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Effect of Impurity Co-implantation on Hydrogen Surface Blistering

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SOI (silicon on insulator) fabrication has become an attractive technology for low power, low voltage and high-speed electronics. Much attention has been given to the hydrogen exfoliation method introduced by Bruel[1] in comparison with other SOI fabrication techniques. This method involves the micro slicing process of silicon by high-dose hydrogen implantation and has advantages of greater uniformity of thickness and higher crystal quality of the silicon layer than other processes[1,2]. Although this unique and useful process has been extensively developed in industrial applications during the past few years, the fundamental phenomenon and the underlying mechanism are still not completely understood[3]. Behaviors of exfoliation on the surface were mainly examined by in-situ microscopic experience. From these results, we attempt to explain the relation between the defects distributions and the exfoliation phenomena, and report the effects of impurities (boron or fluorine) co-implantation.

Hydrogen ion implantation was performed in p-type Cz-grown (100) oriented silicon. The implantation energy was 80keV and hydrogen dose was 8×10^{16} H/cm^2. After the hydrogen implantation, boron ion was implanted with 140keV. The projection rang (Rp) of boron is same depth with the Rp of hydrogen.

These specimens were annealed at in-situ heating optical microscopy (OM) experience. Annealing was carried out till 700° C. Defects distribution was estimated using cross sectional transmission electron microscopy (XTEM). Exfoliated area of surface were evaluated by scanning electron microscopy (SEM) and OM, and the depth of exfoliation was obtained with scanning prove microscopy (SPM). The damaged layer caused by hydrogen ion implantation is located in the region from 600nm to 800nm depth from the surface. Increasing the doses of boron bellow 3×10^{14} B/cm^2, the thickness of the damaged layer became narrower. Bellow 3×10^{14} B/cm^2 dosage, the number of exfoliated pieces was proportional to the boron dose, and average exfoliated diameter was proportional to the hydrogen dose. The total exfoliated area was maximized at 3×10^{14} B/cm^2 dosage. Over the 3×10^{14} B/cm^2 dosage, the number of exfoliated pieces was inverse proportional to the boron dose, and average exfoliated diameter was inverse proportional to the hydrogen dose. The total exfoliated area was maximized at 3×10^{13} B/cm^2 dosage. However, from XTEM observation, long crack was observed in the damaged layer of as implanted specimen. Using this condition, exfoliation with no annealing was observed.

Fluorine ion was implanted with 300keV. The projection rang (Rp) of fluorine is almost coincident with the Rp of 80keV hydrogen. After the fluorine implantation, the defect distributions were observed by XTEM.

In a fluorine dose range from 1×10^{16} F/cm^2 to 5×10^{16} H/cm^2, a thick amorphous layer is formed in the surface vicinity. However, no differences were seen in thickness of amorphous layer.

In defect layer formed by H+F co-implantation (as shown in Fig.1), crystal layer was found on the surface side. After the 700° C annealing, it was found that the thickness of crystal layer was proportional to the hydrogen dose. We found that hydorgen have a roll of impeding the amorphizing.

References

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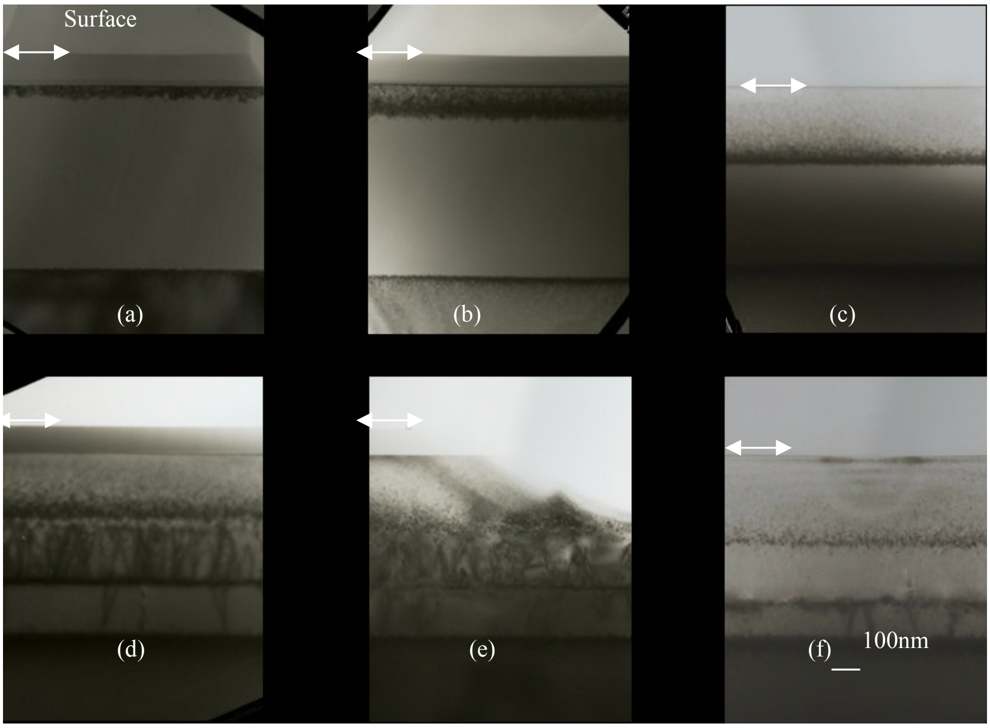

FIG. 1. Damage layers obtained by cross-sectional TEM. (a): (H 1×10^{16} + F 1×10^{16}) / cm^2 as implanted. (b): (H 3×10^{16} + F 1×10^{16}) / cm^2 as implanted. (c): (H 8×10^{16} + F 1×10^{16}) / cm^2 as implanted. (d): (H 1×10^{16} + F 1×10^{16}) / cm^2 as annealed. (e): (H 3×10^{16} + F 1×10^{16}) / cm^2 as annealed. (f): (H 8×10^{16} + F 1×10^{16}) / cm^2 as annealed.