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실리콘 옥시나이트라이드의 플라즈마 식각 마이트로 트렌치
Etch Microtrenching of Silicon Oxynitride

김병환[a*],이병택[b]
[a]세종대학교 전자공학과· [b]전남대학교 재료과학 공학과

1. Introduction

Silicon oxynitride (SiON) films have been extensively studied since SiON is a promising material for manufacturingoptical and electronic devices. In manufacturing optical waveguides, SiON films enable a high refractive index contrast to be achieved between the core and cladding layers. Other features attractive for manufacturing microelectronic devices include the low density of surface states, high dielectric permittivity, and the controllability of band energy in terms of [O]/[N] ratio [1]. SiON films etched in a C_2F_6 inductively coupled plasma (ICP) have been recently studied as a function of process parameters [2]. Unfortunately, a particular microtrenching occurred near the base of etched patterns. The microtrenching was examined by constructing an analytical model [3] and neural network model [4]. The first two approaches are somewhat limited in that they were evaluated with a few of etching patterns. Also, the neural network model provided a qualitative model of maximum microtrenching depth. To gain insight into microtrenching, another important feature (i.e., width) should be investigated in conjunction with the depth. In this study a silicon oxynitride film was etched in a C_2F_6 inductively coupled plasma and microtrenchings of etched features were studied experimentally as a function source power and bias power. A microtrenching geometry (MG) was characterized in terms of the depth and width. Etch mechanisms are examined as well as certain relationships between the depth and width.

2. Results

Test patterns were fabricated on SiON wafers. Using a plasma-enhanced chemical vapour deposition system, SiON films were deposited to 4.09 ㎛ thickness at 150 W rf power, 135 sccm N_2O flow rate, and 45 sccm SiH_4 flow rate, 350 °C substrate temperature, and 26.6 Pa pressure. To fabricate a Ni mask layer, photo resist patterns were first formed. The magnetron sputtering method was used to subsequently deposit Ni films of 0.3 ㎛ thickness on the patterned photoresist. The sputtering continued for 1 hr at 1.06 Pa pressure, 100 W rf power, and 6 sccm Ar flow rate. By removing the photoresist with acetone, an Ni mask layer was formed. The SiON films were etched in a C_2F_6 ICP. In all experiments, the etching time was set to 10 minutes. Using a scanning electron microscope (SEM), both depth and width of the microtrenching were measured. To facilitate the interpretation of the microtrenching, the profile angles were also measured using the SEM.

The depth increased with increasing the source power from 400 to 800 W. The profile angle increased from 81° at 400 W to 84° at 800 W. The larger profile angle enables more ions to focus on the profile sidewall. Moreover, the profile at 800 W was bowed. The bowed sidewall is likely to concentrate more ions onto the profile base [5]. All these variations serve to increase the depth, which explain the increased depth at 800 W. In contrast, the depth decreased with increasing the source power from 800 W to 1000 W. The profile angle decreased from 84 ° at 800 W to 81 ° at 1000 W. The decreased depth at 1000 W is therefore ascribed to the less ion concentration due to the formation of smaller profile angle. Over the entire range of source power, the profile angle variation played an important role in understanding the depth variation. The width is generally seen to increase with increasing the source power. Particularly, the width considerably increased with increasing the source power from 600 to 1000 W. The profile angle measured at 600 W is 81°, which was identical to that at 1000 W already presented. In this sense, both width and profile angle variations are little related.

As the bias power increased from 30 to 45 W, the depth increased from 300 to 950 nm. The profile angles measured at 30 and 45 W are 83° and 86°, respectively. The larger profile angle at 45 W can be ascribed to the enhanced ion bombardment effect as stated earlier. The profile angle at 45 W was also bowed. Hence, the larger depth at 45 W is ascribed to a bowing-induced localized flux of energetic ions at the feature bottom. In contrast, the depth decreased with increasing the bias power from 45 to 90 W. The corresponding profile angles decreased from 86° to 80°. Therefore, the decreased depth at 90 W can mainly be explained by the less ion concentration at the profile feet due to the more sloped sidewall. Meanwhile, the width appears to increase with increasing the bias power. The larger width at 90 W compared to that at 30 W can be attributed to the ions reflected more to the center between two patterns due to more sloped sidewall.

3. Conclusions

In a C_2F_6 plasma, silicon oxynitride films were etched and geometry of microtrenching was characterized as the maximum depth and width. The depth variation was strongly dependent on the profile angle variation. It is noticeable that a deeper depth was caused by a steeper profile (i.e. a larger profile angle). This indicates that the profile angle variation is an important factor to control the microtrenching of plasma etching.

References

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