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Characterization of Corner Induced Leakage Current in Shallow Silicided n^+/p Junction

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1. Introduction

There has been growing interest in shallow junction as the dimension of MOSFET's shrink to minimize punchthrough and short channel effect. The main characteristics of the shallow junction has been considered as leakage current of p^+/n and n^+/p junction at reverse bias . The leakage current is generally characterized by two leakage components, i.e. area and perimeter.[1] However, few has addressed the corner component of leakage current, though quarter micron technology is prevalent nowadays. Recently, corner leakage component of p^+/n diode is extracted by dividing the leakage current as area, perimeter and corner components[2]. However, there is no comment on the n^+/p junction and the process is far from the nowadays' quarter micron VLSI process.

We decomposed the leakage current of n^+/p junction as area, perimeter and corner components by making three kinds of diode structure - area, perimeter and corner intensive diode. The n^+/p junction is fabricated using novel quarter micron MOSFETs technology utilizing shallow trench isolation(STI) and self-aligned silicidation(Salicide).

2. Experiments and discussion

The process flow of n^+/p junction is as follows : STI isolation, As Implantation (30keV, 3e15), Ti Salicide (First anneal : 715 °C - 20 second, Removal of unreacted Ti, Second anneal : 850 °C - 20 second). The depth of STI, the junction depth and thickness of Titanium silicide are 3500 Å, 1500 Å and 1000 Å, respectively. Three kinds of diode structures are prepared for experiments as summarized in Table I. The reverse leakage characteristics of n^+/p diodes at various temperature are shown in Fig. 1 and the leakage currents of three diode at 20 °C and 200 °C are compared in Fig. 2. The leakage current of perimeter diode is about one order of magnitude larger than that of area diode at 20 °C and comparable at 200 °C. Whereas, the leakage current of corner diode is two orders larger than those of area and perimeter diodes at all temperatures as shown in Fig. 2. The perimeter length of corner diode is only three times that of perimeter diode as shown in Table I. This reveals the importance of corner leakage component. The extracted current density(J_R) of area, perimeter and corner leakage component at 20 °C and 3 V are 1.95 fA/μm^2, 1.97 fA/μm and 0.64 pA/corner, respectively. Though the values of area and perimeter leakage component are moderate, that of corner component is much larger than the two components. Therefore, it should be noted that the corner component is no longer negligible compared with area and perimeter components in quarter micron devices.

Arrhenius plots (log Ir/T^3 versus $1/T$) of the leakage current of each diode and extracted leakage component at 3 V reverse bias are shown in Fig. 3. The activation energies of area, perimeter and corner diodes are 0.53, 0.47 and 0.38, respectively and they are constant at all temperature. The activation energies of leakage components are similar to each intensive diodes as in Fig. 3. The activation energy of area component is about Eg/2 (0.56 eV) and that of corner component is much less than Eg/2. The leakage current of all diode structures appear to be exponentially dependent on the applied voltage as shown in Fig. 1. Therefore, the leakage mechanism can be thought as SHR generation-recombination with Frenkel-Poole barrier lowering of a trap potential[3]. Figure 4 shows I_R/E versus $E^{1/2}$ of leakage current at 20 °C and 200 °C. The leakage current of three diodes show similar trend at 20 °C while only corner diode shows linear dependence at 200 °C as shown in Fig. 4. At the corner, the current would be enhanced by increased trap density and concentrated electric field. The applied field is concentrated at the corner area of active region and it causes more electric field dependence and small activation energy of corner component.

3. Conclusion

The leakage current of n^+/p junction of quarter micron technology is divided into three components; area, perimeter and corner components and their property is characterized. The corner leakage component is not negligible compared with the area and perimeter leakage components. The main cause of corner leakage current is thought to be the enhanced electric field and trap density at the corner area. As the MOSFET device shrinks, the corner leakage component will be important.

Acknowledgment

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References

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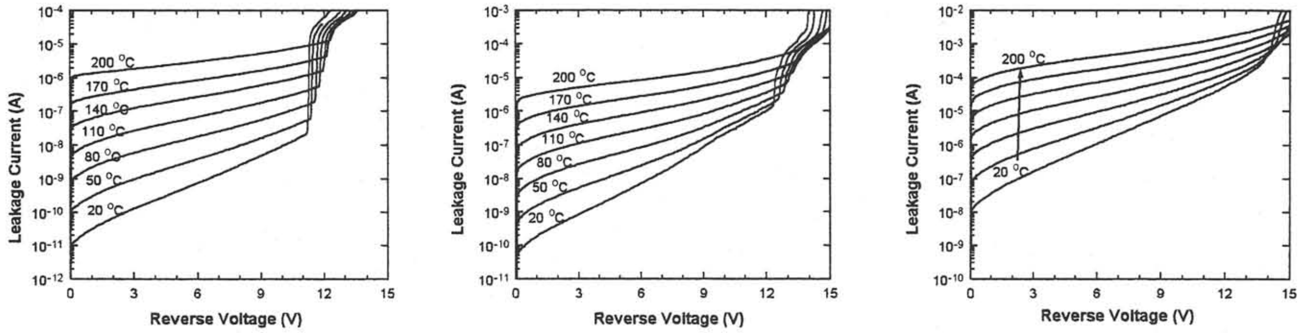
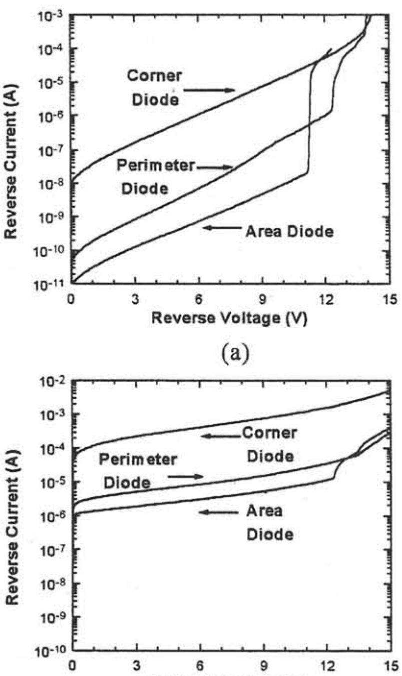
Table 1. Diode structures for experiments.

Diode Type	Structure	Area (um^2)	Perimeter (um)	Corner (Number)
Area Diode	316 μm × 316 μm	99856	1264	4
Perimeter Diode	500 μm × 1.4 μm(× 140)	98000	140392	560
Corner Diode	1 μm × 1 μm(× 316 × 316)	99856	399424	399424



(a) Area Diode (b) Perimeter Diode (c) Corner Diode

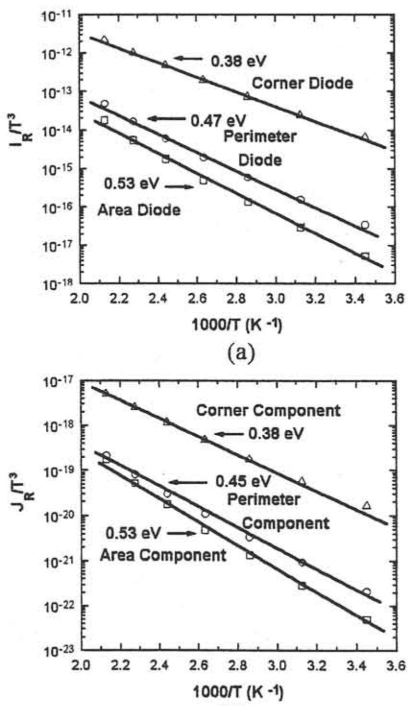
Fig. 1 Leakage current characteristics of area, perimeter and corner intensive n^+/p junction diodes.



(a)

(b)

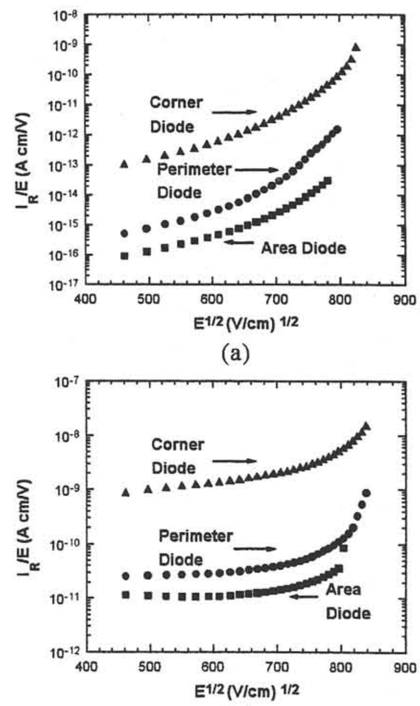
Fig. 2 Comparison of junction leakage of three diodes at (a) 20 °C and 200 °C.



(a)

(b)

Fig. 3 Arrhenius plot of the leakage current of (a) three diodes and (b) each leakage component where J_R is current density.



(a)

(b)

Fig. 4 The ratio of I_R/E versus $E^{1/2}$ at (a) 20 °C and (b) 200 °C.