2003B0322-ND1d-np-Na BL13XU

Behavior of Electromigration Induced Strain in Nano-size Aluminum Interconnect Line

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1. INTRODUCTION

The width of aluminum (Al) interconnect lines in large-scale integration (LSI) has shrunk in recent years with miniaturization and high accumulation of semiconductor devices. Problems associated with electromigration (EM) in the lines are becoming major reliability concerns because of high electrical current applied to such interconnect lines. We investigated the behavior of EM induced strains.

2. EXPERIMENTAL METHOD

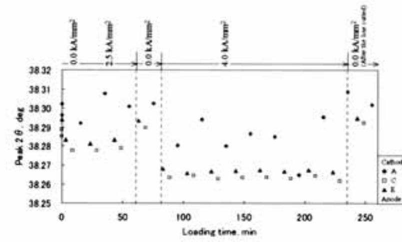
The interconnect line used for EM test was made of Al-1.0%Si alloy. There were two samples; with and without passivation layers. The lines were {111} orientated polycrystal -line structure with the width of 20 μm and the height of 0.5 μm.

The SR energy for measuring EM-induced strains was 8.00 keV (λ = 0.1550 nm) and 12.4 keV (λ = 0.0990 nm). The X-ray irradiation area was 120 × 200 μm^2. The sample was kept at 200℃.

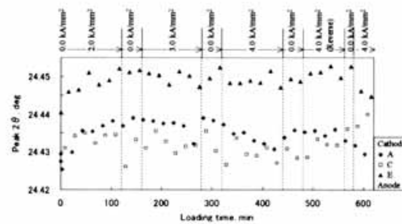
3. EXPERIMENTAL RESLTS

Figure 1 shows the variation in 2θ values of Al 111 diffraction peak for each the measurement points A, E, and C; each corresponds to the position adjacent to the cathode and anode and at the center. Figure 1(a) shows that the 2θ angle decreased with increasing current density but was independent of a loading time. On the other hand, Fig. 1(b) shows that the 2θ angle gradually changed with time duration.

From these results, it is considered that a surface diffusion occurs in the unpassivated line but does not occur in the passivated line.



(a) Unpassivated line



(b) Passivated line

Fig.1 2θ angle of Al 111 diffraction as a function of time during the EM test.

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Thermal Stress Behavior of Nano-size Aluminum Thin Film under Heat Cycling

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1. INTRODUCTION

Widths of aluminum interconnect lines in LSI have shrunk in recent years with the miniaturization and high accumulation of semiconductor devices. As such, problems associated with electro-migration and stress migration in the nano-size lines. Electro-migration is the biased movement of atoms caused by utilizing the high electrical current densities. And stress migration damages are caused by the thermal stress in the line, which is occurred during the manufacturing of the LSI because of the different thermal expansion between lines and a substrate.

The purpose of this study is to investigate basic properties in nano-size film. We measured in-situ thermal stress in nano-size aluminum films with silicon oxide glass (SOG) passivation.

2. PREPARATION OF SPECIMENS

The aluminum films were deposited on the thermal oxidized silicon wafer by RF sputtering. The thickness of the aluminum film was 10, 20 and 50 nm. A typical {111} texture was formed in the all films. After the aluminum film deposition, passivation SiO_2 films are deposited on the aluminum films by spin coating. And then, these specimens were carried out thermal treatment at the temperature below 250℃.

3. EXPERIMENTAL RESULTS

Figure 1 and 2 show examples of in-situ thermal stress measurement of the 50 and 10 nm-thick aluminum film with SOG passivation. The thermal stress behavior was almost linear through the heat cycle between the room temperature and 300℃.

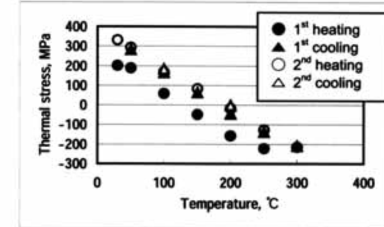

Fig. 1. In-situ thermal stress measurement of 50 nm-thick film with SOG passivation.

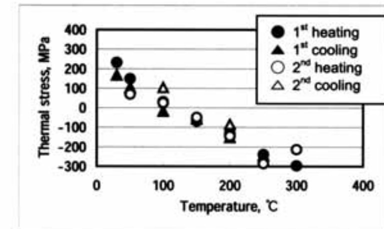

Fig. 2. In-situ thermal stress measurement of 10 nm-thick film with SOG passivation.

4. CONCLUSIONS

In-situ thermal stresses in nano-size Al films were measured by synchrotron radiation equipment. The thermal stresses in the film showed no hysteresis loop, exhibiting linear relation in the thermal cycle.