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Breakdown voltage avalanche effect in the lateral diodes made on thin layers of polycrystalline silicon

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ABSTRACT

Side diodes were fabricated on a thin layer of polycrystalline silicon deposited by the low pressure chemical vapor deposition (L.P.C.V.D) method on silicon oxide. The reverse current-voltage characteristics were measured, and the breakdown voltage was analyzed as a function of temperature.

We have found that for lower temperatures the ionization of traps located in the grain boundaries is due to the electric field but for high temperature electrical conduction is controlled by the thermal emission.

The breakdown voltage increases with the increase of the temperature which is the characteristic of the avalanche breakdown effect. For the diodes formed on the polycrystalline silicon to breakdown voltage of the avalanche effect is small in contrast to the silicon single crystal whose breakdown voltage avalanche effect is higher.

Keywords—Polysilicon N^+P junctions ; LPCVD ; Polysilicon films ; Avalanche

1 – INTRODUCTION

Diodes N^+ P used in this work were performed on a thin layer of polycrystalline silicon deposited by the method L.P.C.V.D on a monocrystalline silicon substrate oxidized.

The study of the breakdown voltage is very useful for the study of several devices such as voltage regulators and other rapid switching devices used the avalanche effect such as oscillators transit time and the photomultipliers.

The study of the breakdown voltage in a PN junction polycrystalline silicon was made for a better understanding of the parameters that influence the breakdown voltage avalanche.

This work involves consideration of the breakdown voltage in the junctions N^+ P as a function of temperature for the doping of the weakened area.

2 EFFECT AVALANCHE: [1]

To highlight the breakdown phenomenon avalanche effect, if injected by any means incidents Holders fields that causes the breakdown, the carriers (electrons or holes) can acquire between two collisions an energy greater than the band gap upon collision with an atom in the crystal lattice, the carrier is capable of ionizing in donating an electron in the conduction band and a hole in the valence band. Newly created carriers involved in turn the general process, there multiplier effect hence the term "avalanche".

The avalanche mechanism has a positive temperature coefficient: the breakdown voltage increases with the temperature growth. The breakdown voltages for the diodes in silicon single crystal have values greater than $6E_g / q$. Eg is the width of the band gap and q algebraic value of the charge of the electron.

3 - MANUFACTURING TECHNOLOGY

Diodes N^+ P were manufactured on a polycrystalline silicon thin film deposited by the method L.P.C.V.D. The polycrystalline silicon layers were deposited on monocrystalline silicon substrates oxidized. The dopant concentration C is given by $C = D / E$, D is the implanted dose and e is the thickness of the polysilicon layer with $e = 370$ nm.

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The region P was doped with boron by ion implantation with two different concentrations (see Table 1). N + region is doped with phosphorus by ion implantation with a concentration (C (N +) = 5.1020 cm^{-3}) after oxidation of the polysilicon layer and the opening of windows N $^+$.

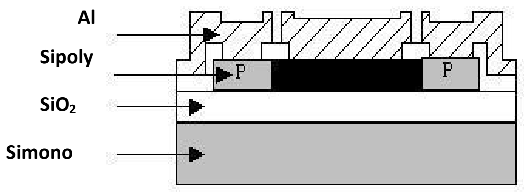

FIG 1 - CROSS SECTION OF DIODES
N^+P – GEOMETRY CYLINDRICAL

Table 1: Values of doses of dopant implanted and their corresponding concentrations.

Echantillon	1CA4	1CA5
Dose (cm^{-2})	**6.10^{14}**	**8.10^{14}**
Concentration (cm^{-3})	**$1.62.10^{19}$**	**$2.16.10^{19}$**

4 - RESULTS

Figures 2 and 3 show the current-voltage characteristics in the breakdown zone and at different temperatures respectively for the diodes and 1CA4 1CA5. We find an increase in breakdown voltage with increasing temperature so the breakdown for the two diodes is due to the avalanche effect. We also note that for the least doped the breakdown voltage is higher diode.

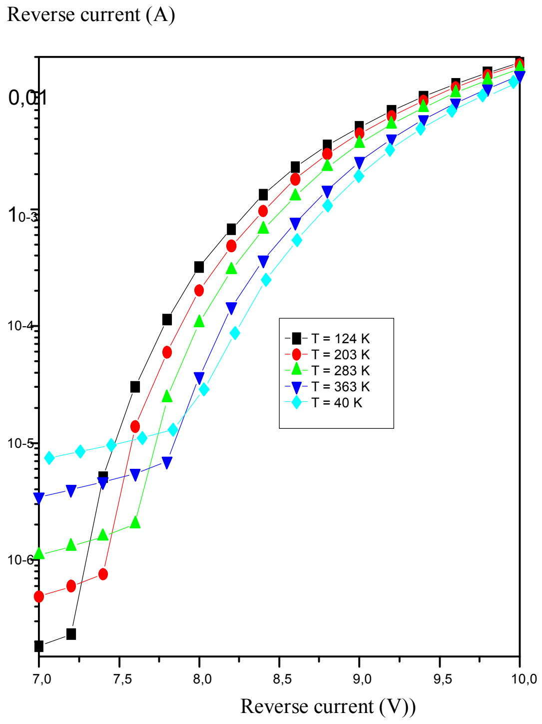

FIG 2 – Reverse current-tension characteristics for various temperatures in breakdown region (Diode 1CA4)

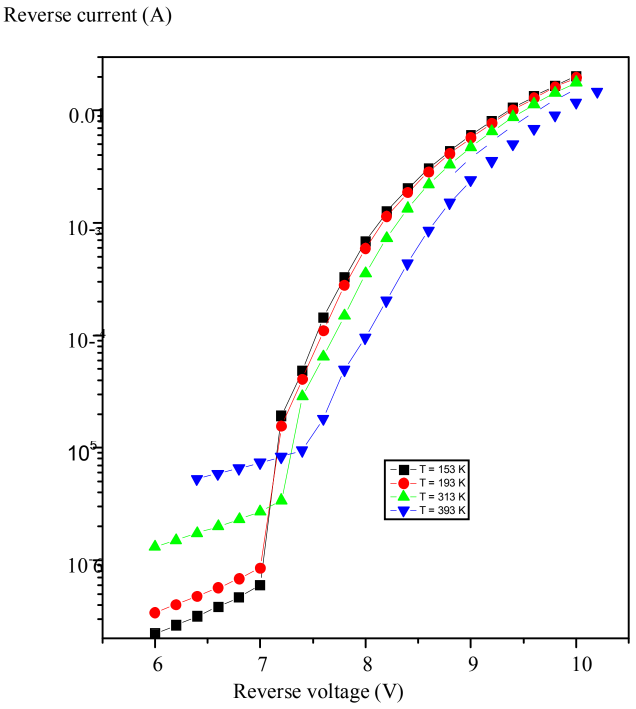

FIG3 – Reverse current-tension characteristics for various temperatures in breakdown region (Diode 1CA5)

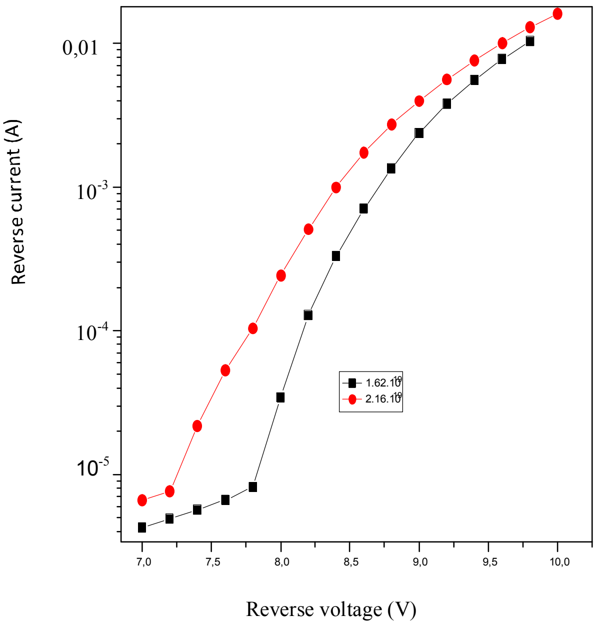

FIG 4 - Current-voltage characteristics for two diodes in the breakdown zone: temperature for the same

Figure 4 shows the current-voltage characteristics of the diodes and 1CA4 1CA5 at the same temperature we find that the diode less than the breakdown voltage more

Unlike the silicon single crystal wherein most doping is increasing the breakdown voltage is low. For the polycrystalline silicon over the doping decreases more the breakdown voltage becomes higher this is the presence of grain boundaries in which there is the presence of dangling bonds which are also many recombination centers for minority carriers that traps statements for the majority carriers giving rise to potential barriers that impede the movement of holders of grain to another, and this increases the breakdown voltage. 5 shows the variation of the current as a function of temperature for fixed voltages in the breakdown zone to the 1CA4 diode and Figure 6 shows the same variations for the 1CA5 diode. We find that for low voltage current is highly dependent on the temperature especially for the least doped diode (1CA4) and for high voltage current is almost constant especially for the most doped diode (1CA5). A low doping a small amount of dopant accumulates at the grain boundaries where it is inactive, the rest of the dopant, assumed distributed within grain ionizes partly giving holders almost all of which are trapped at the grain boundaries. Consequently, deserted areas carriers are created on either side of each gasket and Extend over the region, it gives rise to inter granular potential barriers (barrier deserted areas and potential barriers at grain boundaries) which increases the breakdown voltage

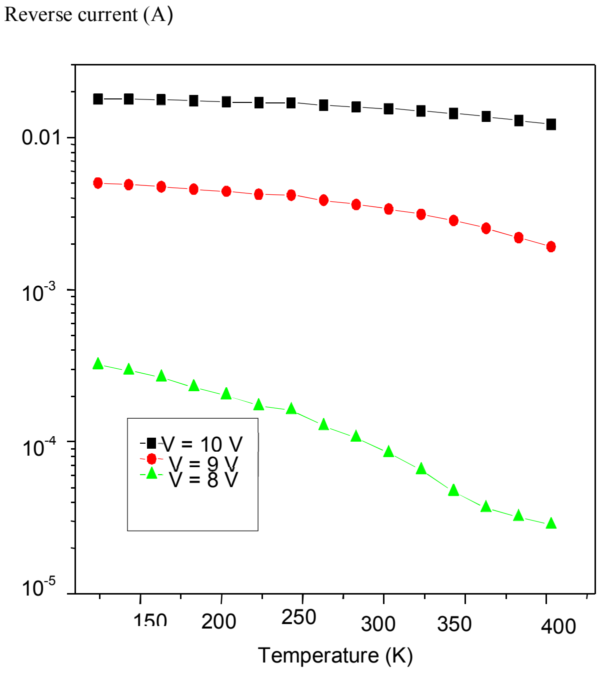

FIG.5: Current changes in function temperature for fixed

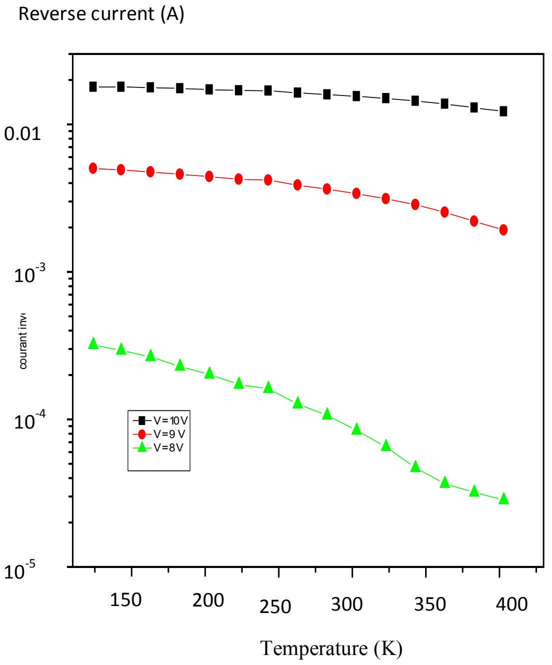

FIG. 6: Current changes in function temperature for fixed voltage (1CA5)

10^{-5}

5 – INTERPRETATION

In a junction formed on the polycrystalline silicon, the generation of carriers in the space charge region is amplified on the one hand, due to the high concentration of traps at grain boundaries and secondly because of the electric field on the electrical activity of these traps [6]. Grain boundaries are prime areas for segregation and precipitation on the one hand and secondly by the presence of dangling bonds constituting both recombination centers for minority carriers that traps statements for the majority carriers giving rise to potential barriers that impede the movement of holders of grain to another.
A low doping, a small portion of the dopant accumulates at the grain boundaries where it remains inactive, the rest of the dopant, supposedly distributed within the grains ionizes in part by giving the holders of which almost all are trapped at the grain boundaries. Consequently, the deserted regions of holders are created from either side of each joint and extend over the whole area, they give rise to inter granular potential barriers (barrier deserted areas and potential barriers to joint grains), which limit the passage of the holders of a grain boundary to another of a number of carriers remained free.

An increase in temperature causes a decrease in the width of the forbidden band that causes elevation of the value of the breakdown voltage. A decrease in the doping value will increase the potential barrier which increases the breakdown voltage.

6 – CONCLUSION

We showed that in the side diodes polycrystalline silicon with a high doping the breakdown voltage is due to the avalanche effect and when the doping is lower breakdown voltage increases. Unlike more monocrystalline silicon doping is increasing the breakdown voltage increases this the important role of grain boundaries in the breakdown mechanism.

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