Splittablity in Double Porous Si Layers for ELTRAN®

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Introduction

The splitting process in conjunction with wafer bonding is one of the major approaches to form ultra-thin film SOI. Especially, the SOI-Epi Wafer™ named ELTRAN® (Epitaxial Layer TRANsfer) [1-3] has potential advantages to form uniform thick ultrathin SOI layers both in the whole wafer surface and among adjacent MOSFETs[4] because the epitaxial Si layer defines the SOI thickness uniformity. In this bond and split SOI, it is crucial to lower the interface energy at the splitting plane than that of bonding plane for controlled splitting by water jet within double porous Si layers. It has been reported that the stress confinement around the interface between the first and second porous layers is responsible for the splitting mechanism[3,5]. In this paper, the splittablity such as the interface energy between the double porous layers is discussed with the porosity and the internal stress. In addition, the split surface is investigated in terms of the splittability.

Processes

The double porous Si layers were formed in seed wafers by anodization with two step current control, resulting in the 1st porous Si layers with a low porosity of ~20 %, that was responsible for the epitaxial quality and porous etching, and the 2nd porous Si buried layers with a higher porosity. In this paper, two types of the 2nd layer with different porosity were fabricated. That leads to modification of the stress in the 2nd layer. Epitaxial Si was grown on the surface of first porous layers of the seed wafers, followed by oxidizing the epitaxial surface. The seed wafers were bonded with handle wafers. The bonded pairs were split at the interface within the double porous layers by water jet[3]. Finally ELTRAN® wafers were fabricated by preferential etching of porous Si and subsequent surface smoothing by H_2 annealing.

Stress in porous Si

Pore configuration and stress in the porous layers were evaluated by scanning electron microscope and x-ray diffraction (XRD), respectively. Porosity was measured as 33% for the low porosity in the 2nd layers and 38% for the high porosity. Figure 1 shows XRD rocking curves from the double porous layers. High porosity in the 2nd layer moves the diffraction angle toward the lower that corresponds to the higher stress. In this case, the internal-stress difference between the double layers was evaluated as 3.8E8 dyn/cm^2 for the porosity of 33% and 6.4E8 dyn/cm^2 for 38%.

Splittability

From the viewpoint of splittability, the interface energy between double porous Si layers and the split surface roughness were evaluated by the crack-opening method[6] and stylus surface profiler, respectively. Figure 2 shows the interface energy as the strength of the splitting plane. In case of the high porosity 2nd layer it was measured as ~3500 erg/cm^2, that was reduced from that of the low porosity as ~4000 erg/cm^2. It is quite lower than the interface energy of the bonding plane that exceeded the upper limit of the measurement (4000 erg/cm^2 at least). Figure 3 shows the roughness in root-mean-square value on the split surface with the scanning length of 900 μm. The roughness of the higher porosity is reduced to one third of the lower porosity. The low interface energy of 3500 erg/cm^2 confines the splitting plane within the thinner region around the interface. This reduces the splitting error, that is the crack of the wafer or splitting elsewhere except the porous layer.

Summary

The stress and the splittability in the porous Si can be evaluated by XRD and crack-opening method, respectively. The 2nd layer with higher porosity induces larger stress difference between the double layers. That contributes to lower interface energy between the double porous layers well below the bonding strength. As a result, the splitting plane is confined within extremely thin layer and the splitting errors can be completely avoided. Moreover the smoother splitting plane can improve the quality of SOI wafers such as LPDs, especially in the ultra thin SOI.

References

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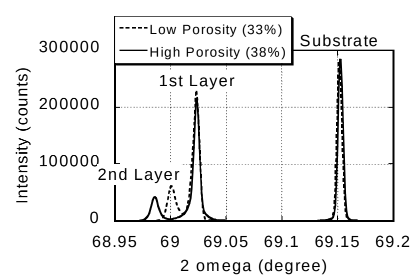

Figure 1. X-ray diffraction rocking curve dependent on the porosity in the 2nd porous layers

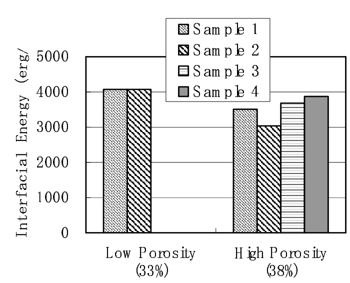

Figure 2. Interface energy at the splitting plane in two types of porous Si

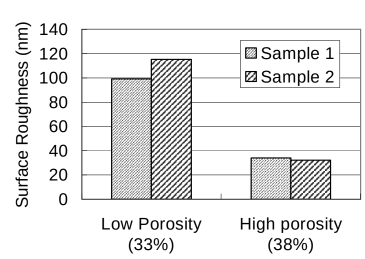

Figure 3. Surface roughness after splitting