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Building the electrical model of the Photoelectric Laser Stimulation of a PMOS transistor in 90 nm technology

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Purpose

- Understand effect of PLS (Photoelectrical Laser Stimulation) on a diode and then on a PMOS transistor in 90nm technology.

- Present an electrical model of a PMOS transistor under PLS.

Outline

Introduction:

◙ **Failure analysis:** extensive use of laser stimulation techniques:

Extensive and time consuming

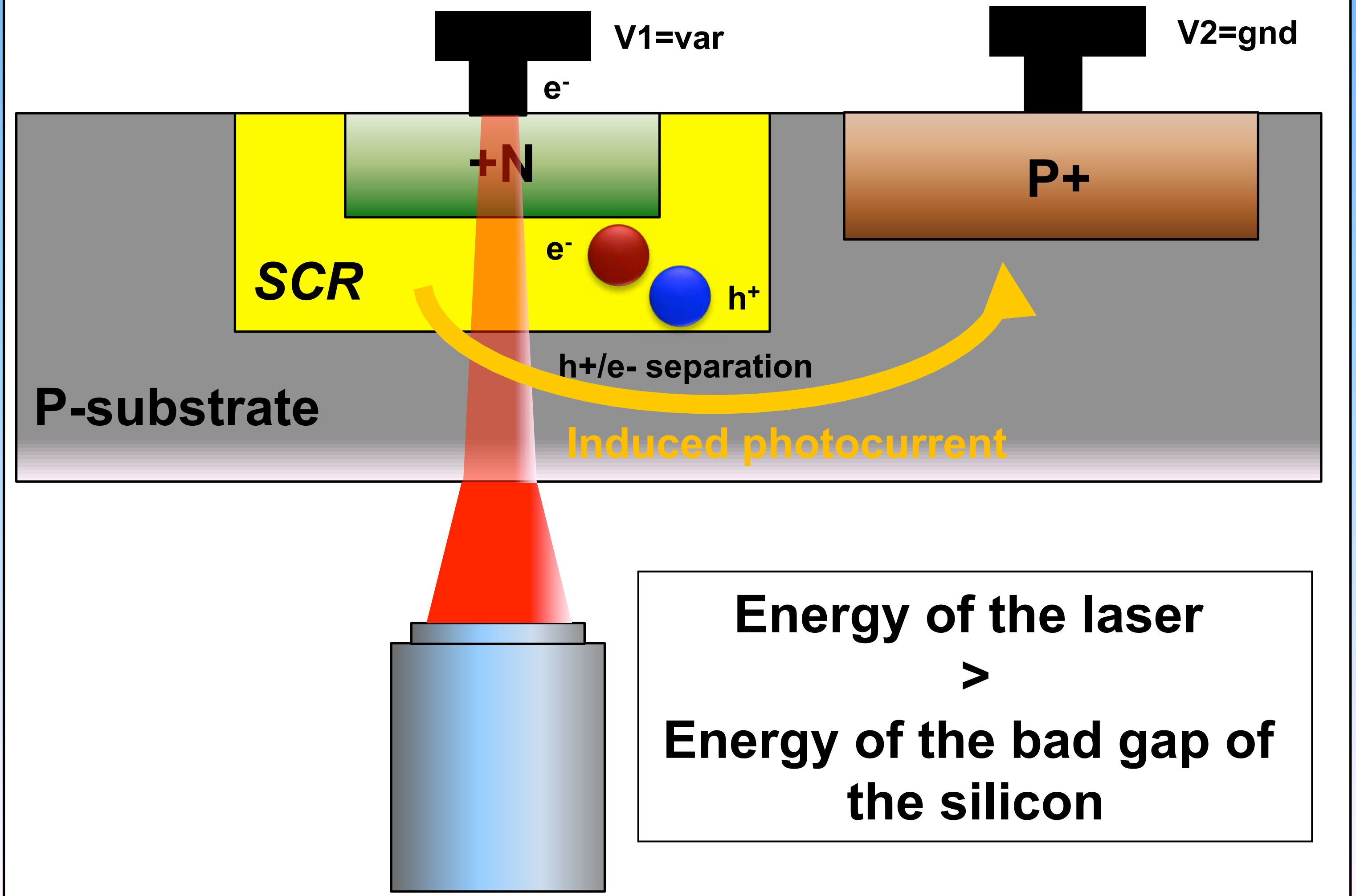
◙ **This paper present:**

↳ an electrical model of the PLS of a PMOS transistor.

↳ Build from: electrical measurements (I-phemos Hamamatsu)

Goal: Predict the response of a PMOS transistor to PLS in a very small amount of calculation time.

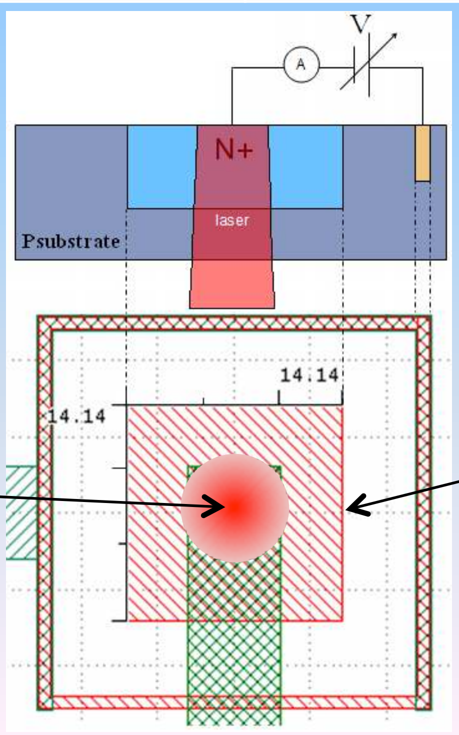
Principe of the Photoelectric Laser stimulation (PLS)



Energy of the laser
>
Energy of the bad gap of the silicon

Characterization of a diode N+ on P-substrate under PLS

Laser parameter	Value
Continuous laser beam	Yes
Laser power	Variable from 0 to 40 mw
Diameter of the spot	Ø 3.25 µm
Laser wavelength	1064 nm

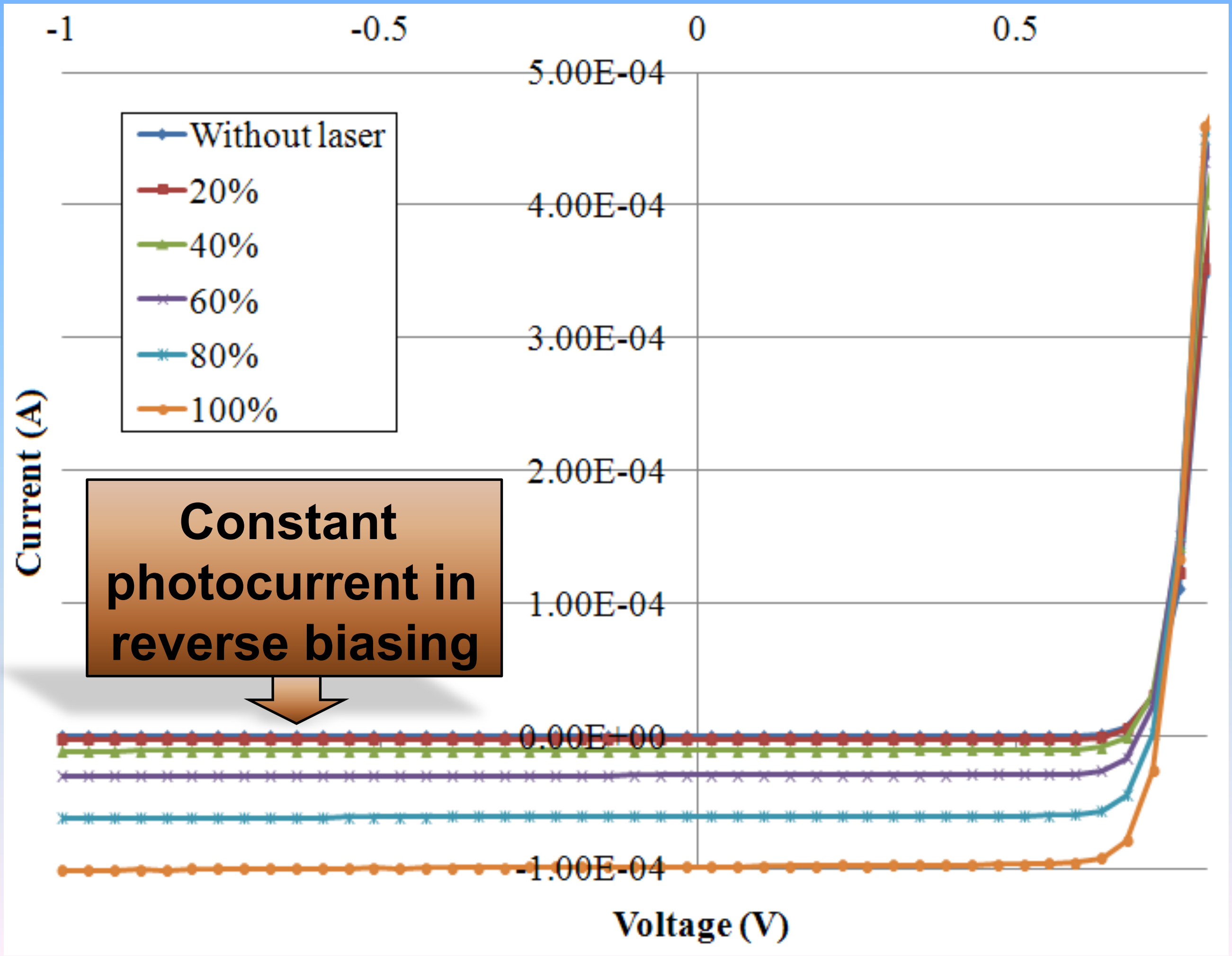


Localization of the laser beam

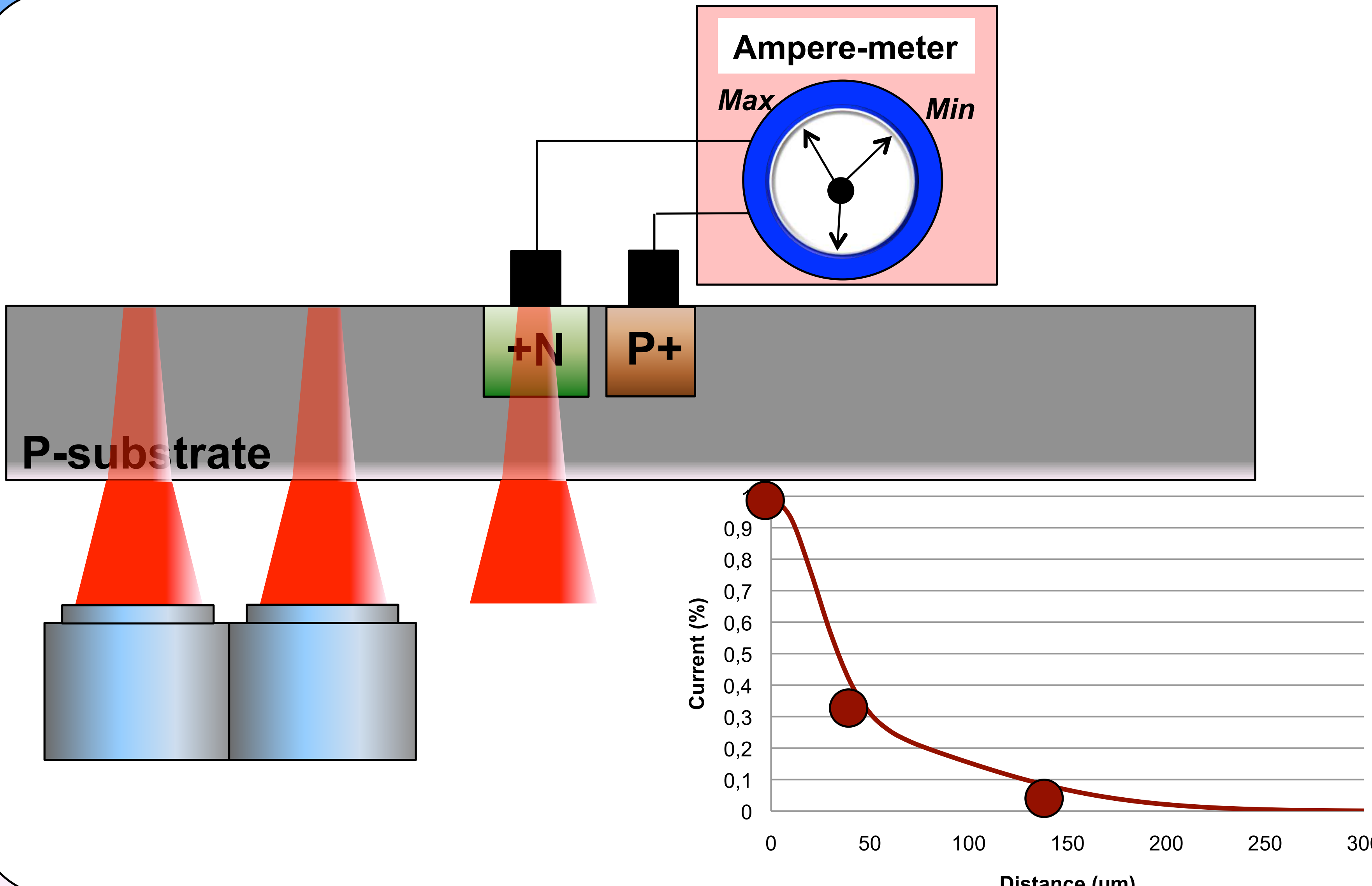
Layout of the diode N+ on P-substrate

Measurement of a diode under PLS

I(V) characteristic of a N+/P-substrate diode under PLS



Gaussian effect on a PN junction



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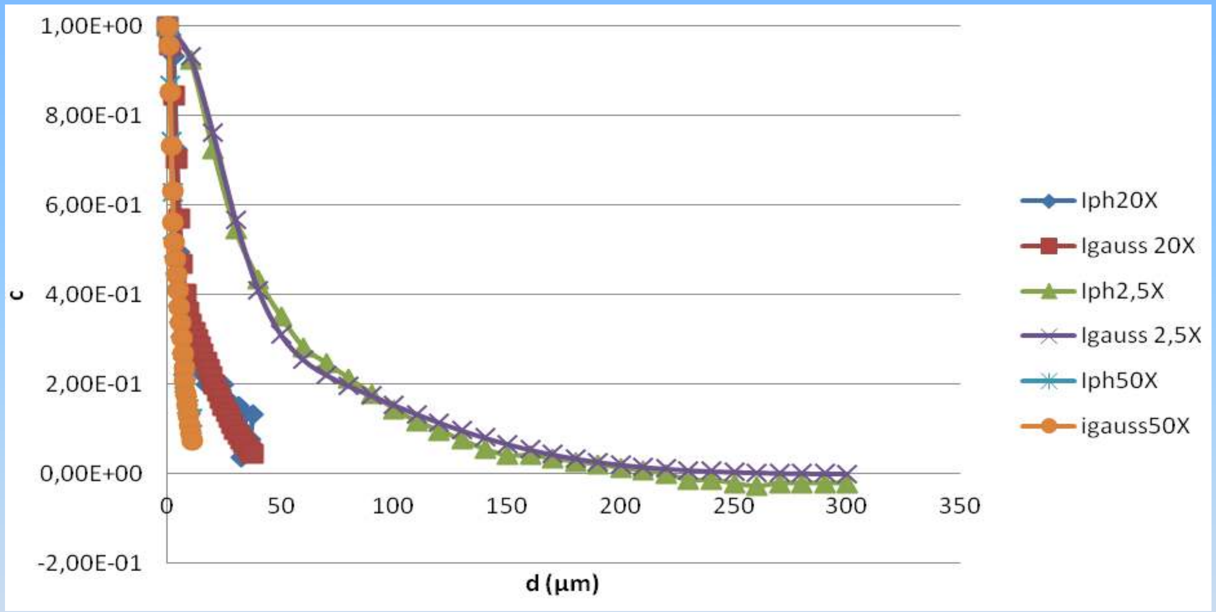
Gaussian like behavior of the N+/ Psubstrate diode

Characterization made for the three objectives of the I-phemos equipment 2.5X – 20X – 50X



Extracted from measurement →

$$\alpha_{gauss}(d) = a*\exp\left(-\frac{d^2}{c_1}\right) + b*\exp\left(-\frac{d^2}{c_2}\right)$$

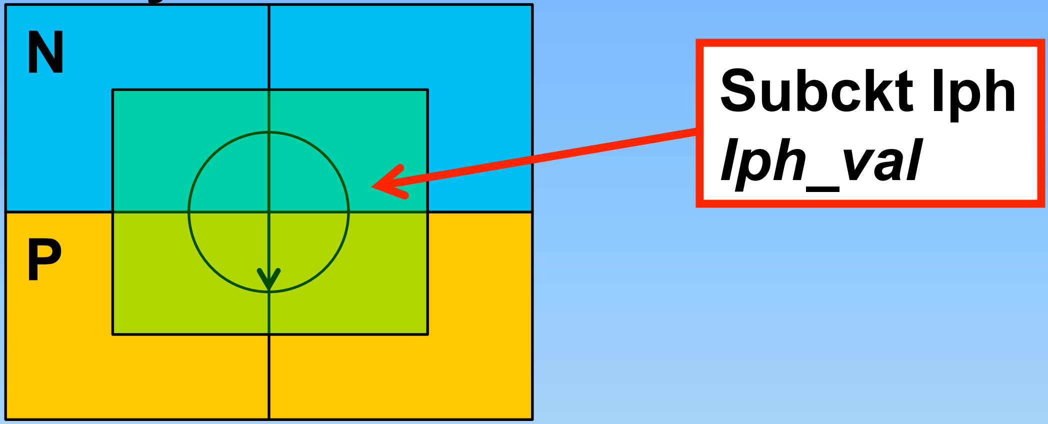
	2.5X	20X	50X
a	0.4	0.6	0.7
b	0.6	0.4	0.3
c_1	2.5	23.8	1000
c_2	55	654	15000

Same methodology for the Nwell/Psubstrate diode

	2.5X	20X	50X
a	0.5	0.6	0.7
b	0.5	0.4	0.3
c_1	2	1000	1500
c_2	48	15000	17000

Presentation of the subckt Iph

In our model every PN junction under PLS are modeled by a current source



$$Iph\_val = S * I_{laser} * \alpha_{gauss}$$

Where: S is the area of the PN junction

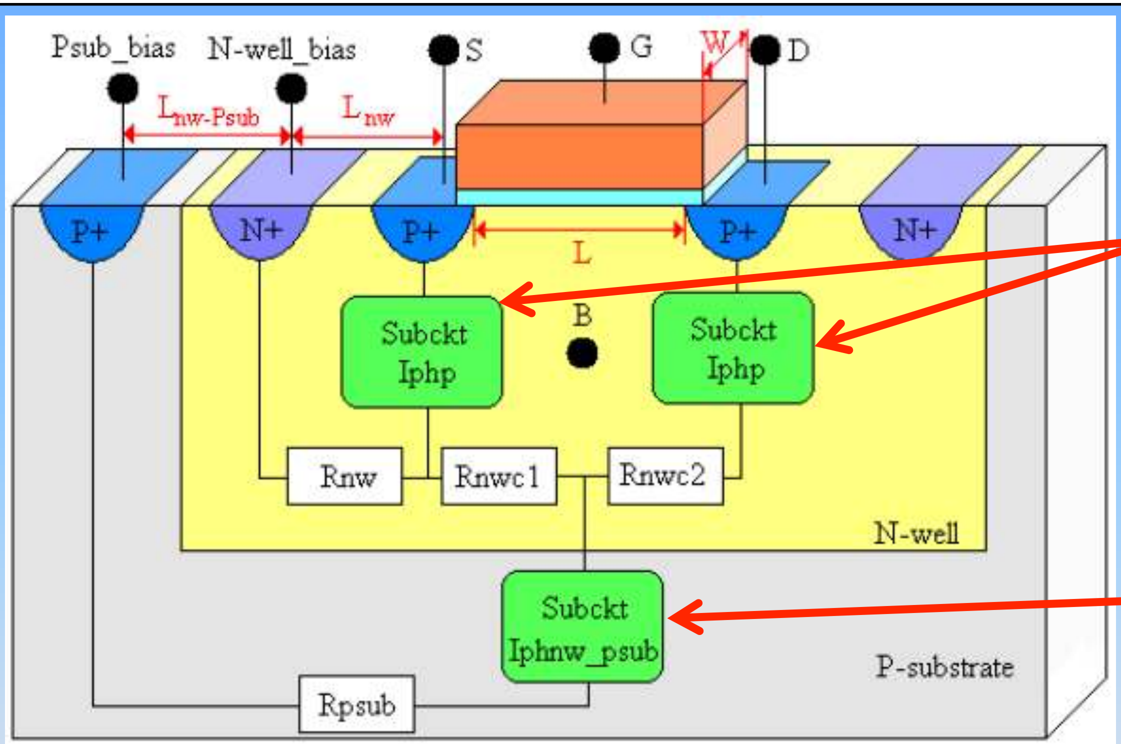
I_{laser} is a function depending of the laser power P_{laser}

$$I_{laser} = 0.0323 * P_{laser}^{2} + 0.3335 * P_{laser} - 0.1624$$

$Alpha_{gauss}$ is a parameter evolved between 0 and 1

$$\alpha_{gauss}(d) = a * \exp\left(-\frac{d^2}{c_1}\right) + b * \exp\left(-\frac{d^2}{c_2}\right)$$

Presentation of the electrical model



2 Subckt Iph

2 Subckt nw_psub

For every PN junction the user have to plug a subckt Iph and set two parameters:

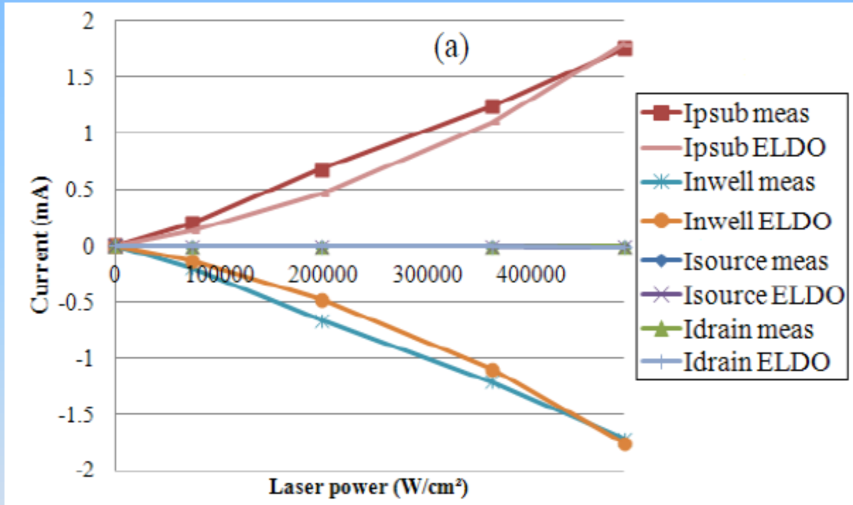
- The area of the PN junction: *S*

- The distance between the laser spot and the closest edge to the junction: *d*

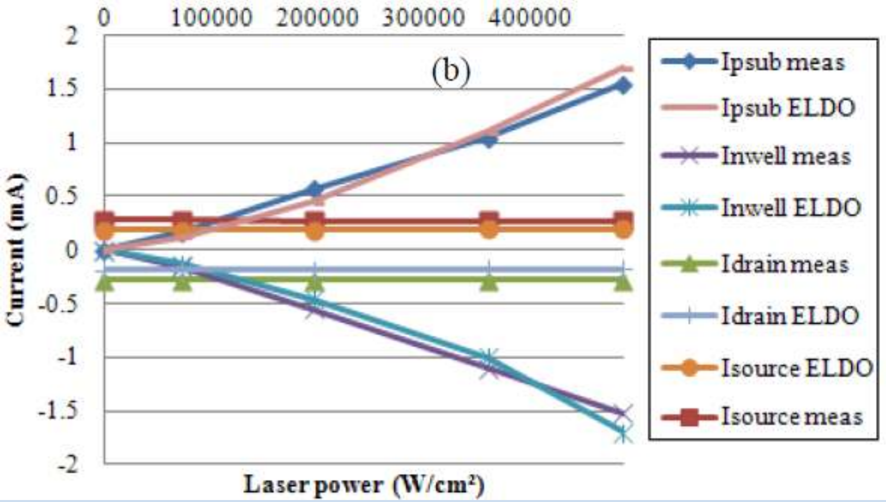
Laser power
ELDO simulation vs measurement

PMOS transistor

W=10µm/L=0.09µm
Turn OFF



W=10µm/L=1.2µm
Turn OFF

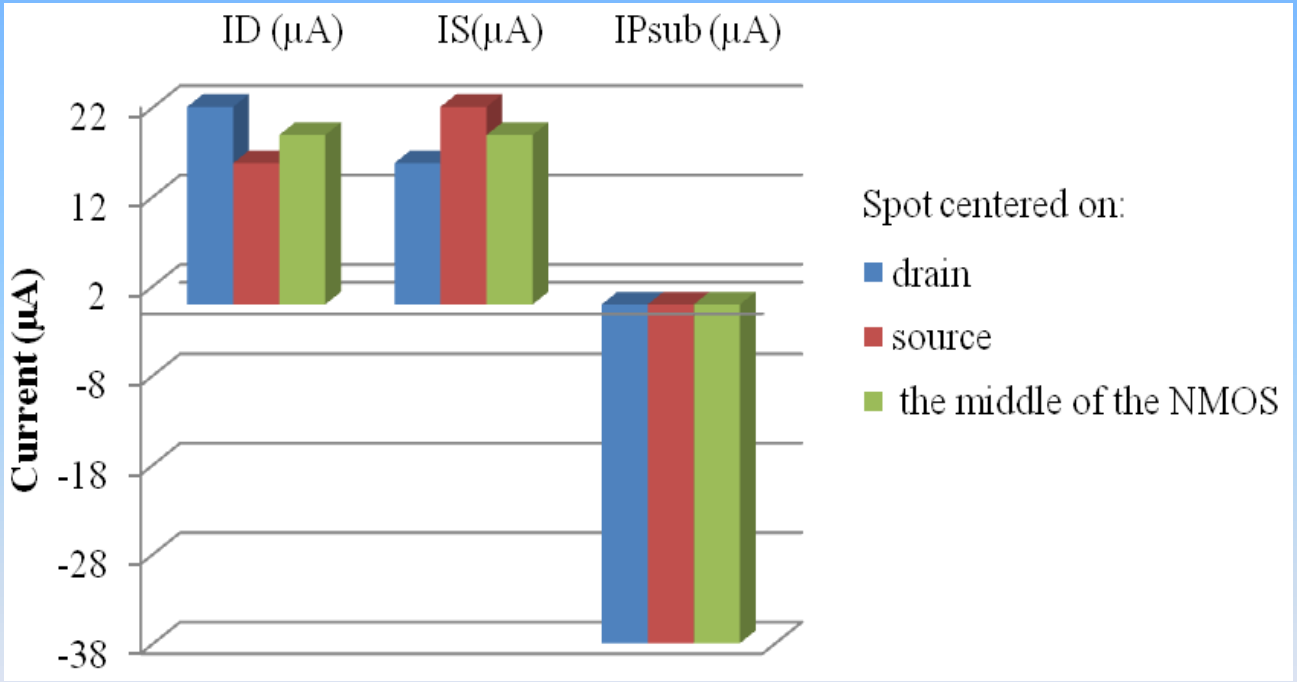


$$|I_{substrate}| = I_{drain} + I_{source}$$

Good correlation between ELDO simulation and measurement

Current cartographies Principe

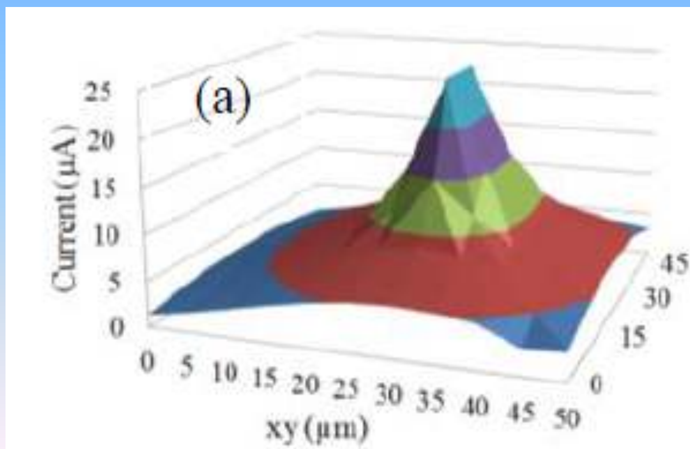
Extracted from ELDO simulation



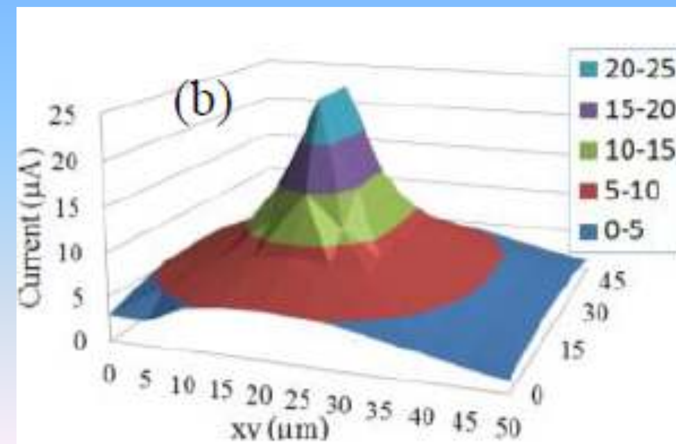
More the spot is close to the PN junction and more its photocurrent is high.

3D current cartographies extracted from ELDO simulation

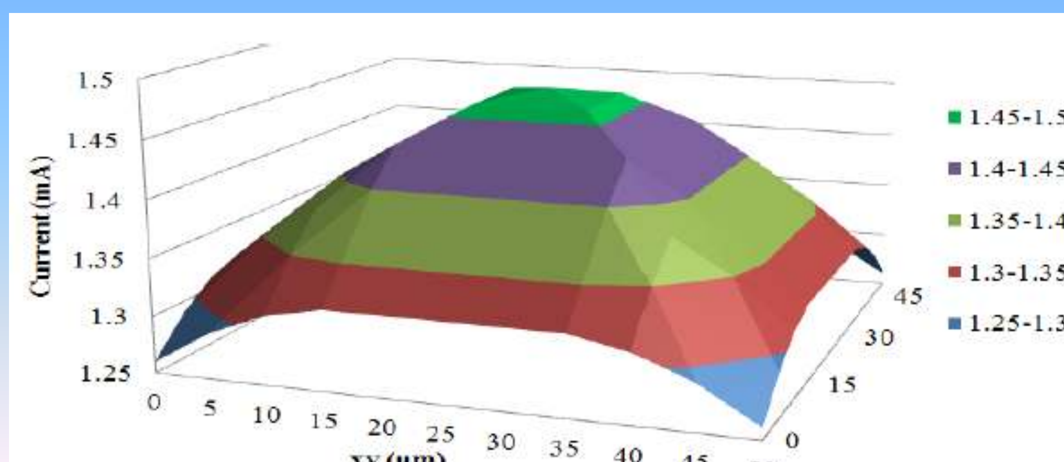
From drain electrode



From source electrode



From P-substrate electrode



Conclusion

- Electrical simulation of the interaction between laser and silicon on a PMOS transistor in 90nm technology seems to be an extremely reliable, fast and also economical tool

- The validity of our approach is assessed by the very good correlation obtained between simulations and measurements.

- This work will be extended to PMOS transistors and then more complex gates.

Thank you for your attention…