Technology of P-on-N, N-on-P, and N-on-N large area microstrip silicon radiation detectors

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I. ABSTRACT

This paper presents the results of the design and fabrication of large area, micro-strip detectors. The main detector is 6×6 cm^2 large. The diodes are capacitively coupled, and biased using high resistivity polysilicon resistors. Both N-in-P and P-in-N types have been fabricated in standard and oxygenated substrates. Behaviour of the final detectors is satisfactory, with low leakage currents, and moderately high breakdown voltages.

II. DESIGN AND FABRICATION

There are three different available technologies to fabricate silicon micro-strip radiation detectors: P-on-N, N-on-P, and N-on-N. Each one has advantages and drawbacks, the object of this work is to allow a direct comparison between them.

A complete mask set was designed at IMB-CNM in collaboration with the University of Liverpool and IFIC. It contains the following devices: A complete set of test structures, repeated in 12 sites; one 5×5 mm^2 pad detector, repeated in 8 sites; baby detectors of different pitches, in 18 sites; and one large area (6×6 cm^2) silicon radiation detector. Figure 1 above shows the layout of the complete wafer. The design has been optimised for N-on-P technology, although it also allows the fabrication of P-on-N. This mask set could be used to evaluate N-on-N technology with some limitations. The layers used are indicated in table 1. The purpose of each one depends on the technology.

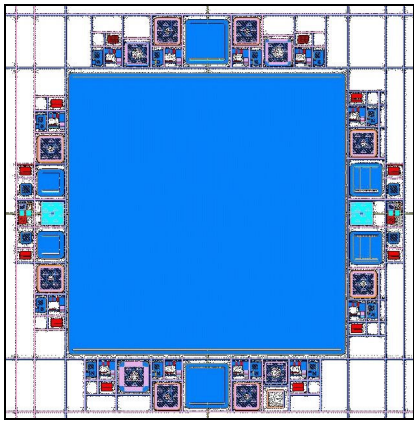

Figure 1. Layout of the complete wafer .

The main structure is a large area detector, taking up the whole central part of the wafer. It has 770 strips diodes, measuring 20 µm wide and 61570 µm long, with a pitch of 80 µm. Every strip has polysilicon biasing resistors, and it is capacitively coupled to the external amplifier through an integrated metal capacitor. Only one metal layer is used. The insulation for the N-on-P technology is

Table 1. Layers used on each technology.

	Purpose		
Layer	**P-on-N**	**N-on-P**	**N-on-N**
P-DIFF	not used	P-stops	P-stops
N-DIFF	P+ junctions	N+ junctions	N+ junctions
RES-CON	Low resistivity polysilicon		
POLY	High resistivity polysilicon		
WINDOW	Contact		
METAL	Metal		
PASSIV	Passivation		

ensured by individual P-stops, and global P-spray. The P-on-N technology does not need any insulation.

N-on-P detectors have been fabricated in standard and oxygenated substrates, 280 µm thick. In order to optimise the breakdown voltage, different values of P-stop implant dose, and the use of a blanket P-spray implant have been evaluated. Figure 2 shows a picture of the bias diode part of the main detector fabricated.

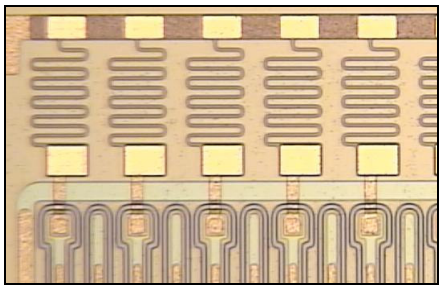

Figure 2. Image of one of the fabricated detectors.

III. RESULTS

With this mask set we fabricated detectors in the three different technologies P-on-N, N-on-P and N-on-N. The behaviour of the detectors is satisfactory. The leakage current is extremely low for all the cases, as it is the percentage of damaged channels due to oxide pinholes, although breakdown voltage is a bit low.

The electrical behaviour for P-on-N is good. Reverse current curves are shown in figure 3. For N-on-P the detectors work with low breakdown voltage. It will be necessary to change the insulation scheme from p-stop to p-spray to get adequate values.

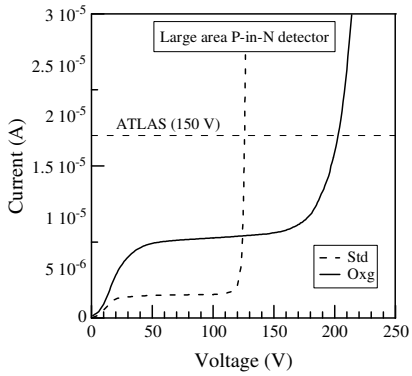

Figure 3. Reverse characteristics of P-on-N detectors.

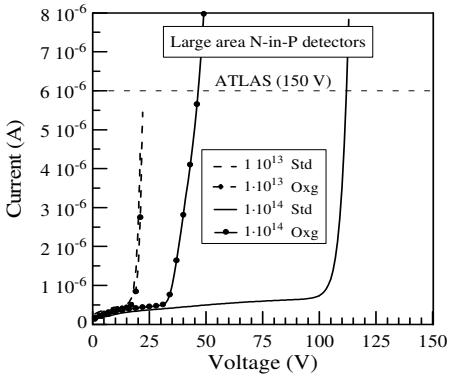

Figure 4. Reverse characteristics of N-on-P detectors.

The large area N-in-P detector has a leakage current density less than 20 nA/cm^2. The breakdown voltage is higher than 100 V, and the full depletion voltage is 80 V. Reverse current curves is shown in figure 4. Finally, the inter-strip capacitance is 4 nF. A potential problem of these detectors is the presence of pinholes in the coupling capacitor oxide; in our technology the oxide integrity is very good, with less than 0.4% bad channels. These good values demonstrate the quality of the fabrication process and the absence of contamination in the clean room.

The N-on-N detectors were included only for radiation hardness studies. Before irradiation these diodes are shorted due to surface states, but after type inversion the detectors work properly.

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