酸化によるシリコンボンドの縮み

Oxidation-induced shrink of Si-Si bond

東北大学, ◦葉 術軍、山部 紀久夫、遠藤 哲郎

Tohoku Univ., ◦Ye Shujun, Yamabe Kikuo, Endoh Tetsuo

E-mail: yeshujun@cies.tohoku.ac.jp

We used TEM to investigate the microstructure of Si nanopillars after oxidation. Based on the difference of microstructure, shape, and size of Si nanopillars under different oxidation conditions, we found that the self-limiting stopping size of Si pillars depends on the initial pillar diameter. After attaining the stopping size, cracks and then undercuts appear at the bottom of the pillar, with concomitant further oxidation. We also found that oxidant diffusion in the oxide and compressive stress for volume expansion from old oxide do not suffice to explain the self-limiting and crack of Si pillars and they affect the oxidation of Si as external factors. The chemical reaction (via broken Si-Si bonds) causes the Si-Si bond to shrink, which strengthens the Si-Si bonds and leads to oxidation-induced stress, was confirmed from the distances change between the (111) crystal planes as shown in Figure 1. The oxidation-induced stress is considered to be the intrinsic mechanisms behind self-limiting oxidation and the cracks of Si pillars [1]. The present work contributes to deep understanding of oxidation mechanism in Si pillars, which is promising for used in the precise fabrication of sub-20-nm Si pillars for vertical GAA MOSFETs.

(This work is supported by the Japan Science and Technology Agency ACCEL, Japan, under Grant JPMJAC1301.)

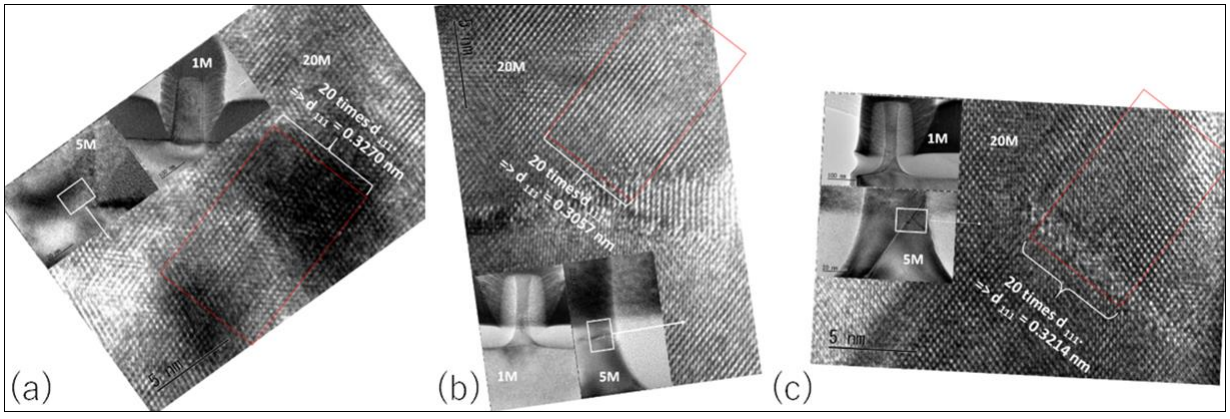

Figure 1. TEM images (1 M and 5 M times magnification) and high-resolution TEM images (20 M times magnification) of 95.8 nm pillars of (a) before oxidation, (b) after oxidation and the crack formation is at the starting point, and (c) after oxidation and the crack is completely formed.

[1] Shujun Ye, Kikuo Yamabe, Tetsuo Endoh, Oxidation-induced stress in Si nanopillars. ***Submitted.***