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Application of CF_4 plasma etching to $Ta_{0.5}Al_{0.5}$ alloy thin film

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CF_4 기체를 이용한 $Ta_{0.5}Al_{0.5}$ 합금 박막의 플라즈마 식각

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

요 약 Ta-Al 합금 박막의 건식식각에 대하여 조사하였다. CF_4 기체를 이용한 반응성 이온 식각(Reactive Ion Etching, RIE)이 1:1 조성의 Ta-Al 합금 박막의 식각에 적용될 수 있음을 확인하였으며, 식각속도는 67 Å/min으로 측정되었다. 그리고 CF_4 기체는 Ta-Al 합금 박막과 SiO_2 층간에 선택성이 없다는 것이 확인되었으며, SiO_2 층의 식각속도는 Ta-Al 박막의 경우보다 약 12배 빠른 800 Å/min으로 측정되었다. 그 외에 CF_4 기체를 이용한 반응성 이온 식각에서는 Shiepley 1400-27 Photo Resist 보다 AZ 5214 Photo Resist가 더 안정적이라는 것이 조사되었다.

1. Introduction

Ta-Al metal alloy formed the basis of an imaging system. Ta-Al metal alloy, consisting of 1:1 ratio of Ta and Al, is chemically stable. The alloy also kept a constant resistance while AlSi (1%) metal alloy showed a linear variation with increasing temperature, although the phenomenon was not proved yet. We considered this might be due to the refractoriness of Ta and high conductivity of Al interact, rather than any effect of one element.

When Ta-Al metal alloy was applied to display device, the alloy had to be patterned with micro-dimensions, and thus etching process was typical. The etching 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 of 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 a high etch rate and superior selectivity as compared to sputtering and IBE, is useful method and the selection of gas is the most

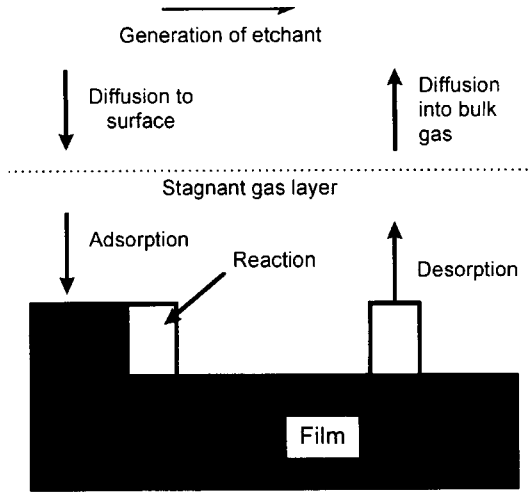


Fig. 1. Schematic diagram of primary processes in plasma etching, from Ref. (2).

important. In the case of etching alloy, 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.

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

2. Experimentals

Ta-Al metal alloy thin film (thickness = 1000 Å) was deposited on SiO_2 layer (1.6 μm) ,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 μm. 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.

3. Results and discussion

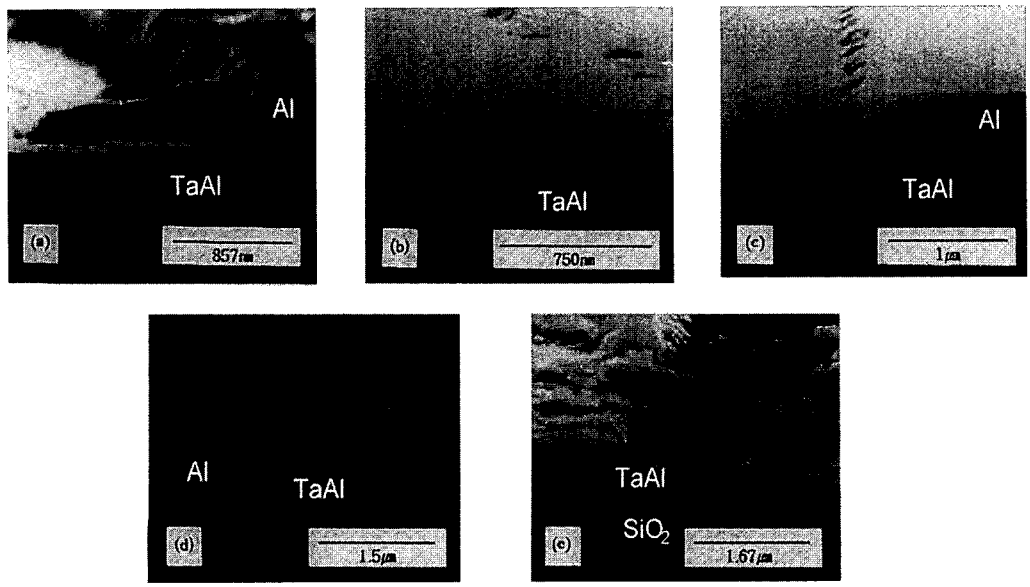


Fig. 2. SEM micrographs of cross-sectional features etched using CF_4 60 sccm, 30 mtorr, 400 volts; (a) 5 min, (b) 10 min, (c) 13 min, (d) 15 min, (e) 20 min.

Resulted from etching by Table 1, Fig. 2 shows the SEM micrographs of tilted cross-sectional features etched into CF_4 with 30 mtorr. Figure 2 (a), 2 (b) and 2 (c) shows that etching was not ended while Fig. 2 (e) shows overetching. Figure 2 (d) shows that etching depth is 1000 Å. In each figure, the etching depth was measured by scale method and the etching rate was calculated with the measured etching depth. By this way, the calculated etch rate of Ta-Al metal alloy thin film with a

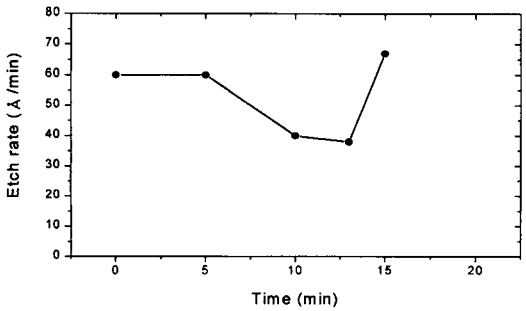
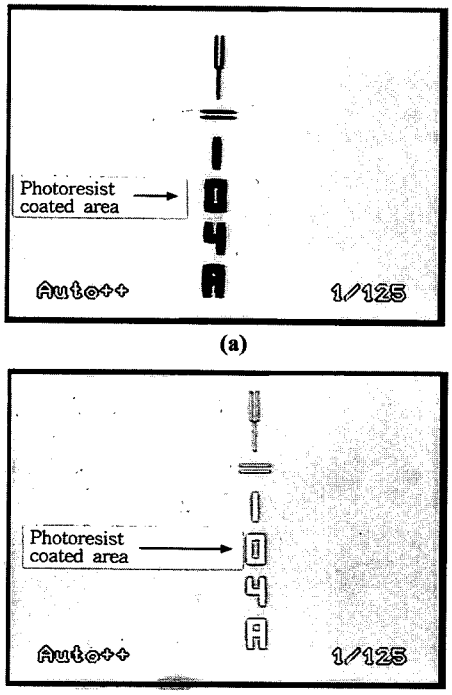


Fig. 3. Etching rate of Ta-Al metal alloy as a function of time in CF_4 60 sccm, 30 mtorr, 400 volts.



(a)

(b)

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

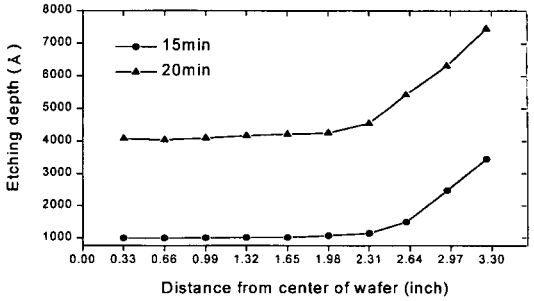
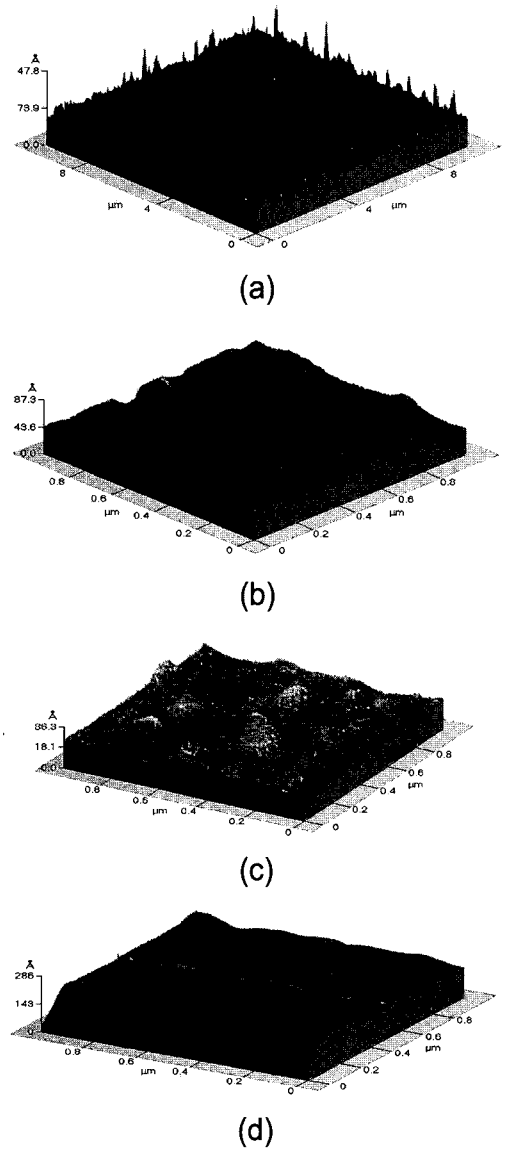


Fig. 5. Distribution of the etching depth in wafer.



(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.

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 meant the total time for etching SiO_2 layer was 5 min and measured etching depth was 4000 Å. The etch rate of SiO_2 layer was calculated about 800 Å/min. From these results, the etching rate of SiO_2 was 12 times faster than that of Ta-Al metal alloy thin film.

Figure 3 shows the variation of etch rate as a function of time. The etching rate decreased with increasing time. The etching rate, however, increased after 13 min. This might be due to the loading effect. Figure 4 shows the photographs after photoresist stripping. ALEG 355 PR stripper was used with no rubbing and no ultrasonic. Shiepley 1400-27 (a) was not stripped while AZ5214 (b) was stripped clearly as seen in Figure. The coating thickness of Shiepley 1400-27 is 1.3 μm and that of AZ5214 was 1.2 μm. The stripping was performed in same conditions but the results were different. From this, photoresist of AZ5214 was more useful in RIE with the CF_4 gas than the photoresist of Shiepley 1400-27. In Fig. 4 (a), the photoresist could be caused by either PR burning or interaction with Ta-Al alloy layer. This was 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 was constant while the etching depth shows linear variation for 20 min. The etching uniformity was influenced by the deposition 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.

4. Conclusions

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

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