Characterization of thin silicon sensors for extreme fluences

Roberto Mulargia[a,b] [1], R. Arcidiacono[b,c], P. Asenov[d,e], G. Borghi[f,g], M. Boscardin[f,g], N. Cartiglia[b], M. Centis Vignali[f,g], M. Costa[a,b], T. Croci[e], M. Ferrero[b,c], F. Ficorella[f,g], A. Fondacci[h], S. Giordanengo[b], O. Hammad Ali[f,g], L. Lanteri[a,b], L. Menzio[a,b], V. Monaco[a,b], A. Morozzi[e], F. Moscatelli[d,e], D. Passeri[e,h], N. Pastrone[b], G. Paternoster[f,g], F. Siviero[a,b], and V. Sola[a,b]

[a] Università degli Studi di Torino, Sezione di Torino, via P. Giuria 1, 10125 Torino, Italy
[b] Istituto Nazionale di Fisica Nucleare, Sezione di Torino, via P. Giuria 1, 10125 Torino, Italy
[c] Università degli Studi del Piemonte Orientale, largo G. Donegani 2/3, 28100 Novara, Italy
[d] CNR-IOM, Sede secondaria di Perugia, via A. Pascoli 23c, 06123 Perugia, Italy
[e] Istituto Nazionale di Fisica Nucleare, Sezione di Perugia, via A. Pascoli 23c, 06123 Perugia, Italy
[f] Fondazione Bruno Kessler, via Sommarive 18, 38123 Povo (TN), Italy
[g] TIFPA-INFN, via Sommarive 18, 38123 Povo (TN), Italy
[h] Università degli Studi di Perugia, via G. Duranti 93, 06125 Perugia, Italy

Abstract

This contribution presents the design, production, and preliminary results of EXFLU1, a new batch of radiation-resistant silicon sensors manufactured at the Fondazione Bruno Kessler (FBK, Italy).

The EXFLU1 sensors utilize thin substrates which are known to be less affected by radiation damage and incorporate the Low-Gain Avalanche Diode (LGAD) technology, enabling internal multiplication of charge carriers to address the challenges posed by thin active thicknesses ranging from 15 to 45 μm. The LGAD structure consists of an *n-in-p* design with a thin p^+ gain layer beneath the n^{++} electrode. However, at fluences greater than 3e15 $\mathrm{n_{eq}/cm^2}$, the multiplication power of LGADs is lost due to acceptor removal, causing them to behave like standard *n-in-p* sensors.

To overcome the present limitations due to acceptor removal, innovative defect engineering techniques have been implemented in the EXFLU1 production. This includes $p^+{-}n^+$ dopant compensation, where a p^+ gain implant is co-implanted together with an n^+ implant to obtain the nominal effective doping density in the gain layer typical of the LGAD sensors. Additionally, a carbon shield is introduced below the gain layer to preserve the acceptor concentration by preventing impurity diffusion. The EXFLU1 design also includes optimized guard-ring configurations to ensure stable and safe sensor operation in extreme fluence environments.

Following production, the EXFLU1 sensors have undergone comprehensive characterizations, including electrical tests such as I-V and C-V measurements. Moreover, performance tests have been conducted before and after irradiation up to 5e15 $\mathrm{n_{eq}/cm^2}$ to examine the sensors' resilience and functionality under challenging radiation conditions.

In our presentation, we will share the preliminary results of the EXFLU1 sensor characterizations, focusing on the I-V and C-V curves. Additionally, we will present the performance test results after irradiation up to 5e15 $\mathrm{n_{eq}/cm^2}$. These findings will provide valuable insights into the effectiveness of the radiation-resistant design strategies and showcase the sensors' performance in extreme fluence environments.

Overall, the EXFLU1 sensors represent a significant advancement in radiation-resistant silicon sensor technology. The combination of innovative defect engineering, thin substrate utilization, and LGAD technology holds great promise for accurate tracking and timing measurements in extreme fluence applications.

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[1] corresponding author - roberto.mulargia@cern.ch