Dead Layer Determination in Planar HPGe Detector Prototypes

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INTRODUCTION

An HPGe detector is a reversely biased diode consisting of three important elements: electric contacts, respectively n+ and p+ contacts, active volume and passivated surface. In order to achieve the complete charge depletion of the Ge crystal volume and sustain high applied voltage with low leakage current, the surface must be passivated [1,2].

Unlike Silicon, Ge oxides are not stable for long term operation [1,2]. The passivation methods that have been used in industry involve sputtering a layer of either SiO2 or amorphous Ge onto the detector surface. Unfortunately, these treatments can modify the electric field configuration near the surface giving rise to the formation of dead layers, where charges are lost.

Different methods for the surface passivation of HPGe detectors have been applied [3-5] and studied at LNL.

MEASUREMENTS

The passivation methods we have studied are methanol passivation, sulfide termination, hydride termination in low concentration acid and hydride termination in high concentration acid.

A lateral scan with low energy gamma source [6,7] has been realized in order to investigate the charge collection behavior near the passivated surface and efficiencies measurements have been performed to highlight the influence of the passivation in the active volume.

RESULTS AND DISCUSSION

The dead layer thickness for the different passivations, as can be seen in Fig. 1, was estimated starting from the counting rate and applying the Beer-Lambert law [8] for the gamma rays absorption by the Ge crystal and by the absorbing layers between source and crystal. The experimental data have been acquired starting at 2.5 mm from the contacts, considering the thickness of contact dead layers and the spot diameter.

The dead layer estimation is based on the assumption that the counting rate which misses is uniformly lost in the surface layer. The trends of the dead layer thickness are quite different for the different passivations.

Several arguments have been given to explain the reason of these passivation-induced dead layers, in which it is not possible to collect all the electric charges induced by the incident radiation. The possibilities are: a non electrically active material, where charges are lost or a weak field region that prevents electric charges collection or a region of distorted fields, which drive the charges away from the active volume [3-5].

![Fig. 1. Dead layer induced by the different passivations as a function of the lateral scan position.](image)

CONCLUSIONS

The dead layer induced by different passivations below the intrinsic surface of a HPGe crystal was measured. For low H, methanol and high H passivations the dead layer is quite similar, while a strong difference is found for the sulfide passivation: this passivation has an average dead layer around 1 mm that gives rise to a 10 % of decrease in active volume.

The behavior of the S-terminated detector, which shows a lower dead layer close to the n+ contact (Fig.1), could be explained in terms of surface channels as described in [9].