Simulation of P-I-N Photodetector on the Basis of Pure Germanium and SiGe Alloy (95% Ge) for Absorption of λ=1.3μm

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At present, the integrated circuits performances are more and more determined by their interconnections. One of the limitations of most metallic interconnections is the propagation time of an electrical signal from one side to the other of a flea becomes superior to the clock period of the integrated circuit. Due to this the impulses are distorted and are attenuated during the propagation process and thus requiring the introduction of repeaters which increases the warming-up of the circuit considerably. The use of a new type of interconnections intra fleas become essential such as the optical interconnections, which present themselves as an adequate solution to this problem [1]. In the present microprocessors that have a 2GHZ clock, the circuit must distribute signals of frequency superior to 10GHZ. It requires a high speed photo-detector in addition to the optical power in the circuit being mW. It is also necessary that the photo-detector receives a power of the order of 10μW and that it generates a photo-current Iph of the order of μA. The photo-detector must obey to the imperatives of speed and sensitivity raised in the range of polarization imposed [2].

The photodetector to study receive the signal of a wave guide in silicon, this last is transparent to the length of work wave (λ=1.3μm). to make possible the photodetection, we must choose an element possessing a strong coefficient of absorption [3]. Germanium could be a potential candidate because of its strong disagreement of stitch (4%) with the silicon and which makes the thickness critical for germanium layer epytaxie on the silicon that is only some nanometers [3]. To become independent of this inconvenience, we used another material having some properties close to those of Germanium with regard to the absorption (to λ =1.3μm), but also having some properties nearer of those of the Si. It is the SiGe alloy that seems an excellent choice in our case since it permits us to minimize the differences [4], [5].

Simulations showed that detectors studied on basis of Ge, have a very strong absorption. To replace the Ge by the SiGe alloy permits us to eliminate dislocations and so to avoid losses of luminous energy. But this solution does not improve the performances of photo detectors. Indeed, the absorption of a SiGe layer is in the same way weaker than the absorption of a simple layer of Ge dimension. Therefore we conclude that it is necessary to:

- Decrease the x fraction of germanium to decrease dislocations; and
- Increase the x fraction of germanium to increase the absorption

Results

Simulation in obscurity

a. For the pure germanium:

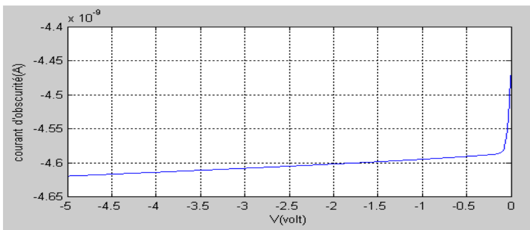

Fig.1: Obscurity current according to the inverse polarization for an inter-electrode distance of 3μm.

b. For the SiGe alloy (95% Ge):

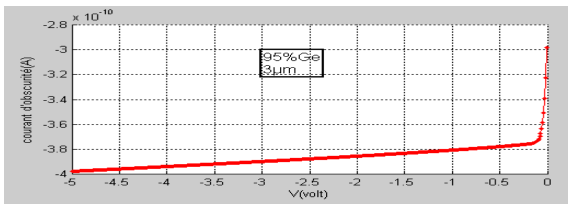

Fig.2: Dark current for PIN in Si0.05Ge0.95 and inter-electrode distance of 3μm.

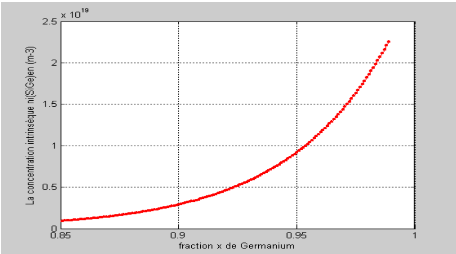

Fig.3: The intrinsic concentration of SiGe alloy according to the fraction of germanium (0.85 <x <0.99).

Under continuous illumination

Table 1: Summary of the temporal response under continuous illumination of two photo detectors, one in pure Ge and the other in SiGe (95%Ge).

		Sensibilité (Ge pur)	Sensibilité (SiGe(95%Ge))
3µm	-1v	32.11%	4%
	-2v	57.65%	7.10%
	-3v	83.10%	10.23%

Under transient illumination

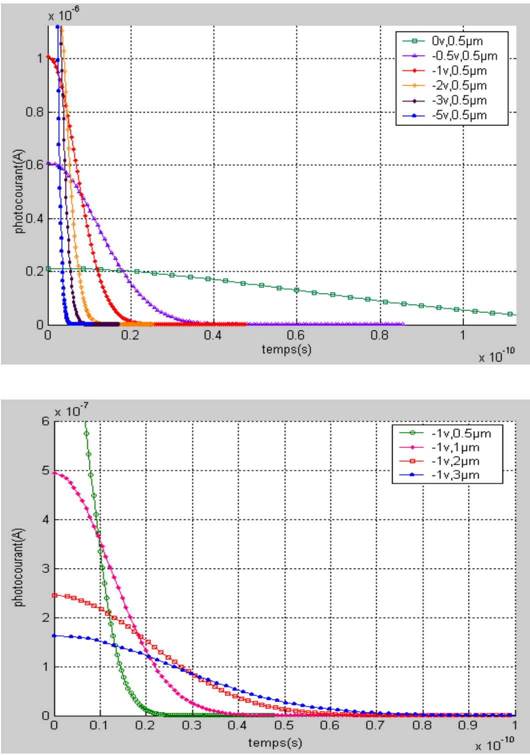

Fig.4: Temporal response of the PIN (pure Ge).

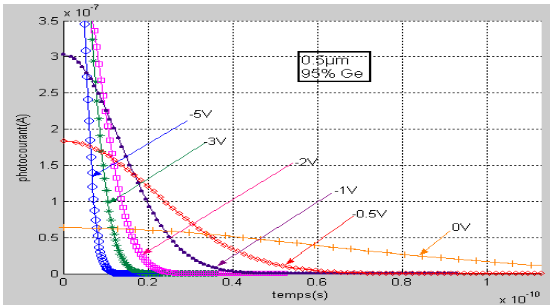

Fig.5: Temporal response of the PIN (95%Ge).

Table 2: Summary of the temporal response under transient illumination.

		0V	-0.5V	-1V
0.5µm	Ge	2.29GHZ	8.98GHZ	22.45GHZ
	SiGe(95%Ge)	2.27GHZ	5.93GHZ	9.46GHZ
		-2V	-3V	-5V
0.5µm	Ge	31.84GHZ	46.58GHZ	91.22GHZ
	SiGe(95%Ge)	17.51GHZ	18.63GHZ	43.78GHZ

References

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