

Properties of aluminum oxynitride (AlON) thin film grown by reactive RF magnetron sputtering

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Abstract

In this study, Aluminum Oxynitride thin films were grown on semiconductor (100) Si-substrates using the reactive RF magnetron sputtering technique with gas timing [Ar(sec):N₂(sec)] 10:90. Surface profiler, scanning electron microscope and Auger electron spectroscopy were used to determine the thickness and compositional depth profile. The films were then annealed in air at various temperatures. The morphological features of the annealed films were studied via scanning electron microscopy.

Keywords: aluminum oxynitride; Reactive RF Magnetron Sputtering

1. Introduction

Aluminum Oxynitride (AlON) is a solid solution of aluminum oxide (Al₂O₃) and aluminum nitride (AlN). Due to the excellent chemical and mechanical properties, AlON has potential applications as high-performance structural ceramics including protective coatings against wear, diffusion and corrosion, optical coatings, opto-electronics, micro-electronics and other fields of technology (J.J Araiza et al., 2005; S.Dreier, 1999). The film properties can be tailored between those of pure Al₂O₃ and AlN, depending on the demands. (A.G.Erlat et al., 2001)

2. Experimental

AlON thin films were prepared on semiconductor (100) Si-substrates by reactive RF magnetron sputtering of the Al target. After the optimization of the growth parameters, Ar(sec):N₂(sec) gas timing ratio and the RF power in the chamber were kept constant at 10:90 and 200 W, respectively. Argon was used as the background and nitrogen was used as the reactive gas. The sputtering conditions are listed in Table 1 for the film thickness of 500 nm. A surface profiler and cross-sectional SEM images were used to

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determine the thickness and uniformity of the as-deposited films. The compositional depth profiles of the thin films were obtained using AES.

The AlON thin films were subjected to post deposition annealing in air at 300, 500 and 800 °C. Holding time at each annealing temperature was 1 h. Ramp up and ramp down temperatures were maintained at 5 °C/min. SEM was used to study the surface morphology of the annealed films.

3. Results and discussion

3.1. Film compositions

AlON thin films of 100 nm were examined by Auger electron spectroscopy depth profile. The composition throughout the thickness of a thin film is shown in Figure 1 for an example. Total of 45 samples from 5 different sputtering processes showed repeatability of the results. The atomic concentrations of the as-deposited films at room temperature were ~55% aluminum, ~35%nitrogen and ~10% oxygen.

3.2. Film thickness and uniformity

A surface profiler was used to measure thicknesses of as-deposited AlON thin films. Each sample was measured at 9 different points to investigate the uniformity of the films. All samples were found to be uniform and of the expected thicknesses. Thickness of the films were confirmed by SEM. A cross-sectional image of 500 nm AlON film on semiconductor (100) Si-substrate is shown in Figure 2.

3.3. Film morphology

SEM images of the annealed AlON thin films were investigated as shown in Figure 3. The as-deposited film (Figure3 (a)) exhibited non-uniform

form grain sizes. The average grain size was 30 nm. Annealing at 300°C caused no significant changes in grain size of the film as shown in Figure 3 (b). When the film was annealed at 500°C (Figure3 (c)), the grain size decreased due to nucleation process (L.K. Teh et al.,2001). Further increasing in annealing temperature to 800°C resulted in grain growth as shown in Figure 3 (d) (S.Kocha wattana, 2008). All the annealed films exhibited densely packed grains with no visible pores and large interface defects.

4. Conclusions

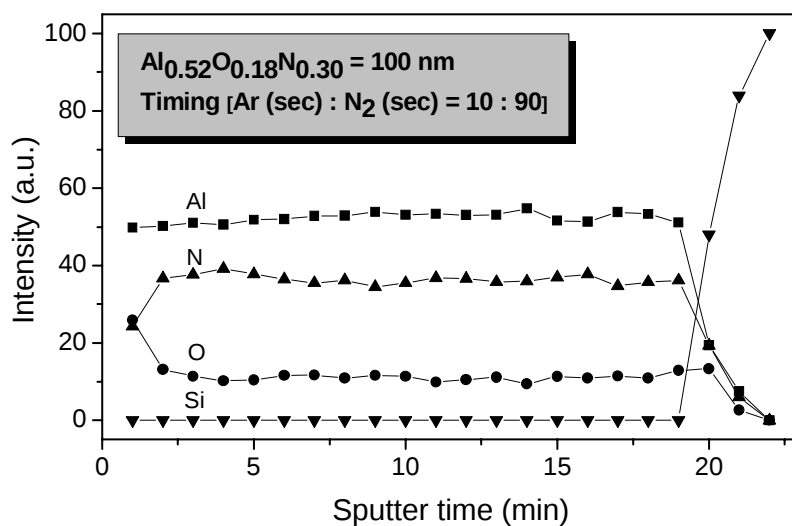
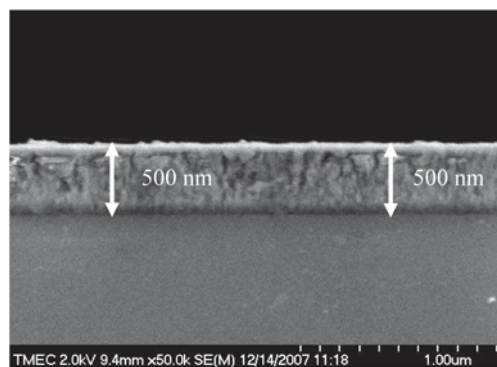
AlON thin films were successfully prepared with reactive RF magnetron sputtering with the sputtering conditions of 10:90 Ar(sec):N₂(sec) gas timing ratio and 200 W RF power. All film samples from different sputtering processes showed repeatability in compositions, thickness and uniformity. The compositions of the thin films were 55% aluminum, 35% nitrogen and 10% oxygen. Results from surface profiler and cross-sectional scanning SEM showed that the as-deposited films were uniform and of the expected thicknesses. The annealed films were dense and exhibited nucleation and growth.

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Table 1 Sputtering conditions used to grow AlON films

Ar Flow Rate (sccm)	12
N ₂ Flow Rate (sccm)	7
Timing [Ar (sec) : N ₂ (sec)]	10:90
Power (Watt)	200
Thickness (nm)	500
Deposition Rate (nm/sec)	0.94

**Figure 1.** AES depth profile of an as-deposited AlON film on Si-substrate.**Figure 2.** Cross-sectional SEM image of an as-deposited AlON thin film of 500 nm.

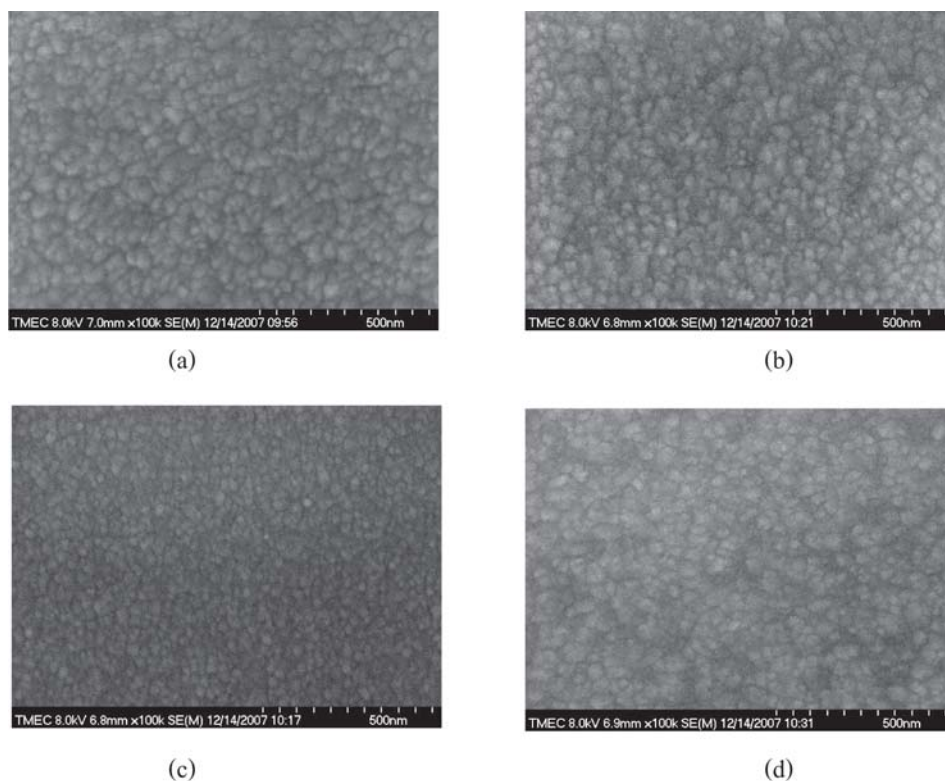


Figure 3. SEM images of AlON film surface (a) as-deposited, (b) annealed at 300 °C, (c) annealed at 500 °C and (d) annealed at 800 °C.

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