고밀도 플라즈마를 이용한 $HfAlO_3$ 박막의 식각 특성 연구

Dry Etching Characteristics of $HfAlO_3$ Thin Films using Inductively Coupled Plasma

하태경, 우종창, 김창일†
Tae Kyung Ha, Jong Chang Woo, Chang Il Kim†
전자전기공학부, 중앙대학교
School of Electrical and Electronics Engineering, Chung-Ang University

Abstract : The etch characteristics of the $HfAlO_3$ thin films and selectivity of $HfAlO_3$ to SiO_2 in $Cl_2/BCl_3/Ar$ plasma were investigated in this work. The maximum etch rate was 108.7 nm/min and selectivity of $HfAlO_3$ to SiO_2 was 1.11 at Cl_2(3sccm)/BCl_3(4sccm)/Ar(16sccm), RF power of 500 W, DC-bias voltage of - 100 V, process pressure of 1 Pa and substrate temperature of 40 ℃. As increasing RF power and DC-bias voltage, etch rates of the $HfAlO_3$ thin films increased. Whereas as decreasing of the process pressure, those of the $HfAlO_3$ thin films were increased. The chemical reaction on the surface of the etched the $HfAlO_3$ thin films was investigated with X-ray photoelectron spectroscopy (XPS).

Key Words : Etch, $HfAlO_3$, ICP, High-*k*, XPS

1. 서 론

Metal-oxide-semiconductor field effect transistor (MOSFET) device scaling to smaller physical dimensions has led to continuous improvement in device performance. The continuous reduction in MOSFET dimensions requires simultaneous reduction in the thickness of the gate insulator SiO_2 [1]. As dimensions shrink, the gate insulator becomes so thin that charge tunneling result in leakage current [2]. One solution to the problem is the replacement of SiO_2 by high-*k* materials such as HfO_2, Al_2O_3, and ZrO_2. Although these materials have been identified as potential replacement SiO_2 due to high dielectric constant, no single material exists that surpasses the originally SiO_2 in all material property such as thermodynamic stability, recrystallization temperature, and band gap. One solution for the alloyed complex oxide gate dielectric material is employed. For example, the addition of Al in HfO_2 to form a $HfAlO_3$ has been shown to increase the recrystallization temperature to above 800 ℃ and the band gap to 6.5 eV as well as improve the thermodynamic stability.

In this study, the $HfAlO_3$ thin films were etched in $Cl_2/BCl_3/Ar$ inductively coupled plasma (ICP) by varying the gas mixing ratio, DC-bias voltage, RF power, and process pressure. The chemical reaction on the surface of the etched the $HfAlO_3$ thin films was investigated with X-ray photoelectron spectroscopy (XPS).

2. 결과 및 토의

In this study, using ICP, the etching trend of the $HfAlO_3$ thin films was investigated as functions of $Cl_2/BCl_3/Ar$ gas mixingratio, a RFpower, a DC-bias voltage and a process pressure. The maximum etch rate of the $HfAlO_3$ thin films was 108.7 nm/min and the selectivity of $HfAlO_3$ to SiO_2 was 1.11 at Cl_2(3ccm)/BCl_3(4sccm)/Ar(16sccm), RF power of 500 W, DC-bias voltage of - 100 V, process pressure of 1 Pa and substrate temperature of 40 ℃. This result can be influenced on the concurrence of chemical and physical pathways in the ion assisted chemical etching for the $HfAlO_3$ thin films. The surface analysis by XPS showed the chemical reactions effect on surface of $HfAlO_3$ was changed by addition of Cl_2 to BCl_3/Ar plasma.

참고 문헌

[1] A. I. Kingon, J. I. Maria, S. K. Streiffer, Nature. Vol. 406, p. 1032, 2000.
[2] G. D. Wilk, E. M. Wallace, J. M. Anthony, Appl. Phys. Vol. 89, p. 5243, 2001.

† 교신저자) 김창일, e-mail: cikim@cau.ac.kr, Tel:02-820-5334
주소: 서울시 동작구 흑석동 중앙대학교, 전자전기공학부