Compositionally Bi-layered Formation of Interfacial Voids in a Porous Anodic Alumina Template Directly Formed on Si

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1. Introduction

In contrast to the conventional anodization of aluminum foils [1-3], one notable feature that has recently been reported [4-7] in the fabrication of wafer-level PAA templates is the formation of interfacial voids with inverted barrier morphology. A comprehensive understanding of the key factors affecting void formation is of great importance if one is to specifically tailor the void profiles along with the inverted shape of the barrier layers. Unfortunately, the origin of void formation and the relevance of the inversion behavior of the barrier morphology remains poorly understood. Here, we show that the formation of interfacial voids consists of multiple stages, such as the substrate touching a barrier layer, curvature inversion of the barrier layer by void nucleation, dendritic branching from the pore bottom edges, the formation of channels between pore bottoms and voids, and a local oxidation of silicon (LOCOS) [8] by electrolytes infiltrating through the channels. The compositionally bi-layered morphology of interfacial voids was found to be a thin Al-rich layer surrounded with the Al-deficient oxide.

2. Experiments

A 1- μm-thick aluminum film was deposited on n-type, <100> 4-in. silicon wafers using thermal evaporation. A two-step anodization process was used to fabricate the PAA templates on the Si substrates. As an electrolyte, diluted oxalic acid (0.3 M) was chosen for the anodization process under constant bias of 60 V at 5 °C. After the first anodization step, the alumina film was removed using a solution of 6.4 vol.-% H3PO4 and 19 g/L CrO3 acid at 60 °C for 10 min.

3. Results and Discussion

Fig. 1 depicts the process flow of void formation with curvature inversion of the barrier membrane. Further anodization of the Al metals remained when the barrier layer touched the substrate creates additional stress at the interfacial region between the pore bottoms and the substrate for alumina transformation. In contrast to the anodization of Al foils, the residual Al, firmly attached to the rigid substrate, can not accommodate the stresses by volume expansion without interfacial restructuring to create the necessary additional space.

The driving force for void nucleation is the stress pushing the substrate downwards owing to a laterally confined structure that is tightly attached to a rigid substrate. Corre-
between the pore bottoms and the top-side of voids, which allows the infiltration of electrolytes into the voids. Then, the silicon surfaces inside the voids were oxidized by electrolytes (fig. 4). This feature has been named a “bird’s beak (BB)” [8]. The BB formation, in our case, was chemically driven by electrolytes.

4. Conclusions

In summary, we have explained the process of void formation in an alumina film anodized on a Si substrate. EDS analysis revealed that the voids were surrounded with a typical bi-layer structure that consisted of thin, Al-rich and thick, Al-poor regions.

References