same conditions but the results are different. From this, photo resist of AZ5214 was more useful in RIE with the CF_4 gas than photo resist of Shiepley 1400-27. In Fig. 4(a), photoresist is looked like either PR burning or interaction with Ta-Al alloy layer. This is not observed distinctly yet.

Figure 5 shows the uniformity in a wafer by α-step scan. In case of RIE for 15 min, the etching depth is constant while the etching depth shows linear variation for 20 min. The etching uniformity is affected by deposited conditions of thin film and gas flow rate. The linear variation shows that the gas flow rate(60 sccm) is large and even though that gas flow rate(60 sccm), the etching uniformity is achieved in RIE for 15 min.

CONCLUSIONS

Reactive ion etching(RIE) using CF_4 gas is effective for Ta-Al metal alloy thin film with a thickness of 1000 Å and the etch rate is about 67 Å/min, 1/12 slower than that of SiO_2 layer. This is achieved at conditions of CF_4 60 sccm, 30 mTorr. It is also achieved that photoresist AZ5214 was more useful in RIE with the CF_4 gas than photoresist Shiepley 1400-27. When the etching is performed at the conditions of CF_4 60 sccm, 30 mTorr, 15 min, the uniformity in a wafer is achieved.

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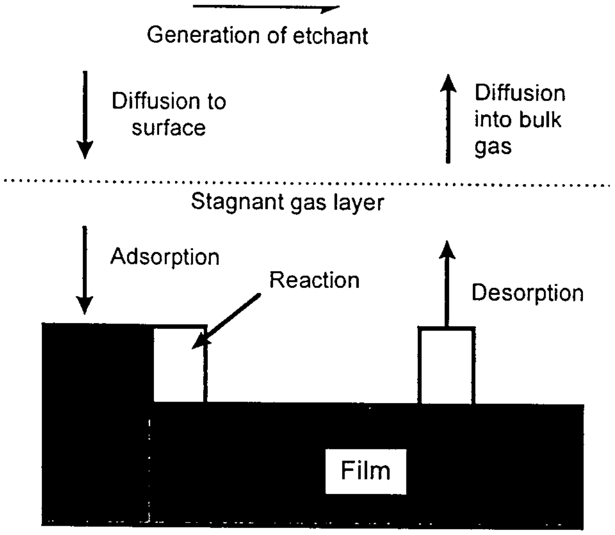


Fig. 1. Schematic diagram of primary processes in plasma etching, from Ref.(2)

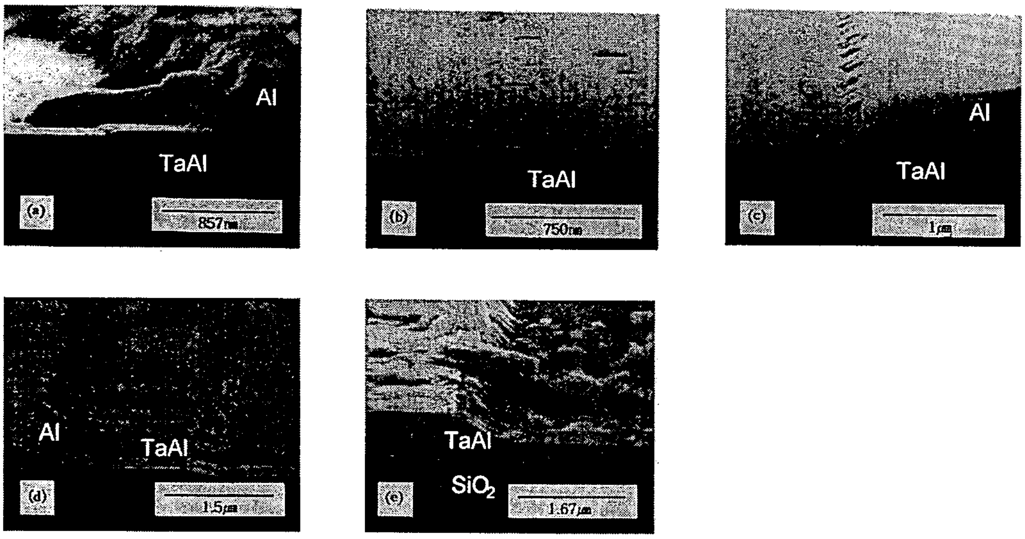


Fig. 2. SEM micrographs of cross-sectional features etched using CF_4 60 sccm, 30 mTorr, 400 volts; (a) 5 min, (b) 10 min, (c) 13 min, (d) 15 min, (e) 20 min

Table 1.Reactive ion etching condition of Ta-Al alloy thin film

Parameter	Value
Gas flow rate	CF_4 60 sccm
Working pressure	3.99 Pa
In. Power	600 watts
Re. Power	0.7 watts
Bias Voltage	400 volts

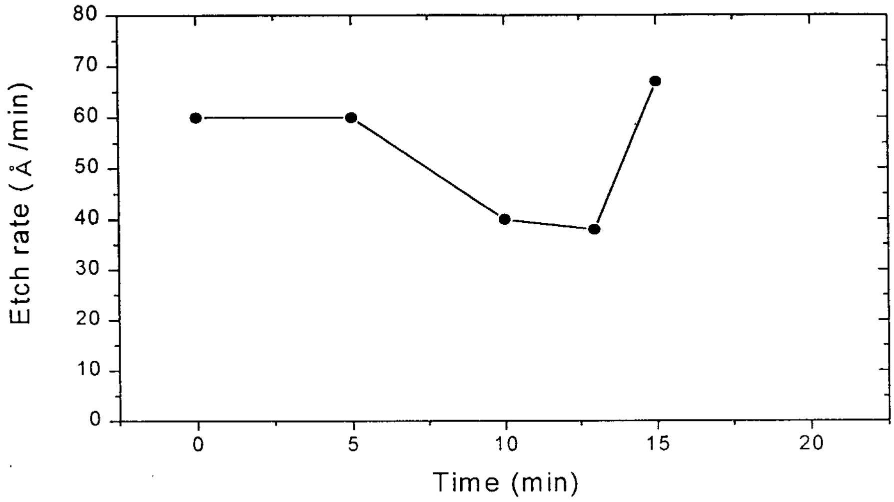
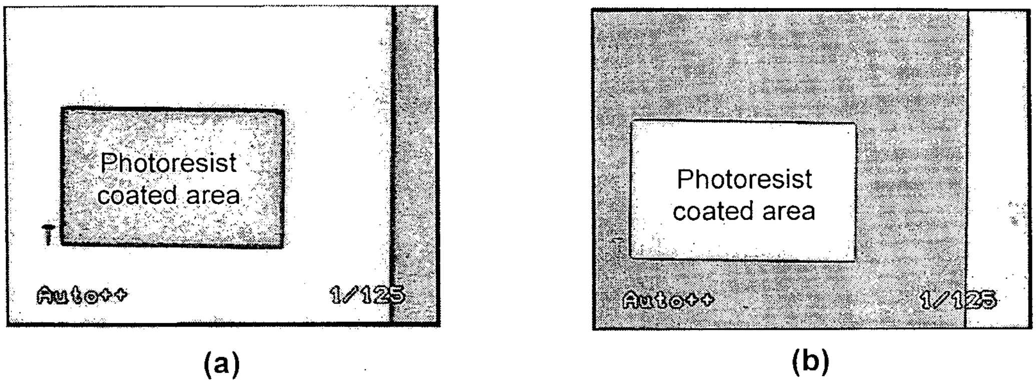


Fig. 3. Etching rate of Ta-Al metal alloy as a function of time in CF_4 60 sccm, 30 mTorr, 400 volts.



(a) (b)

Fig. 4. Micrographs of features after the photoresist stripping using ALEG 355 PR stripper. ; (a) Shiepley 1400-27, (b) AZ5214

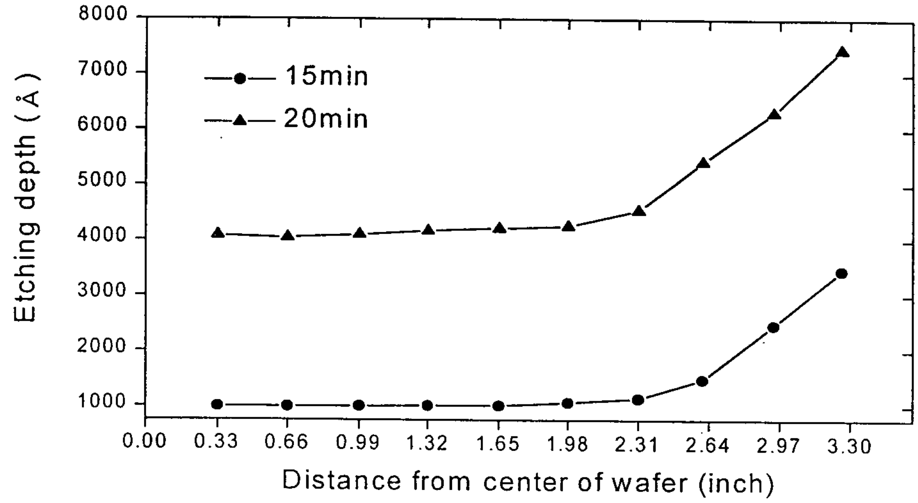
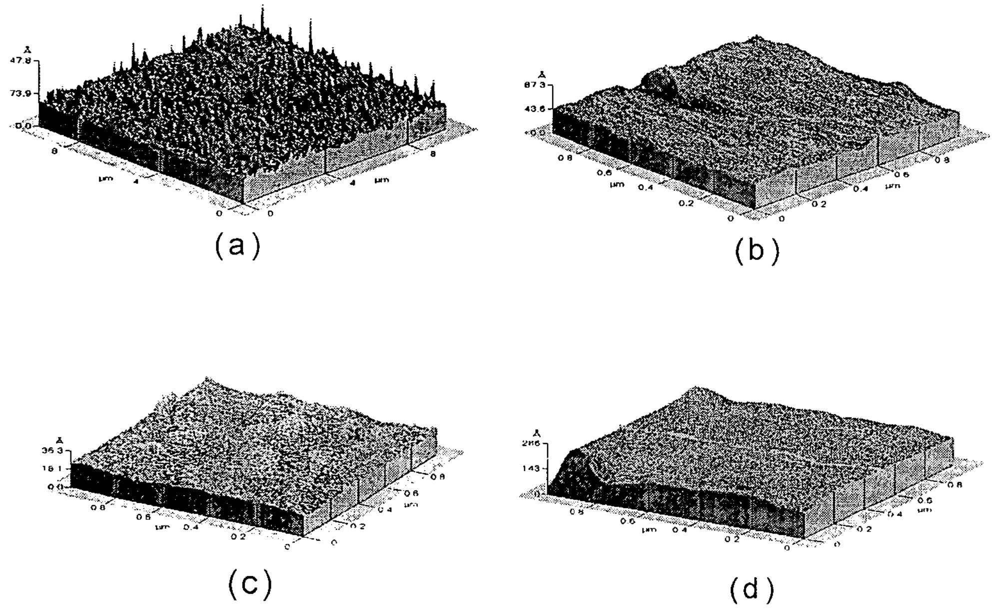


Fig. 5. Distribution of the etching depth in wafer.



(a) (b)

(c) (d)

Fig. 6. AFM images of the etched surface; (a) 5 min, (b) 10 min, (c) 13 min and (d) 15 min in CF_4 60 sccm, 30 mTorr, 400 volts.