Elimination of Early Breakdowns in Fully-Depleted Detectors of Ionizing Radiation

Krzysztof Kucharski, Paweł Janus, Andrzej Panas, Grzegorz Głuszko, Daniel Tomaszewski, Konrad Krzyżak

Łukasiewicz-Instytut Mikroelektroniki i Fotoniki, Al. Lotników 32/46, Warsaw, Poland

Reverse-biased P-N junctions are basic elements of many silicon detectors of electromagnetic radiation. They work under high reverse bias conditions (nominally 40 V). Therefore, a so-called early breakdown is a key parameter that determines whether given detector is good or bad. The term early breakdown denotes a rapid increase of the I-V characteristics of the reverse-biased P-N junction below an avalanche breakdown. Only detectors without early breakdowns can be candidates for real applications depending on the value of a so-called "dark" current. This work presents results of our technological experiments aimed at elimination of the early breakdowns in P-N junctions.

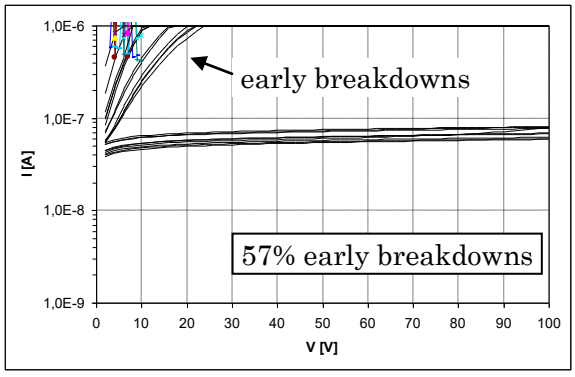
Circular diodes (diameter 4 mm) were fabricated on 4-inch high resistivity silicon wafers using different processing sequences. Next, electrical measurements of the junctions were done along the wafer diameter. The following technology variants were taken into consideration:

- devices after so-called "spray" n-type implantation (low dose and energy) of front side of the wafer;
- devices with different methods of doping of contact areas at the back side of the wafer: P implantation or diffusion from the $POCl_3$ source;
- devices with two thicknesses of poly-Si getter at the at the back side of the wafer: 1.1 µm, 1.6 µm;

Results of the experiment were as follows:

- "Spray" n-type implantation of front sides and back side contact implantation eliminated efficiently early breakdowns (Fig. 1). However, such doping methods can lead to degradation of "dark" currents. In such a case "dark currents" can be effectively improved using a poly-Si getter at the wafer back sides.
- Using the standard (thickness 1.1 µm) gettering process without implantation did not eliminate early breakdowns. However an increase of the getter thickness to 1.6 µm allowed to eliminate early breakdowns. Obviously, this method required a longer wafer processing.

a)



b)

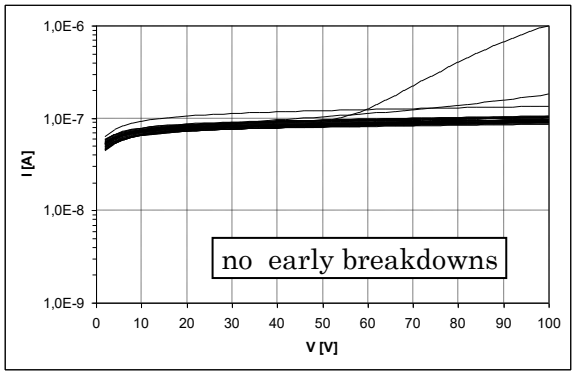


Fig.1 Effect of type of ohmic contact at the back side: a) $POCL_3$, b) P-implant.; in both cases standard, 1.1 µm-thick phosphorus doped poly-Si getter at the back side used.