SiGe wet oxidation at low temperature : application to SiGeOI thinning

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Introduction

Smart Cut™ technology [1] can be utilized to produce SGOI wafers, i.e. Strained Silicon grown on SiGe on Insulator. This technology works as a scalpel that transfers a thin layer of a relaxed SiGe onto a handle wafer. Then, the SGOI wafers are obtained by growing the final strained silicon layer on top of SiGeOI.

We propose here an oxidation process to thin down the SiGe layer on top of a SiGeOI structure. For that purpose, it is necessary to avoid the germanium pile-up that usually occurs when SiGe is oxidized. The germanium pile-up may induce stress in the SiGe layer, which will eventually relax when energetically favorable at a given oxide thickness[2,3]. The actual thinning is obtained by removing the oxide formed by low temperature oxidation of the SiGe. A second benefit of this oxidation process can be utilized for the finishing stage of the Smart Cut™ SiGeOI process, consuming the damaged surface layer formed during the splitting.

We performed low temperature wet oxidations for various durations on both as-grown SiGe and transferred SiGe in order to extract oxidation kinetics. We also investigated the germanium redistribution during oxidation as well as defectivity of the remaining SiGe layer.

Experiments

The oxidations were performed in an industrial horizontal furnace in wet ambient obtained by pyrogenic steam at atmospheric pressure. Oxidation time varied between 60 and 120 minutes. The wet oxidation was preceded and followed by a dry oxidation step in pure O_2 ambient.

As-grown relaxed SiGe 20% and as-split SiGeOI wafers were oxidized in wet ambient at low temperature in order to minimize the germanium pile-up phenomenon [2,3]. We focused our study on the low temperature regime, i.e. below 750°C.

We characterized the final SiGe structure by RBS, TEM, defects revelation, and AFM. The crystal quality and oxide composition was deduced from the measurements.

Results

We verified by RBS measurements that the germanium is incorporated in the oxide during oxidation. Fig 1 shows that a SiGe oxide is formed with uniform Ge concentration that is consistent with the Ge content in the non-oxidized SiGe.

We measured the formed oxide thicknesses with a spectroscopic ellipsometer, looking at both the thickness and the refractive index. We extracted from these thickness measurements the oxidation kinetics for both epitaxial SiGe and as-splitted SiGe. Figure 2 shows these two time dependencies and point out that the thickness difference between the two curves is almost constant over the explored time range. We will show that the as-grown SiGe low-temperature wet oxidation time dependence can be described by the well-known Deal-Grove (or Linear-Parabolic) model, giving a new evidence that this oxidation process is germanium-pile-up free. Otherwise, the Deal-Grove model should have been corrected with silicon atoms diffusion through the germanium-rich-layer to fit the oxidation law [4]. We will present the TEM results indicating that the crystal quality of the SiGe layer does not change due to the oxidation process.

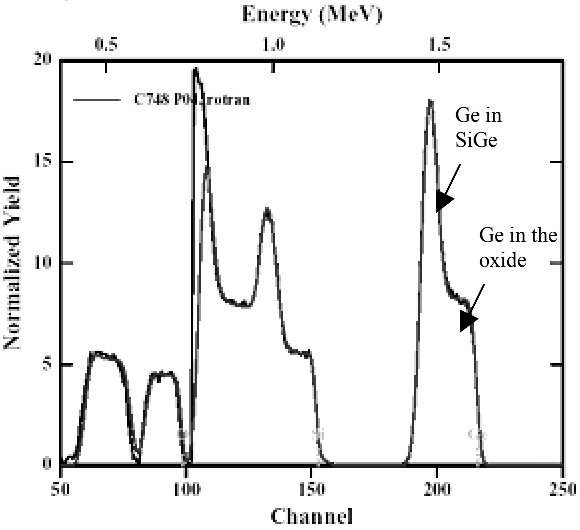

Figure 1 : RBS spectra of the oxidized SiGeOI structure. The Ge part of the signal indicates that the formed oxide contains Ge and there is no detectable Ge pile up at the oxide/SiGe interface.

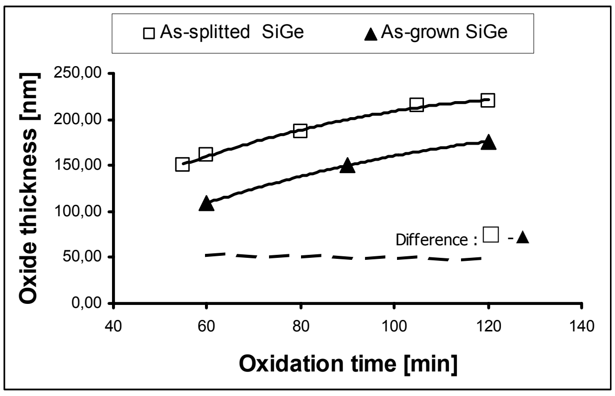

Figure 2: Measured oxide thicknesses vs the duration of the wet oxidation for the $Si_{0.8}Ge_{0.2}$. The solid lines are parabolic fitting laws. The dashed line indicates an almost constant difference between the two kinetics.

Reference

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