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MILESTONE REPORT

LGAD THICKNESS TECHNOLOGICAL CHOICE

MILESTONE: MS50

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Abstract:
This milestone specifies the Low Gain Avalanche Diode (LGAD) active thickness agreed for the LGAD common run to be carried out within the WP7 program. The preferred thickness is 30 \( \mu m \) active devices manufactured in a SOI technology with a device wafer thickness of 35 \( \mu m \). TCAD simulations and data from recent test beams indicate that 30 \( \mu m \) thin detectors are expected to achieve better radiation tolerance than the 50 \( \mu m \) thin sensors that were implemented in the latest LGAD runs.
AIDA-2020 Consortium, 2017
For more information on AIDA-2020, its partners and contributors please see [www.cern.ch/AIDA2020](http://www.cern.ch/AIDA2020)

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Executive summary

Due to the recent approval of timing subdetectors for the ATLAS and CMS HL-LHC upgrades, the radiation tolerance of the LGAD sensors has become a critical R&D topic. LGADs with smaller active thickness (50 µm) have demonstrated superior radiation hardness as TCAD simulations had suggested. Within the AIDA-2020 WP7 activities, a common LGAD run with an agreed active thickness of 30 µm is foreseen. The sensors will be manufactured using a SOI technology on a wafer with a physical thickness of 35 µm.

1. INTRODUCTION

Low Gain Avalanche Detectors (LGAD) are the baseline choice for the future end-cap timing subdetectors to be operated in ATLAS and CMS during the HL-LHC running period. Within the context of the WP7, a common LGAD run is scheduled for 2017. Among other technological design options, the active thickness of the LGAD is a critical parameter to achieve the required radiation tolerance. This milestone states the agreed LGAD active thickness to be used for the common production.

As it was described in another deliverable of this WP (D7.3), reducing the substrate thickness of LGAD sensors increases the slewing rate of the signal’s leading edge compared to a thicker LGAD, as long as both LGADs are operated at the same gain, as shown in Fig 1. Therefore, the timing resolution of thinner detectors is expected to improve since higher slewing rates yield better timing resolution as long as the noise remains constant. Nonetheless, decreasing the detector thickness increases the sensor’s capacitance which degrades the timing performance. Therefore, we expect that there is an optimal thickness to achieve the best timing resolution.

Previous TCAD simulations (see D7.2) also suggest that reducing the active thickness increases the radiation tolerance of LGADs, which has been demonstrated experimentally very recently.

![Simulated slew rates measured by a 50 W broadband amplifier, Cdet = 2 pF](image)

**Fig. 1** Left: signal slew rate as a function of sensor thickness for 5 different values of gain. Right: current shape of LGAD sensors for equal gain and different thicknesses.
2. TCAD SIMULATION OF THIN LGADS SENSORS

Prior to the LGAD manufacturing, it is important to demonstrate that the new design of the sensors on thinner substrates achieves the necessary breakdown voltage and reaches the desired gain values. The TCAD simulations described in D7.2 were used to verify that the expected performance meet these requirements. In Fig 2 and Fig 3, the current-voltage characteristics and the voltage dependence of the gain are shown. The thinner devices still achieve a relatively large breakdown. No technical show-stoppers are expected during the operation.

In brief, the simulation confirms the soundness of producing LGADs with an active thickness of 30μm.

![IV Characteristic 30μm thin LGAD (35μm SOI wafer)](image)

*Figure 2: IV characteristic for 30 μm thin LGAD (35μm SOI wafer).*

![LGAD Gain (35μm thin SOI wafer)](image)

*Figure 3: Gain vs Bias Voltage for 30μm thin LGAD (35μm SOI wafer)*