MATERIALS PROPERTIES AND CARRIER RECOMBINATION LIFETIMES IN THIN EPI-LESS BOND-ETCH SILICON ON INSULATOR (EL-BESOI)

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The use of MeV boron implantation as an etch stop for epi-less bond etch silicon on insulator (EL-BESOI) has been recently reported [1,2]. In that work a 490 nm device film was demonstrated with thickness uniformity on the order of 8 nm. However, details on the characterization of materials properties and carrier recombination lifetimes in the device material were not presented. Since the device film will have had a high energy (2.5 MeV) boron beam pass through it, as part of the etch stop processing, it is necessary to do such a study to confirm that, after annealing, the material is not left in a damaged or defective state. The present work undertakes to study these properties with the objective of examining such SOI layers with nominal 250 nm thickness.

A significant amount of the materials characterization can be accomplished prior to bonding since the device wafer can be deep implanted at 2.5 MeV and then examined near its surface where the final device material will reside. These studies are done, before and after annealing, using cross-sectional transmission electron microscopy (TEM) and Rutherford backscattering (RBS) channeling through the original crystal face. The as-implanted damage and post annealing defect structures can be observed and quantified in this way. The results are then further compared to similar measurements taken after the bond and etch thinning steps are completed.

The final SOI material is also evaluated relative to electronic defect states by way of minority carrier recombination lifetimes. These measurements are done in a side by side comparison of MOSFET devices in the SOI material relative to similar bulk monitor devices. Material quality is determined relative to benchmark lifetimes that are above and below 20 µs.

In Figure 1 are presented RBS channeling spectra from the silicon device material before and after ion implantation and furnace annealing at 950°C for 0.5 hour. The as-implanted material, which received 2.5 MeV B^+ ions to a fluence of 6×10^{15} cm^{-2}, exhibits a regular increase in dechanneling with depth corresponding to a fine distribution of clustered point defects extending from the near surface region all the way to the maximum depth of the implant where nuclear stopping dominates. Most of the energy loss of this beam occurs as electronic stopping prior to the end of range region which occurs around 3.5 µm in depth. Cross-sectional TEM shows that these defects increase sharply in concentration near the end of range of the implant. The furnace annealed material exhibits a channeling spectrum that is identical to the unimplanted material throughout the material from the surface to a depth of approximately 3.5 µm where upon a very abrupt increase in dechanneling signal occurs. This point marks the location of an annealing induced defect zone which is observed, in cross-sectional TEM, to consist of a narrow band of tangled dislocations. The specific depth at which this occurs represents the end of range in the implant damage as well as the peak in the boron distribution. Figure 2 shows a cross-sectional TEM micrograph of the boron etch-stop implanted material after rapid thermal anneal (RTA) at 1100°C for 20 sec. in an atmosphere of N_2 and 10% O_2. It is observed, as in the RBS data above, that the clustered point defects associated with the ion implant have been completely eliminated and a residual band of thinly mixed dislocation loops remain which are centered once again at

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a depth of 3.5 µm corresponding to the peak in both the boron implant and damage profiles. It is important to recognize that the entire band of annealing induced dislocations, as seen in these data, will be removed by the subsequent sequence of etchants applied from the back face, to produce the final SOI film.

REFERENCES

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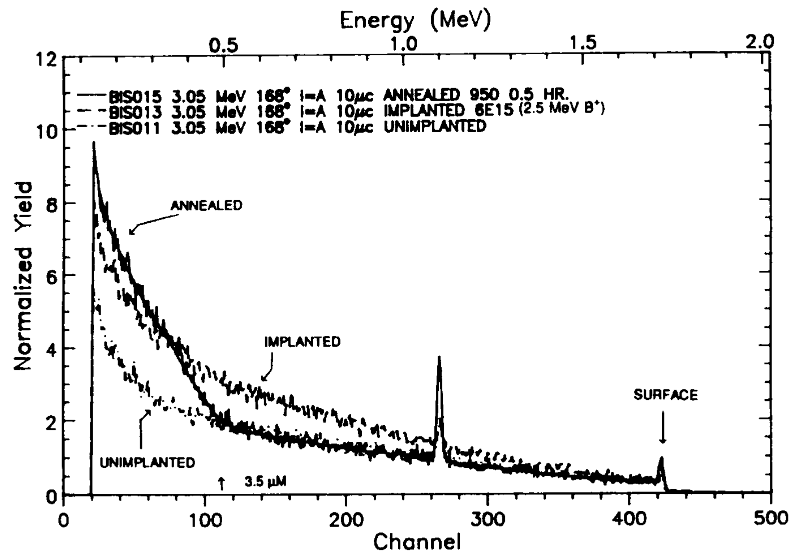

Fig. 1. He^{+} Channeling Spectra after implant and anneal

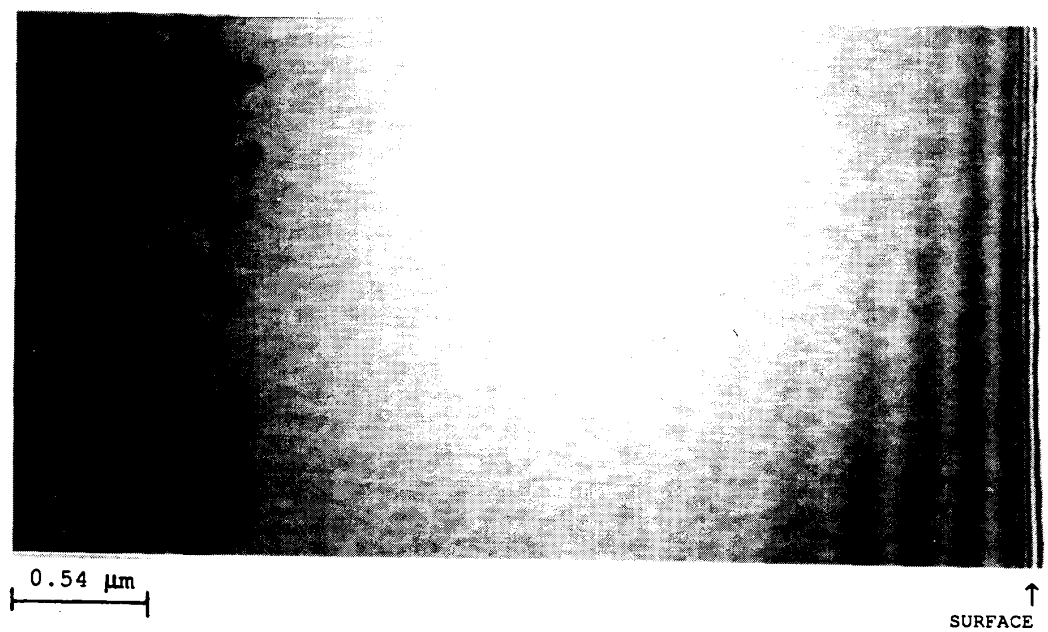

Fig. 2 Cross-Sectional TEM of RTA Annealed Material (1100°C, 20 sec.)