An Improved BDJ Color Detector Physical Model

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Successful design of integrated color sensors using Buried Double pn Junction (BDJ) detectors requires a reliable model that describes accurately the BDJ behavior. In order to improve the BDJ physical model, we adopted a new modeling approach. The approach gives good agreement between simulation results and measurements curried out on a CMOS test circuit.

BDJ color detector

In a standard n-well CMOS technology, the BDJ color detector structure consists of two buried pn junctions. Under illumination and reverse bias conditions, two currents I1 and I2 flow through the structure (Fig.1). Each current has two components, the dark current component and the photocurrent one. The photocurrents spectral responses present two peaks: one in the blue wavelength region and the other in the red one. The current ratio I2/I1 shows a monotonically increasing function with the wavelength. Thus, both wavelength and optical power of a monochromatic light can be determined.

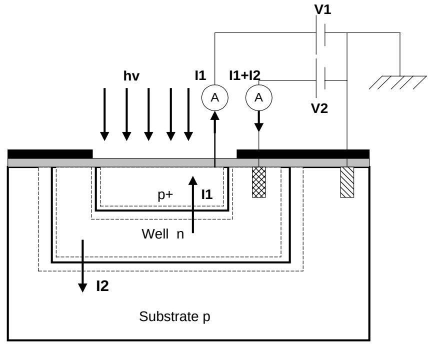

Fig1 BDJ Structure

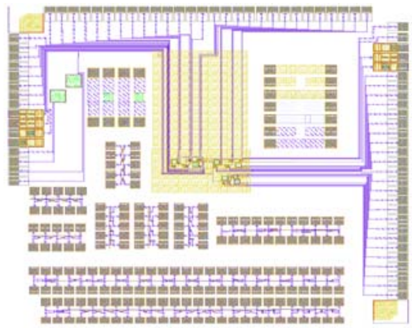

Fig2. Test circuit layout

Modeling approach

The approach we adopted takes into account the physical phenomena that intervene to form the BDJ dark and photo-generated currents. It consists also on experimental extraction of some physical and electrical parameters by using the C-V technique. The experimental procedure consists of measuring the depletion capacitance of the BDJ shallow and deep junction versus reverse bias. By exploiting the C-V experimental curves (Fig.3 and Fig4), some physical and electrical parameters are determined.

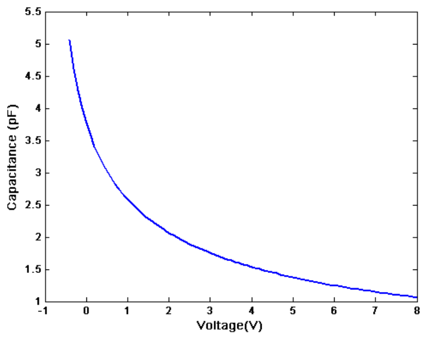

Fig.3 Shallow junction depletion capacitance

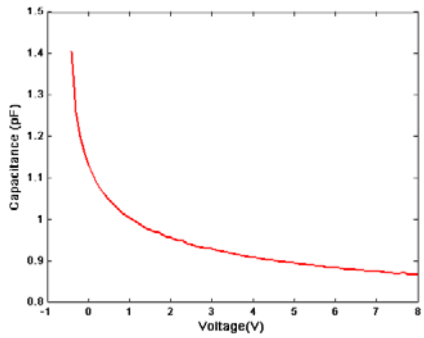

Fig.4 Deep junction depletion capacitance

Simulation and experimental results

The approach is evaluated by comparing simulation results of both dark and photo-generated currents to measurements curried out on a CMOS test circuit (Fig.2).

1. Dark currents

Good agreement is obtained between simulation results and measurements (Fig.5).

Dark current of shallow junction exhibits a wide variation versus reverse bias. This is due to the non-negligible contribution of generation and tunneling phenomena

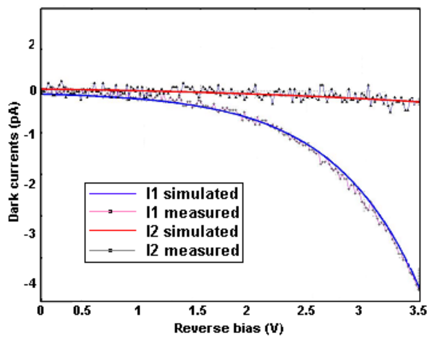

Fig.5 BDJ dark currents

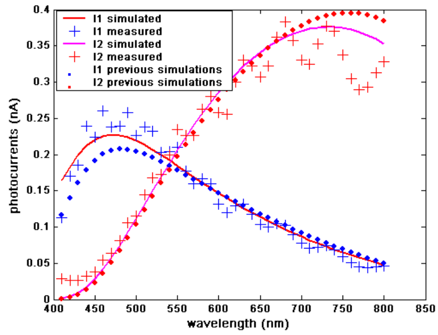

Fig.6 Photocurrent spectral responses

2. Photocurrents

Both experimental data and simulation results obtained in previous works are plotted against to our simulations.

We note that experimental curves give best fit to our simulations compared to that of previous works (Fig.6). This is confirmed by the photocurrents ratio plots (Fig.7).

To evaluate our model accuracy, we calculated at every wavelength the relative error between simulation and experimental results. By using our modeling approach the difference is reduced. It is about 1% in the wavelength range 490nm to 750 nm (Fig.8).

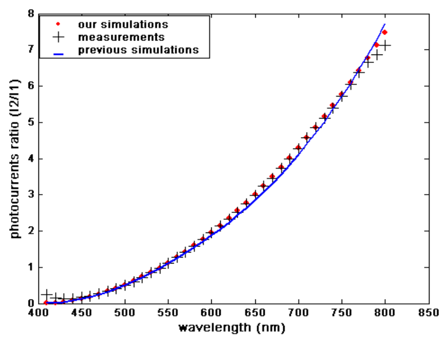

Fig.7 BDJ photocurrents ratio

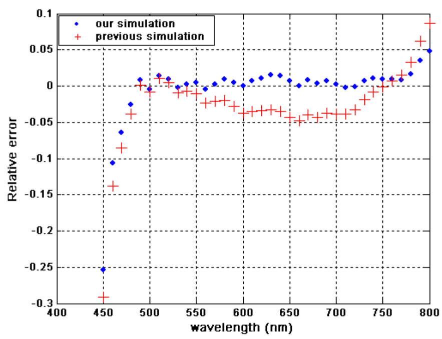

Fig.8 Relative error between simulations and measurements.

Conclusion

A new approach has been proposed in order to develop a reliable model that describes accurately the BDJ color detector behavior. To validate the model, measurements of the dark and photogenerated currents are carried out on a CMOS test circuit and compared to the simulation results. We note that using our approach the difference between simulation and measurements is reduced.