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Low/very low dose and multi-buried oxide layers SIMOX materials formed from appropriate dose-energy matches

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1. Introduction

Scaling down and increasing requirements on low voltage, low power consumption and highly speed circuit promote demand for ultra-thin SOI materials [1] (Ultra-thin SOI layer or Ultra-thin SOI and BOX layers), which usually can be realized by low /very low dose implantation. Low / very low dose implantation also shows more advantages including such as significantly increasing implanter capacity and higher quality SIMOX materials compared to standard full dose implantation. Some technologies have been commercialized to realize low dose/high quality SIMOX materials, such as ITOX and MLD [2]. The limits the process to SOI prepared using relatively high-energy oxygen ions to produce a sufficiently thick surface layer of Si to serve as a sacrificial layer during oxidation. In this paper, we reported our work, which is supported by Shanghai Simgui Technology Co., Ltd, on low/very low dose-energy match implantation. An effort was made at understanding the cross effect of dose-energy match on the formation of SOI structure, furthermore, control the thickness of high quality low /very low dose SIMOX wafers in order to meet various requirements on both the thickness and quality of SOI/BOX layers.

2. Experimental Procedure

Oxygen ions ($^{16}O^{+}$) were implanted into 100 mm p type (100) CZ silicon wafers with doses of $1.8 \sim 5.5 \times 10^{17}$ cm^{-2}, at acceleration energies of 45~160 keV. All samples were subsequently annealed in an Ar+O_2 (<3%) ambient over 1300°C for 5 hours.

3. Results and discussion

In our previous work, we have observed that dose-energy match plays an important role for the formation of high quality low dose SIMOX wafers, i.e., the higher the oxygen dose, the higher the implanted energy required for the formation of Si-island free BOX [3,4]. By extending dose-energy range, the ultra-thin SOI/BOX SIMOX wafers have been successfully fabricated. Figure 1 shows the XTEM pictures of SIMOX wafers fabricated at different optimum low dose-energy matches. All samples show sharp Si/SiO_2 interfaces, and no detectable silicon islands in the continuous BOX layers. Modified enhance chemical analysis of defects by diluted Secco was introduced to characterize the occurrence of defects in these materials. The results reveal that the silicon defect (Secco etch pit) density in the samples implanted at optimum dose-energy matches is usually lower 10^4 cm^{-2}. $CuSO_4$ electrolytic

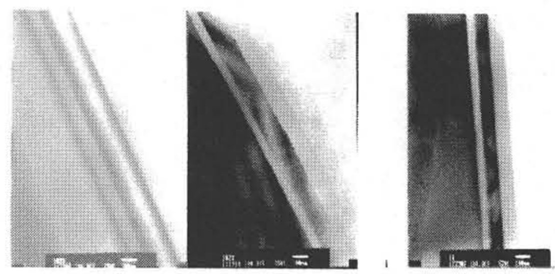

Figure 1 XTEM pictures of SIMOX materials fabricated at various appropriate low/very low dose-energy matches

plating technique was applied to characterize the pinhole density in BOX layer. It is observed that samples implanted at the appropriate dose-energy matches have a pinhole

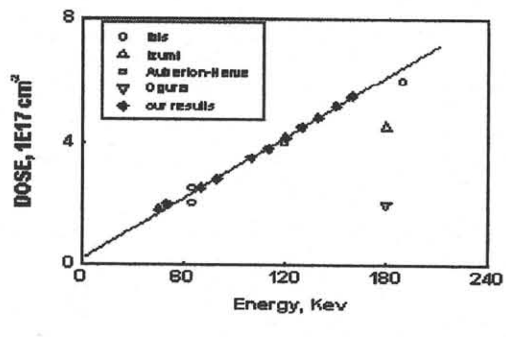

Figure 2 Plot of a series of good dose-energy matches for the formation of high–quality low-dose SIMOX materials

density of lower 0.1 cm^{-2}, which is comparable to the commercialized SIMOX materials. The typical breakdown field is about 6 MV/cm. Figure 2 plots a series of good dose-energy matches for the formation of high–quality low-dose SIMOX materials. In which, the solid circles come from our experiments, the open circles from references [5-7]. The solid line is plotted to guide view. It is seen that the high quality SIMOX wafers have been successfully obtained

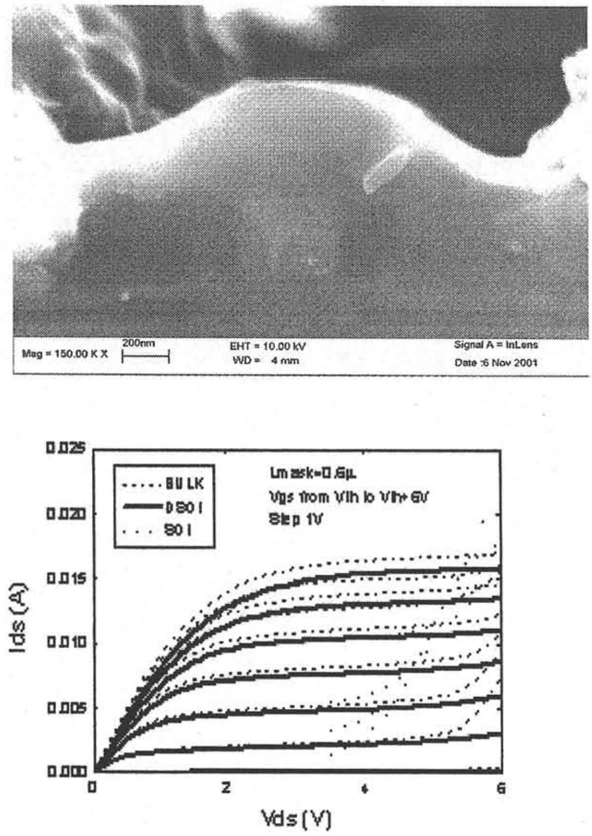

Figure 3 Typical patterned SOI structure (a) and comparable I_{ds} versus V_{ds} for SOI, bulk and patterned SOI (DSOI) structure (b).

around the solid line at a fixed annealing and cleaning procedure by selecting an appropriate dose-energy match. Out of the plotted line, the high quality SIMOX wafers usually need special high temperature annealing procedure such as ITOX [6] or very slow ramp rate [7]. Generally, the higher the oxygen dose, the higher the implanted energy required for the formation of Si-island free BOX. It also implies that the thickness of superficial silicon layer and BOX layer can be flexibly controlled, furthermore, it is easy to realize ultra-thin SOI/BOX layers SIMOX wafers by selecting appropriate dose-energy implantation.

The dose-energy match implantation was used to realize patterned SOI device and multi-BOX layers structure. We have fabricated patterned SOI devices with various thickness BOX layers by selecting appropriate dose-energy matches, in which, the source and drain were constructed on BOX layer while well on bulk silicon. Figure 3(a) shows the typical SEM pictures and (b) the I_{ds} versus V_{ds} . Figure 4 shows a typical multi-BOX layers.

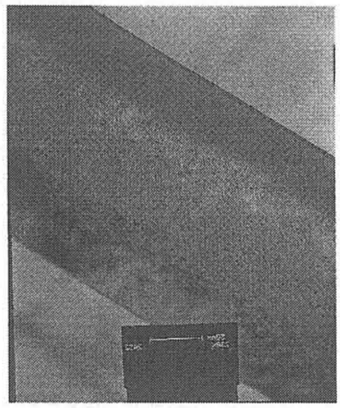

Figure 4 Typical Multi-BOX layers structure

4. Summary

In general, experiments on dose-energy match reveal low / very low dose SIMOX wafers with a low dislocation density and Si-island free BOX layer can be fabricated from good matches of dose-energy combination. The technology has been applied to realize patterned SOI and multi-BOX layers structure. This work indicates a possibility to fabricate ultra-thin SIMOX wafers with ultra-thin SOI and BOX layer by selecting an appropriate low energy-dose match. Furthermore, these materials are now available in Shanghai Simgui Technology Co., Ltd.

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