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A Novel High Voltage Device Structure on Thin SOI for VLSIs

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It is well known that thin SOI is a good candidate for high speed CMOS logics. It was shown[1] that an SOI layer as thin as 1000Å is also a good candidate for high voltage ICs. This paper shows, for the first time, that more than 700V breakdown voltage can easily be realized in the same thin SOI structure without using a complicated impurity profile, if a SIPOS resistive field plate is utilized. This makes it possible that high voltage devices can be implemented in VLSIs with completely compatible processes.

Figure 1 shows a proposed diode structure with a SIPOS resistive field plate over a 3μm thick bottom oxide film. If a positive high voltage is applied to the cathode layer with the substrate of earth potential, the proposed structure can be optimized so that all of the voltage is applied across the bottom oxide film under the cathode layer and that the electric field is uniformly distributed between the cathode and the anode layer. A 3μm thick bottom oxide film is sufficient for a high voltage because the critical electric field for oxide breakdown is greater than that for silicon. The diode breakdown voltage is mostly determined by the distance between the cathode and the anode layers.

Figure 2 shows the calculated electric potential distribution for an optimized diode by a device simulator TONADDEⅡB. The thickness of the silicon layer is chosen to be as thin as 1000Å. The vertical electric field component does not contribute to an ionization integral, because the vertical silicon layer thickness is sufficiently thin. The electric field inside the SIPOS is uniformly distributed due to the nature of the SIPOS itself. The electric field inside the silicon layer is forced to be aligned with that of SIPOS and is uniformly distributed, if the silicon dioxide film between SIPOS and the thin silicon(SOI) is as thin as 1000Å. Figure 3 shows breakdown voltage dependence on the oxide thickness between the SIPOS and silicon layers. The breakdown voltage can be greatly increased with the decrease in the oxide film thickness between the SIPOS and the silicon layer. 700V breakdown voltage was obtained with a 70μm cathode and anode distance.

Figure 4 shows that the electric potential distribution for a non-optimized device with an identical device structure except for a relatively thick oxide film between the SIPOS and the silicon layer. Althogh the electric field in the SIPOS is uniform, this is not reflected in the electric field distribution in the thin silicon layer.

The breakdown voltage also depends on the impurity concentration of the silicon layer as shown in Fig.5. It was shown that a high breakdown voltage can be realized by a SIPOS resistive field plate and an optimized uniform silicon layer impurity dose.

This structure is readily applied to high voltage lateral MOSFETs. High voltage functions can be implemented in VLSIs on a thin SOI by simply adding a SIPOS layer. This will lead to wider application fields of VLSIs on SOI.

References

[1]S.Merchant et al, Proc. of ISPSD'91, p.31

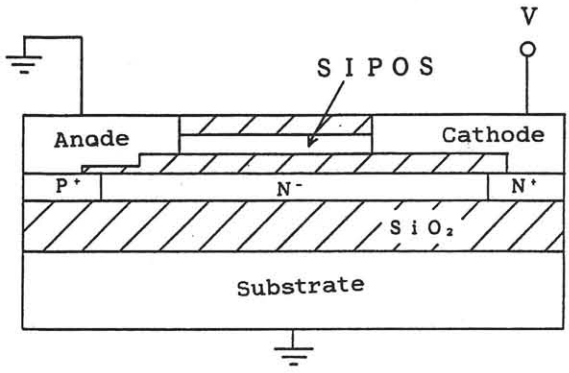

Fig.1 Proposed high voltage diode structure.

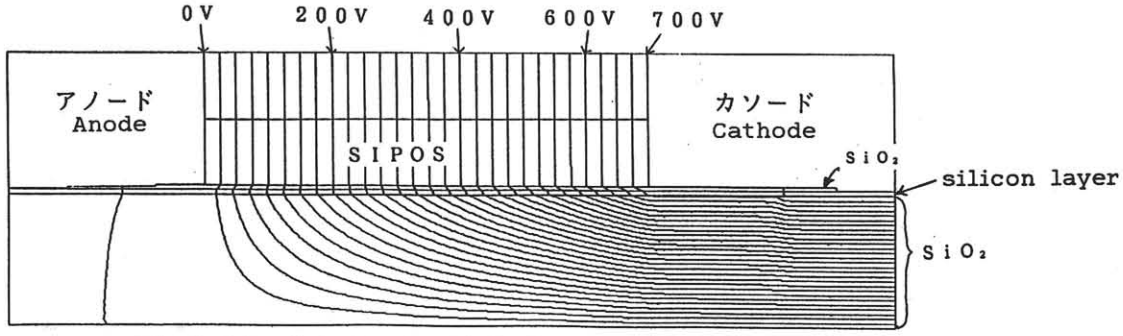

Fig.2 Calculated potential distribution for an optimized high voltage diode with 1000Å SOI, 1μm thick SIPOS 3μm thick bottom oxide.(700V case)

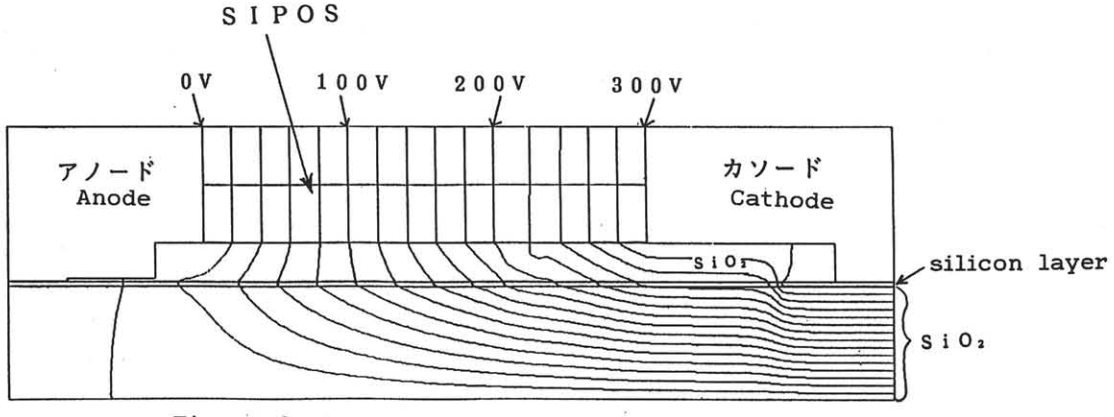

Fig. 4 Calculated potential distribution for a diode with identical device parameters except for a thicker oxide between SIPOS and SOI layer.

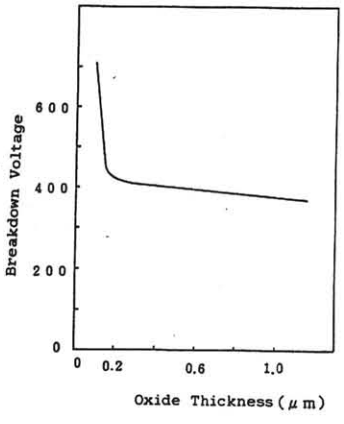

Fig.3 Breakdown voltage vs. oxide film thickness between SIPOS and silicon layer.

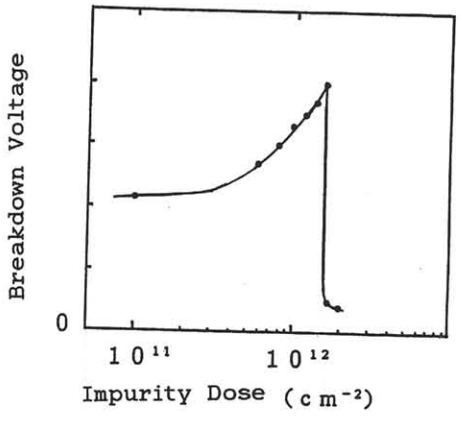

Fig.5 Breakdown voltage vs. impurity dose for SOI layer.