STUDY OF DISLOCATIONS AND STRESS IN SILICON-ON-INSULATOR TUBS USING TRANSMISSION ELECTRON MICROSCOPY AND FINITE ELEMENT MODELLING

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Silicon- on –Insulator (SOI) technology is becoming increasingly important for the fabrication of electronic devices. The advantages of SOI over conventional silicon substrates include reduced leakage currents and parasitic capacitances, reduced power consumption, faster switching speeds, high quality and versatility of the silicon type layer, and die shrinkage[1].

In applying the trench isolation technique, the oxide sidewall must be sufficiently thick to give a suitable breakdown voltage. Increasing thickness of oxide and decreasing tub size leads to an increase in tensile stress exerted on the sidewalls of the trenches by the oxide. This stress is expected to peak close to the bottom corner of the trench and lead to the generation of dislocations if the stress exceeds the yield strength of the material. Dislocations can be detrimental to the electrical properties of the device and must therefore be understood to effectively minimise die size and increase the isolation breakdown voltage.

Slip lines at the surface of the silicon tubs have been observed previously using Nomarski Optical Microscopy[1]. The slip is seen as lines running parallel to the sidewalls of the tubs and the angle between the slip line and the wafer surface has been shown, by Secco etching cross sections, to be 50-54° (similar to the angle between the (100) and (111) crystallographic planes). This slip is thought to emanate from the corner of the tub where the stress is expected to be the greatest.

We have performed finite element calculations of the stress around the trench at various stages of the fabrication process. The stress is found to be significantly greater at the corners of the trench than the bulk silicon in the tub prior to filling with TEOS and polysilicon. In the completed structure the corners of the tubs remain at higher stress than the bulk of the tub, as was expected.

SOI wafers produced by ADB were also examined for dislocations using Transmission Electron Microscopy. Cross-sections of the bottom corner of the tubs were prepared on the FIB with care taken to avoid considerable beam damage. The sections were examined in the TEM (operating at 200kV) and two main features were noted. The corners of the tubs were not smooth but instead showed a more complex structure caused during the trenching process. This may have considerable effect on the stress at the corner. Images also clearly show dislocations propagating from the bottom corner of the tub. Figure 2 shows the dislocations observed when imaged down the (111) zone axis. When imaged down the (110) zone axis the dislocations were unable to be seen as the line vector was parallel to the zone axis. They must therefore be screw dislocations.

[1] W.A.Nevin, K.Somasundram, P.McCann, S.Magee, A.T.Paxton, *Journal of the Electrochemical society* **148(11):** G649 (2001)

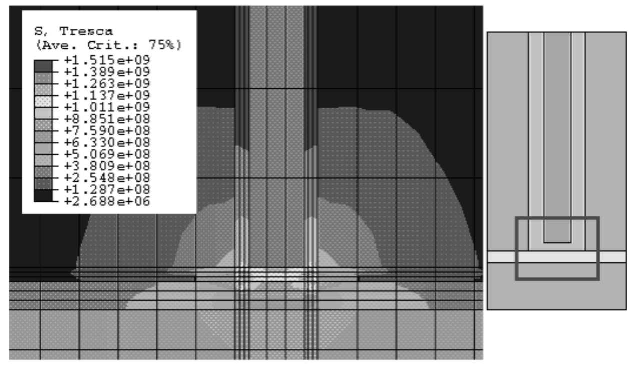

Figure 1- Completed SOI structure showing calculated stresses.

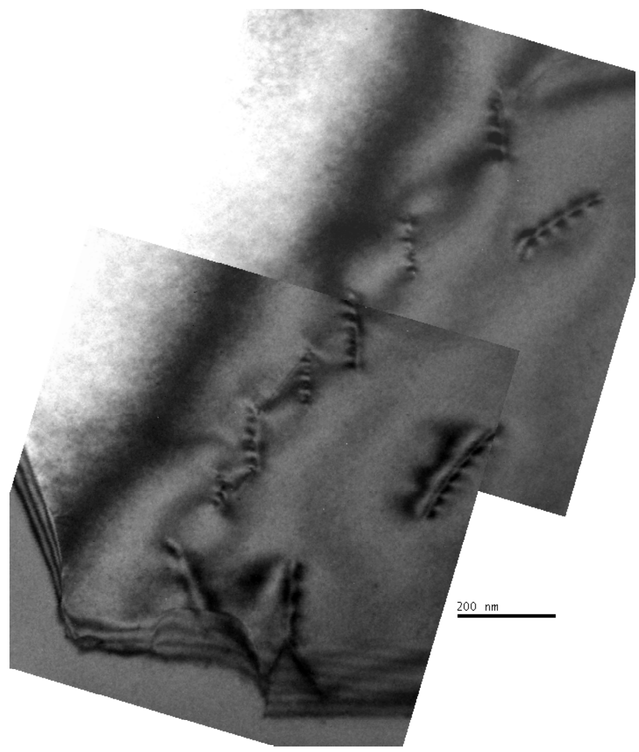

Figure 2- Image of the corner of the SOI tub showing dislocations propagating from it. Beam direction- (111).