Passivation Stress versus Top Metal Profiles by 3D Finite Element Modeling

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Abstract

Passivation stress is investigated as a function of top metal profiles with a 3D Finite Element Modeling (FEM). A new structure is proposed for reducing the passivation stress at the corner of top metal foot to prevent a potential passivation crack.

INTRODUCTION

Passivation cracks are always a concern for semiconductor IC in both Si and compound semiconductor devices. Figure 1 shows an example of a passivation crack at the corner of the top metal foot. Many investigations have been conducted by FEM simulation [1], [2] or experiments [3], [4]. In this paper, the passivation stress is investigated as a function of the top metal profile and passivation thickness with a 3D FEM. Based on the results of the simulation, a new structure of top metal profile is proposed.

SIMULATION AND RESULTS

As shown in the Figure 1, the structure of interest is a top metal (Au) connected to an underlying metal layer (Au) underneath through a via. The inter-level dielectric film is bisbenzocyclobutene (BCB) and the passivation film is the plasma deposited SiN. Although the thickness and film stress of the SiN are important factors for the passivation crack, we keep them fixed here to reduce process variables. The simulation of the passivation thickness is only for the reference as the crack threshold. Since SiN is very brittle, Principle Stress model is used in the 3D FEM simulation.

Figure 2 shows the detail of four different top metal profiles investigated here and the 3D simulation results. These four profiles are (a)Right Angle, (b)Sloped Angle, (c)Right Angle with Curving Foot, and (d) Sloped Angle with Curving Foot.

The summary and the comparison of the passivation stress of these four different profiles are shown in Figure 3. The Right Angle profile gives the highest stress and the stresses of both Right Angle with Curving Foot and Sloped Angle profiles are improved from the Right Angle profile. However, by comparing to the crack threshold, which is determined by the experiments and simulation of the passivation thickness, these profiles are not expected to fully eliminate the cracks. The only one that has the stress lower than the critical crack threshold is the combination of both Sloped Angle and Curving Foot profiles.

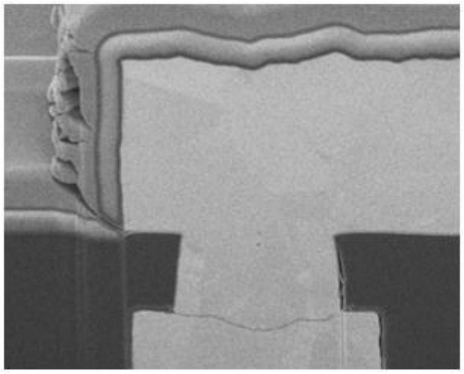

FIGURE 1 PASSIVATION CRACKS AT THE CORNER OF THE FOOT OF TOP METAL

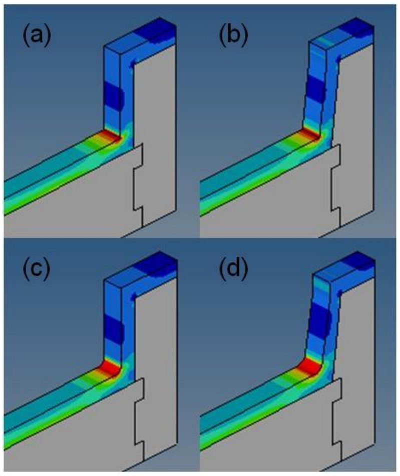

FIGURE 2 4 DIFFERENT TOP METAL PROFILES SIMULATED WITH 3D-FEM. (A) RIGHT ANGLE; (B) SLOPED ANGLE; (C) RIGHT ANGLE WITH CURVING FOOT; (D) SLOPED ANGLE WITH CURVING FOOT

CONCLUSIONS

Neither sloped profile or curving foot profile of the top metal is enough to eliminate the passivation crack by themselves. Only the combination of both sloped and curving foot profiles of the top metal is promising as a solution. However, realizing the required profile is still a challenge.

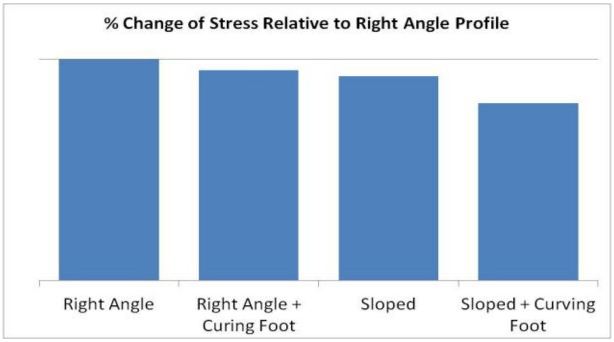

FIGURE 3 STRESS COMPARISON OF 4 DIFFERENT TOP METAL PROFILE RELATIVE TO CRACK THRESHOLD

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ACRONYMS

FEM: Finite Element Modeling
BCB: bisbenzocyclobutene
SiN: Silicon Nitride