



Discussion session on LGAD

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Milestones at th *Prolongation request* (May 2018)

Understanding the radiation effects [9] in LGADs is under intensive investigation within RD50 and will be a priority for the next five years. Different technological solutions are being investigated, such as Carbon or Gallium doping, and new fabrications with thinner sensors with a variety of gain values will be carried out within the RD50 collaboration manufactures. Recent analysis suggests that the decrease in gain can be ascribed to “acceptor removal” which changes the electric field, and to effects associated with a “double junction”. This last effect is the presence of a strong electric field located very close to the backside ohmic junction caused by the hole current dependent and that exhibits strong dependence on annealing.

New geometries such as the Inverted LGAD (iLGAD) will also be explored in thin substrates in order to increase the fill factor in large area experiments.

- M1: Understand the effect of Carbon and Gallium on gain after irradiation (Q1/2019)
- M2: Model the acceptor removal effect after irradiation (Q3/2019)
- M3: Produce new LGAD design to increase the fill factor (Q2/2020)
- M4: Design and simulate new LGAD geometries for operation at $1 \times 10^{17} \text{ n}_{\text{eq}}/\text{cm}^2$ (Q4/2022)

Ongoing projects (some of them completed)

2017-01 LGAD based on EPI wafers (G.Pellegini, CNM, Barcelona)

2017-03 LGAD fabricated with epitaxial layer (G.Pellegrini, CNM, Barcelona)

2017-05 50 μm thin LGAD fabricated with Ga multiplication layer (Joern Lange, IFAE Barcelona)

2017-06 Thin LGADs characterization using IBIC and time-resolved IBIC at CNA (Carmen Jiménez-Ramos, Sevilla)

2017-08 50 μm thin AC-LGAD (Mar Carulla, CNM Barcelona)

2018-01 Development of Segmented LGAD with small pixels and high Fill-Factor (Giovanni Paternoster, FBK)

2020-02: Proof-of-concept and radiation tolerance assessment of thin pixelated Inverse Low Gain Avalanche Detectors (ILGAD) (Ivan Vila, UC-CSIC, Santander)

Hot topic at this workshop (11+2 talks)

Thu 04/06

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11:00	[AS] Radiation performance of the Low Gain Avalanche Diodes developed by NDL and IHEP in China <i>Dr Yuryun Fan</i>	11:30 - 11:50
12:00	First LGAD timing/jitter measurement at ELI with fs-lasers of 800 nm and 1450 nm <i>Prof. Gordana Lastovicka-Medin</i>	11:50 - 12:10
	Lunch Break	
13:00		12:10 - 13:20
	Investigation of LGAD performance dependence on neutron flux <i>Gregor Kramberger</i>	13:20 - 13:40
	Annealing effects on operation of thin Low Gain Avalanche Detectors <i>Alissa Howard</i>	13:40 - 14:00
14:00	AC-LGAD strip sensor measurements with 120 GeV protons <i>Karri Folan Di Petrillo</i>	14:00 - 14:20
	Break	14:20 - 14:40
	Latest results on RSD spatial and timing resolution <i>Marta Tornago</i>	14:40 - 15:00
15:00	Position reconstruction using machine learning algorithms applied to Resistive Silicon Detectors (RSD) <i>Federico Siviero</i>	15:00 - 15:20
	Acceptor removal and gain Reduction in proton and neutron irradiated LGADs <i>Evangelos - Gkougkousis</i>	15:20 - 15:40
	[US] Deep Junction LGAD: a new approach to high granularity LGAD <i>Yuzhan Zhao</i>	15:40 - 16:00
16:00	Break	16:00 - 16:20
	[US] Energy dependence of the acceptor removal by protons for several UFSD types <i>Hartmut Sadrozinski</i>	16:20 - 16:40
	Discussion Session: LGAD <i>Ivan Vila Alvarez et al.</i>	16:40 - 17:20
17:00		

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10:00	[AS] TCAD Simulation of Radiation Damage for LGAD Sensor <i>Tao Yang</i>	10:00 - 10:20
	[AS] TRACS development for LGAD sensor <i>Suyu Xiao</i>	10:20 - 10:40
	Simulation of thickness dependence of time resolution for simple planar devices <i>Marius Mahlum Halvorsen</i>	10:40 - 11:00
11:00	Discussion: Simulations <i>Joern Schwandt</i>	11:00 - 11:30

Study topics (old and new)

TOPICS (LGAD)	Sub-topic	APPROACHES/COMMENTS	MENTIONED IN TALKS
Radiation Tolerance	Q > 4fC @ 2.5 Neq/cm ² , 2MGy Delta_t < 70ps Mixed irradiation (protons and neutrons with different mixtures).	Alternative dopands: Galium Enhancing E field at GL junction: bulk thinning. Suppression of BiOI defect formation: Carbon infusion. Gain Layer profile engineering (shallow vs deep)	3
Radiation Tolerance (LGAD+ASIC)	Highly Ionizing Particles	Sensor fine at least for alpha particles (LGAD + ASIC ?)	1
Radiation Tolerance: (LGAD+ASIC)	max. revers current < 5uA/1.3x1.3x0.05mm ³	Pay attention to bulk reverse current (bulk material)	1
Radiation Tolerance:	extreme fluences 1e17	Optimized thinkness (balance between multiplication region GL and BJ)	0
System aspects:	Max. power dissipation O(100mW/cm ²)	Additional limit on the max Vbias.	1
Reliability:	Long term stability	Signal stability and annealing	1
Reliability:	Spurious Pulses (PCN, self-triggering)	Quantify the and define acceptance criteria (max. rate?)	1
4D tracking: Increase fill factor	AC-LGAD, RSD, I-LGAD (BNL, FBK, CNM)	Complementary strategies : Capacitive coupling, segmentation of ohmic junction.	3
Technology spreading		Increasing number of manufactures BNL, CNM, FBK, HPK, IHEP-NDL	-