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A — 4 — 7 Tapered Sidewall Schottky Diodes with Very Low Taper Angles

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Tapered sidewall Schottky diode with very low taper angles have been demonstrated to have considerably higher breakdown voltage than the conventional metal-overlap diode by numerical analysis as well as experimental results.

Potential and electric field distribution within the Schottky diodes have been obtained by three-dimensional numerical analysis. Electric field profiles along the silicon surface at specific bias voltage of -100V are plotted in Fig.1. The taper angle, θ is varied between 2.9^o and 90^o with all other parameters fixed as given in the inset of Fig.1. The results of calculation show two peaks of the electric field, one at the contact edge and the other at the edge of the metal electrode. When the taper angle is large, electric field peak at the contact edge is high and electric field peak at the metal edge is low. The results also show that as the taper angle decreases, the principal peak of the electric field at the contact edge diminishes, while the secondary peak at the metal edge remains nearly unchanged. The magnitudes of the two electric field peaks become equal to each other at the taper angle of about 6^o. Hence, for the taper angle of 6^o or less, field peak at the edge of the metal electrode is responsible for the breakdown. Also, for the taper angle of 6^o and above, field peak at the contact edge is the cause of the breakdown.

Fig.2 shows a thecretical plot of the reverse breakdown voltage versus taper angle for devices having 1.0 μm oxide thickness and 7×10^{14} cm^{-3} background impurity concentrations. The breakdown voltages reaches a maximum value for the taper angle of 6^o or less, while it is more or less constant at the minimum value for the taper angle of 50^o or more. Theoretical results show that the tapered sidewall Schottky diode with a taper angle of 6^o or less brings about four-fold increase in breakdown voltage when compared with the conventional metal-overlap diode with a taper angle of 50^o or larger.

For an experimental study on the reverse breakdown voltage of a metal-semiconductor diode, aluminum-silicon tapered sidewall Schottky diodes have been fabricated using the graded etching process with silicafilm.[1] The wafers used in this study are n-type silicon materials with 20 to 25 μm thick epitaxial layers, (111) oriented, and 5 to 7 ohm-cm in resistivity (7×10^{14} cm^{-3} in concentration). The ideality factor, n, was empirically determined from the slopes of the

1) Y.I. Choi, Y.S. Kwon and C.K. Kim, "Graded etching of thermal oxide with various angles using silicafilm," IEEE Electron Device Letters, vol. EDL-1, pp. 30-31, March 1980

forward I-V curve to be 1.01 with the tapered sidewall and conventional metal-overlap diodes. Experimental results of the breakdown voltages have been represented by the error bar, "I" in Fig. 2 and compared with the theoretical results for taper angle between 3^{o} and 90^{o}. Experimental results have shown good agreement with the theoretical results.

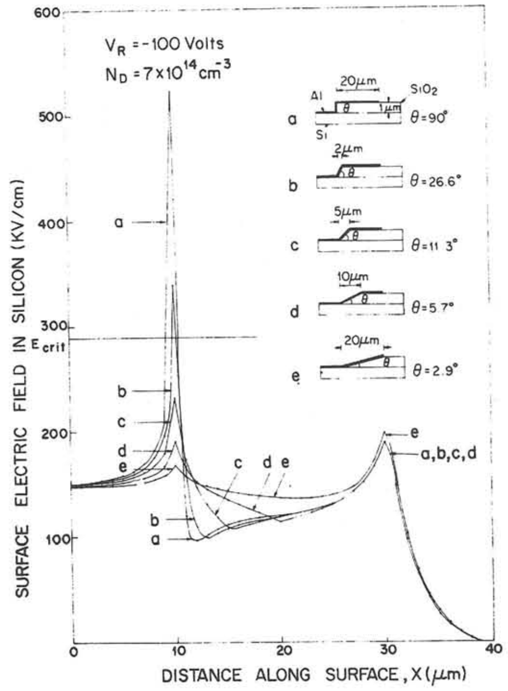

Fig. 1 Electric field distribution along the silicon surface of the Schottky diode shown in the inset for several taper angles.

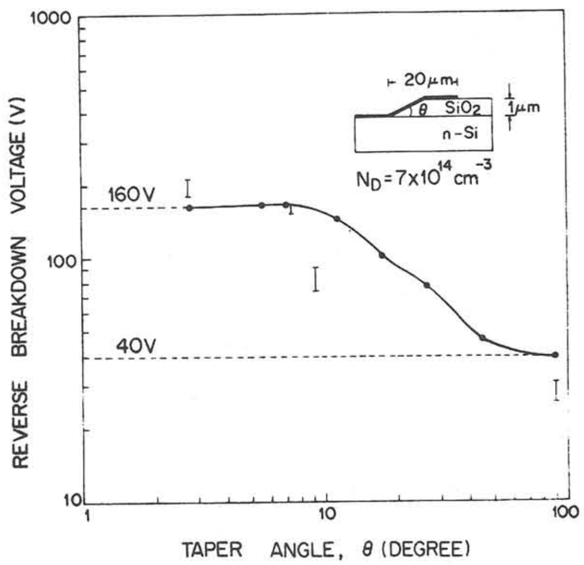

Fig. 2 Relationship between reverse breakdown voltage and taper angle for Al-n Si Schottky diode by numerical analysis. Experimental values are represented by the error bar, "I".