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Research Article

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The Effective Lifetime and Recombinaison Rate Dependence on Minority Excess Carrier for Silicon Doped p and n

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Abstract In this paper we study the impact of excess carrier on the recombinaison rate and effective lifetime. We study two types of dopand species the Boron and the phosphorus. Considering the all types of recombinaison (Auger, radiative and SHR recombinaison). The model used for these types of recombinaison is Niewelt 2022. In indirect band gap semiconductors such as silicon (Si), the carrier lifetime strongly depends on the concentration of recombination centers. The simulation was done under the temperature of 300 K. The results show that, the effective lifetime depends on the the types of dopand species and the excess carrier density.The lifetime decreases as the excess carrier density increases.

Keywords Silicon Doped p and n, silicon (Si)

1. Introduction

The performance of silicon [1] wafer can be evalueted by the effective lifetime [2] of minority carrier density [3]. This depends on the dopand especies and the recombinaion types (Auger , radiative and SHR).The effective lifetime is an important parameter for studying the effeciency of the solar cell [4]; Most of the time to caracterize a solar cell we use the I-V caracteristic [5] parameters (currant, voltage, fill factor,) [6] and news technic as photoluminesence [7] and electroluminescences [8].

In this work we measure the effective lifetime by considering the auger recombinaison which happends most of the time in indirect band gab such as in commercial silicon wafer.

By using the excess carrier density from different dopant species we are going to show their impact in the recombinaison rate [9] and the effective lifetime.

2. Materials and Model

Semiconductor material

The silicon was doped in the first hand by a boron and the second hand by a phosphorus. The dopand concentration was constant N_A equals to 10^{15} cm^{-3} and equilibrium resistivity r0 equals to 135 Ω·cm for the boron and 458 Ω·cm for the phosphorus.

Physical model

- To study the effective lifetime , we combine several physical models which are the following
- The intrinsic band gap model is the passler2002
- The density of states is the sentaurus 2008 DOS form.
- The carrier statistic is fermi Dirac
- The band gab narrowing is Schenk1998
- The mobility model is the KLAASSEN 1992 model

- The photon recycling is Niewelt 2022
- The simulation was run under the pvlighthouse calculator and the results are shown

3. Results and Discussion

The following figures show the results from the simulation of our physical model running under the pvlighthouse calculator [10].

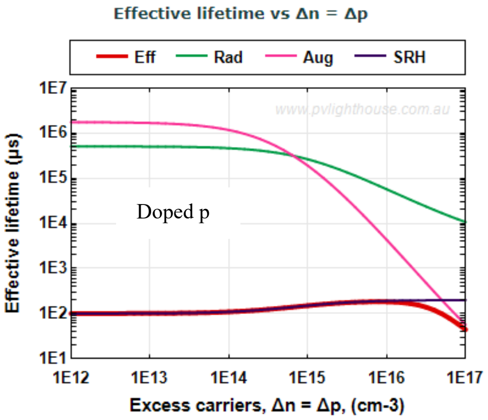

Figure 1: Effective lifetime versus excess carriers for boron dopand specie $N_A=10^{15}$ cm^{-3}, r_0= 135 Ω·cm

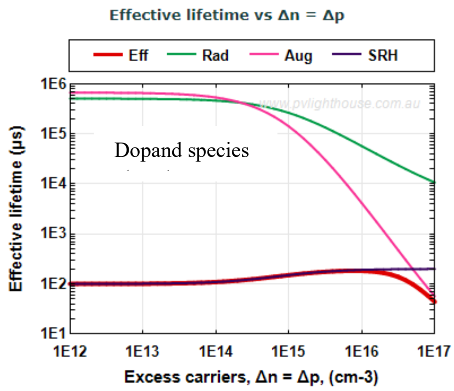

Figure 2: Effective lifetime versus excess for carriers phosphorus dopand specie $N_A=10^{15}$ cm^{-3}, r_0= 4 35 Ω·cm

The effective lifetime is constant and maximum for the excess carriers values in between 10^{12} cm^{-3} and 10^{14} cm^{-3} for Auger recombianaison. That means we have a low injection material that implies a moderate excess carriers. But the effective lifetime is more important for the boron than the phospohorus.

The SHR recombinaison does not effect the effective lifetime , it's very low compare to the radiative and Auger recombinaison.

For excess carriers passes over the value 10^{14} , the effective lifetime decreases linearly for both auger and radiative, nevertheless this deceasing is quick for the auger recombinaison. This correpond to an important injection material that more excess carriers.

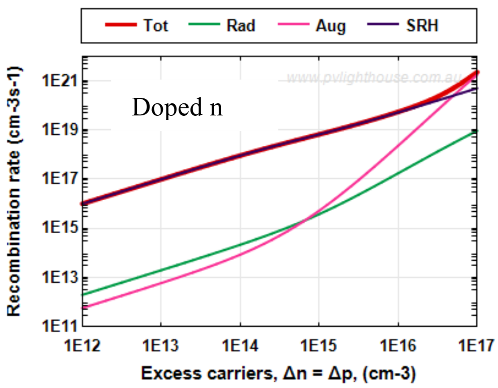

Figure 3: Recombinaison rate versus excess carriers for boron dopand specie $N_A=10^{15}$ cm^{-3}, r_0= 135 Ω·cm

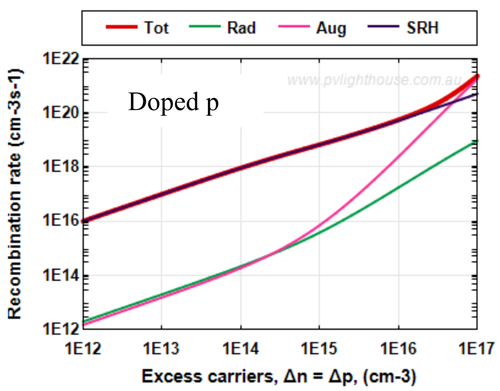

Figure 4: Recombinaison rate versus excess for carriers phosphorus dopand specie $N_A=10^{15}$ cm^{-3}, r_0= 4 35 Ω·cm

$$\tau = \frac{\Delta n}{R} \quad (1)$$

Relating by the formula above , the recombinaison depends on the excess carriers and effective lifetime.From the formula we understand that the effective lifetime is very weak when the recombinaison rate is important .This fact is shown for both dopand species for figures 3 and 4.The recombinaison rate is more important for the dopand species boron than the phosphorus.

$$\frac{1}{\tau_{\text{bulk}}} = \frac{1}{\tau_{\text{Band}}} + \frac{1}{\tau_{\text{Auger}}} + \frac{1}{\tau_{Defect}} \quad (2)$$

Table 1 the recombinaison rate and the lifetime relative to recombinaisons for the for silicon doped P types

	Recomb.Rate $cm^{-3}.S^{-1}$	**Proportion (%)**	**Lifetime (us)**
Auger	$5.27 * 10^{15}$	0.08	$1.90 * 10^{5}$
Radiative	$3.80 * 10^{15}$	0.06	$2.63 * 10^{5}$
Shockley-Read-Hall	$6.67 * 10^{18}$	99.86	$1.50 * 10^{2}$
Total or effective	$6.67 * 10^{18}$	100	$1.50 * 10^{2}$

Table 2 the recombinaison rate and the lifetime relative to recombinaison for silicon doped n type

	Recomb.Rate $cm^{-3}.S^{-1}$	**Proportion (%)**	**Lifetime (us)**
Auger	$711 * 10^{15}$	0.11	$1.41 * 10^{5}$
Radiative	$3.81 * 10^{15}$	0.06	$2.63 * 10^{5}$
Shockley-Read-Hall	$6.67 * 10^{18}$	99.84	$1.50 * 10^{2}$
Total or effective	$6.68 * 10^{18}$	100	$1.50 * 10^{2}$

Comparing the two tables, the recombinaison rate is more important for the (Si) dopand specie phosphorus than the (Si) dopand boron. The reason can could be given by the recomabinaison rate shown by both tables.More the recombinaison rate is important, the les sis the effective lifetime time.

4. Conlusion

The aim of this study is to show the impact of dopand species and the effective lifetime and the recombinaison rate considering the excess carriers concentration. The results show that the lifetime is more important for the silicon doped p than the silicium doped n consider the Auger recombinaison. The lifetime for SHR and Radiative recombinaison change slightly for both dopand species.

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