高信頼性 ULSI-Cu 配線用 PVD-Co(W)単層バリア/ライナーの特性調査

Characteristic study of PVD-Co(W) single barrier/liner for highly reliable ULSI Cu interconnects

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Introduction

In semiconductor device, Cu interconnect is buried in low-dielectric-constant (low-k) materials with interlayers [1]. These are double layers of TaN and Ta, serving as barrier against Cu diffusion and liner, rspectively [2]. With continued downscaling of the device dimensions [3], these layers cause some critical reliability issues such as electromigration (EM) failure, short-circuit failure, and resistive-capacitive (RC) signal delay. Introduction of new materials is beneficial to EM failure and short-circuit failure. However, it cannot relieve RC delay. Meanwhile, single barrier/liner has potential to solve all three issues because transition from double layer to single layer can decrease RC delay as well.

In this context, we previously demonstrated the high performances of ALD-Co(W) superior to PVD-Ta/TaN [5]. More recently, we reported that PVD-Co(W) exhibited these three performances superior to both PVD-Ta/TaN and ALD-Co(W) [4]. However, in the evaluation of diffusion barrier property of PVD-Co(W), we found that we underestimated the barrier property. In this research, we evaluated the barrier property correlctly by employing new measurement method using XPS, that is called back-side measurement.

Experimental

PVD-Co(W) films with four different W contents were prepared by dual-target plasma sputtering machine. To evaluate the barrier property, we assessed the diffusivity of Cu within Co(W) using XPS depth analysis. To eleminate the nock-on effect of Cu into underlying Co(W), which is the origin of uncertainity of XPS depth analysis, we undertook the XPS depth analysis from back-side of the sample. Obtained data was finally converted to diffuisvity of Cu within Co(W).

Result and discussion

Figure 1 shows the Arrhenius plot of diffusivity of PVD-Co(W) with various W compositions. W composition of 43 and 58 at.% exhibited higher activation energy of diffusion, i.e., better barrier property, than the others.

Figure 2 shows the Arrhenius plots of diffusivity of PVD-Co(W), ALD-Co(W) [5], and PVD-TaN [4]. PVD-Co(W) (W: 43at.%) exhibited the highest activation energy, i.e., highest barrier property among these three layers.

Conclusion

PVD-Co(W) single barrier/liner exhibited smaller resistivity [4], higher adhesion strength [4], and better barrier performance than PVD-TaN. Thus, it is expected as a leading candidate to replace current Ta/TaN double layers.

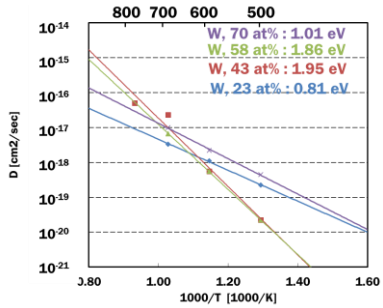

Fig. 1 Diffusivity of Cu within PVD-Co(W) films with various W composition.

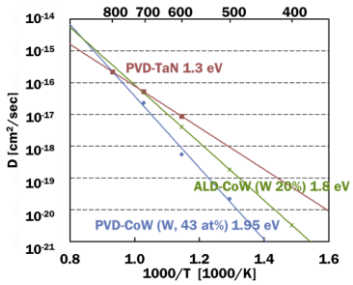

Fig. 2 Diffusivity of Cu within PVD-Co(W), ALD-Co(W), and PVD-TaN.

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