FORMATION OF OXIDATION INDUCED STACKING FAULTS DURING SACRIFICIAL THINNING OF SIMOX MATERIALS.

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Sacrificial thermal oxidation of standard SIMOX is currently the main route to form ultra thin film SIMOX structures. During the oxidation process self interstitials are injected into the silicon overlayer and, as has been discussed by Guillemot et al. [1], these point defects can lead to the growth of secondary defects, in particular oxidation induced stacking faults (OISF). Previous results[2] have shown that the formation of these OISF is influenced by the presence of stacking fault tetrahedra (SFT) [3,4] in the silicon overlayer. In this paper we investigate the formation of OISF using transmission electron microscopy (TEM) and a recently developed chemical defect etchant[5]. We propose a model which describes the evolution of OISF from the existing SFT.

Experimental details

In this work SIMOX wafers containing different densities of threading dislocations and SFT have been dry oxidised at 900 °C for 74 hrs. (see table 1). Crystallographic defects present in the silicon overlayer have been identified using a JEOL 200 CX electron microscope. The chemical etchant used in this work has been specially prepared in order to delineate stacking faults and other crystallographic defects (threading dislocations, dislocation loops) in very thin silicon overlayers (≈ 500 Å). This new etchant is based on the HF:HNO_3:H_2O system and uses potassium dichromate ($K_2Cr_2O_7$) as the oxidising agent[5]. The measured defect densities are average values from sets of at least 5 identical samples from each wafer. The tabulated densities (Table 1) summarise a trend which has been found following detailed analysis of many other samples. The silicon overlayer thicknesses before and after oxidation were measured using 1.5 He^+ MeV RBS analysis and mechanically using a Rank Taylor Tallystep instrument.

Sample	Initial Si thickness (Å)	Dislocation density (cm^{-2})	SFT density (cm^{-2})	Si overlayer after oxidation (Å)	OISF density (cm^{-2})
A	2000	$1.0X10^5$	$3.0X10^7$	500	$2.0x10^4$
B	2100	$6.0X10^5$	$2.0x10^7$	600	$5.0x10^4$
C	2200	$5.0X10^4$	$1.0x10^6$	700	$5.0x10^5$

Table 1 - Dislocation, SFT and OISF densities for samples oxidised at 900°C for 74 hrs.

Results and discussion.

Fig 1 shows plan view TEM micrographs of sample C before and after oxidation. Before oxidation (fig 1 a) only SFT having a mean length of 0.1 µm are resolved whilst after oxidation large OISF (2.0 µm) are observed (fig 1 b). The densities of dislocation and SFT before oxidation and OISF after oxidation are listed in table 1. It is evident that the material containing the lowest density of SFT before oxidation contains the highest density after oxidation.

SFT in quenched gold were first identified by Silcox and Hirsch[6] in 1959 as vacancy type defects formed due to the condensation of vacancies and more recently, Coene et al.[7] also have proposed that SFT in P^+ implanted silicon are vacancy type defects. The intrinsic/extrinsic nature of these defects in SIMOX has yet to be determined but if, as seems reasonable, we assume they are vacancy type defects then the inverse correlation between the SFT and OISF densities (table 1) can be explained in the following manner.

Previous measurements[4] have shown that the SFT in SIMOX are predominantly located at the Si/SiO_2 interface. Although the nucleation sites have not been identified we postulate that the defects are formed at irregularities which are along the Si/SiO_2 interface and are associated with the coalescence of SiO_2 precipitates during the latter stages of the high temperature annealing process. During sacrificial oxidation these SFT act as effective sinks for self interstitials. These interstitials are captured by the stair-rod dislocations that bound the faults, and thus the interstitial super-saturation in the overlayer is decreased. Under this mechanism the SFT shrink until they are completely annihilated. However, the irregularities that nucleated the SFT remain and can act as nucleation sites for extrinsic OISF which now grow during further oxidation. As a consequence of this mechanism samples with a high density of SFT (eg, specimen A, table 1) are able to accomodate more silicon interstitials and, thus, after sacrificial oxidation will contain fewer and smaller OISF. In order to test this model we have estimated the number of vacancies available in a SFT using simple considerations about their geometry[1]. This estimation shows that the lower OISF densities observed in samples A and B can be explained by the higher rate of recombination of point defects due to the presence of high density of SFT. In the future to further investigate the nucleation process of OISF, we will implant SIMOX materials with B^+ and Ge^+ prior to oxidation to increase the possible nucleation centres for OISF in the silicon overlayer.

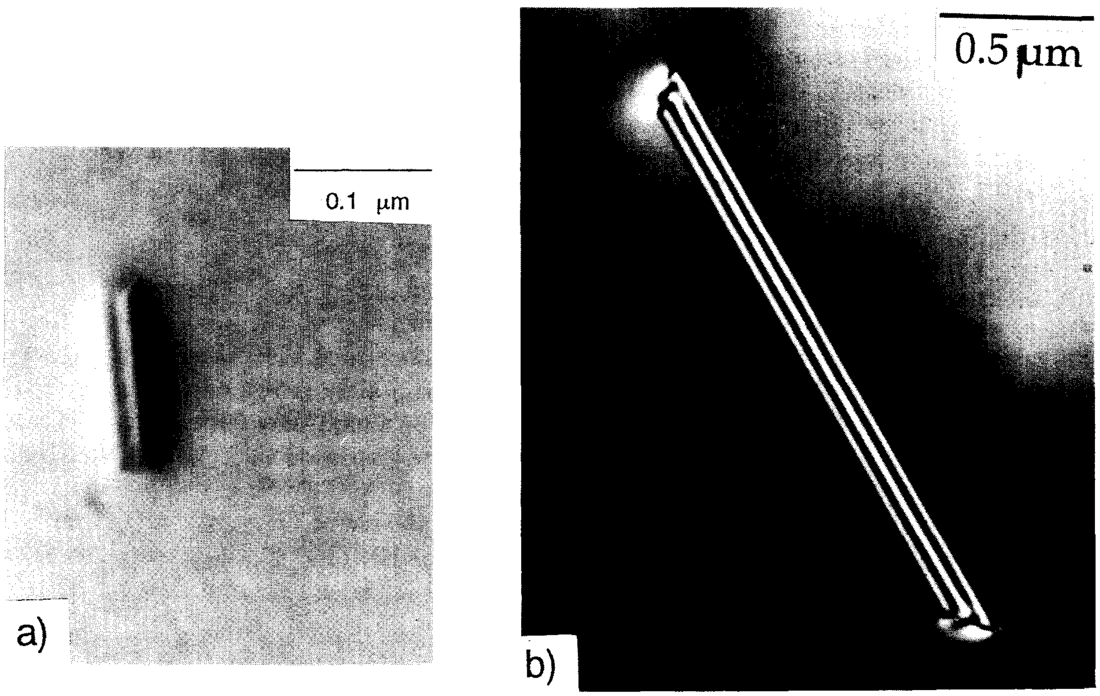

Fig. 1 - Plan view TEM micrographs of sample C before (fig. 1a) and after oxidation (fig.1 b).

<u>References</u>

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