Science & Technology Facilities Council

UK Research and Innovation

Preliminary results on LGAD

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TELEDYNE e2v Everywhereyoulook

Overview

- LGAD project description and goals
- design simulations
- preliminary results
- next steps

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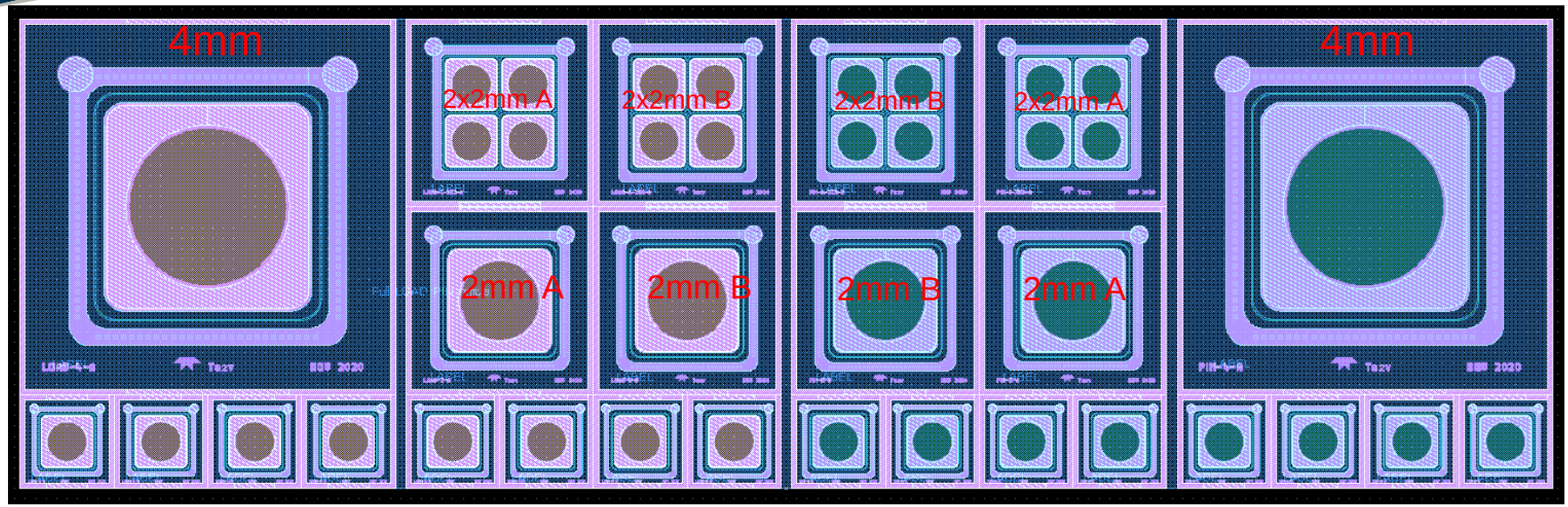
LGAD Project description and goals

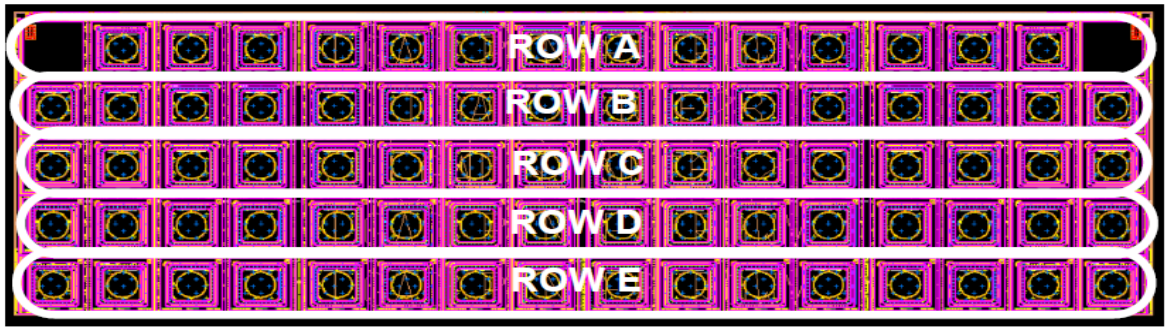
Field 1



A RAL, University of Oxford, University of Birmingham and Open University project in collaboration with Teledyne e2v foundry for LGAD production

- Three types of cathode size of single cells (**4**,**2** & **1**mm) and one of 2 x 2 array of **1**mm cells. Up to four different cell layout flavors (**A,B,C,D**) are implemented with different distances of guard ring to the cathode
- LGAD and PiN diodes share the same layouts , only difference being the presence or not of the gain layer

LGAD Project description and goals



Field 2

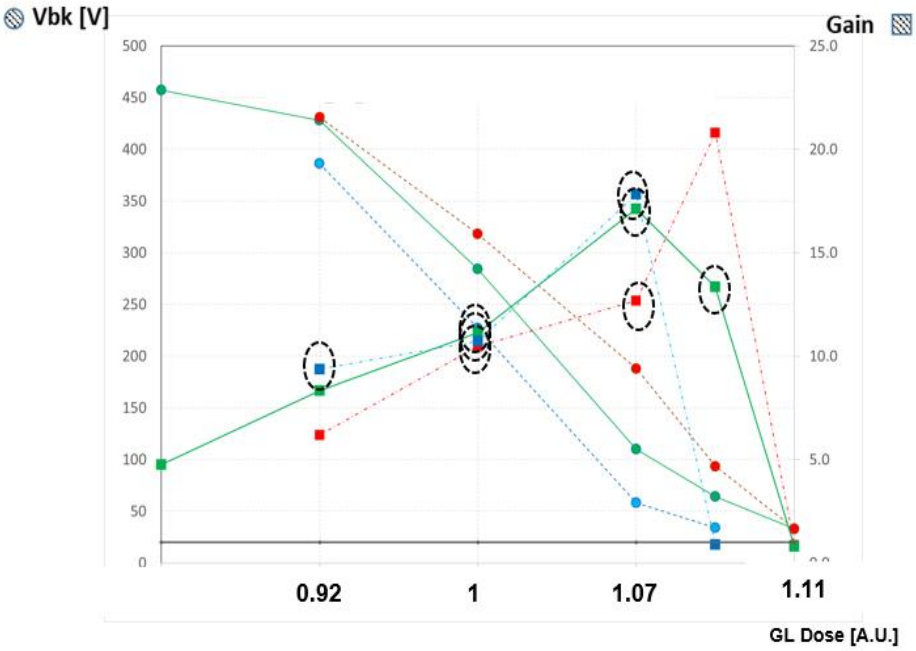
Field 3

- Additional devices are available on each wafer, which has 3 fields, to investigate various effects, including separate biasing of P-stop, retraction of gain layer from JTE contact, further extension or reduction of metal cathode over JTE
- Capacitors, diodes and resistors available too

LGAD Project description and goals

Wafer #	GL dose	GL energy	GL type
1	1	1	Boron
2	1.07	1	Boron
3	0.92	1.05	Boron
4	1	1.05	Boron
5	1.07	1.05	Boron
6	1.15	1.05	Boron
7	1	1.11	Boron
8	1.07	1.11	Boron

Table 1: devices variants

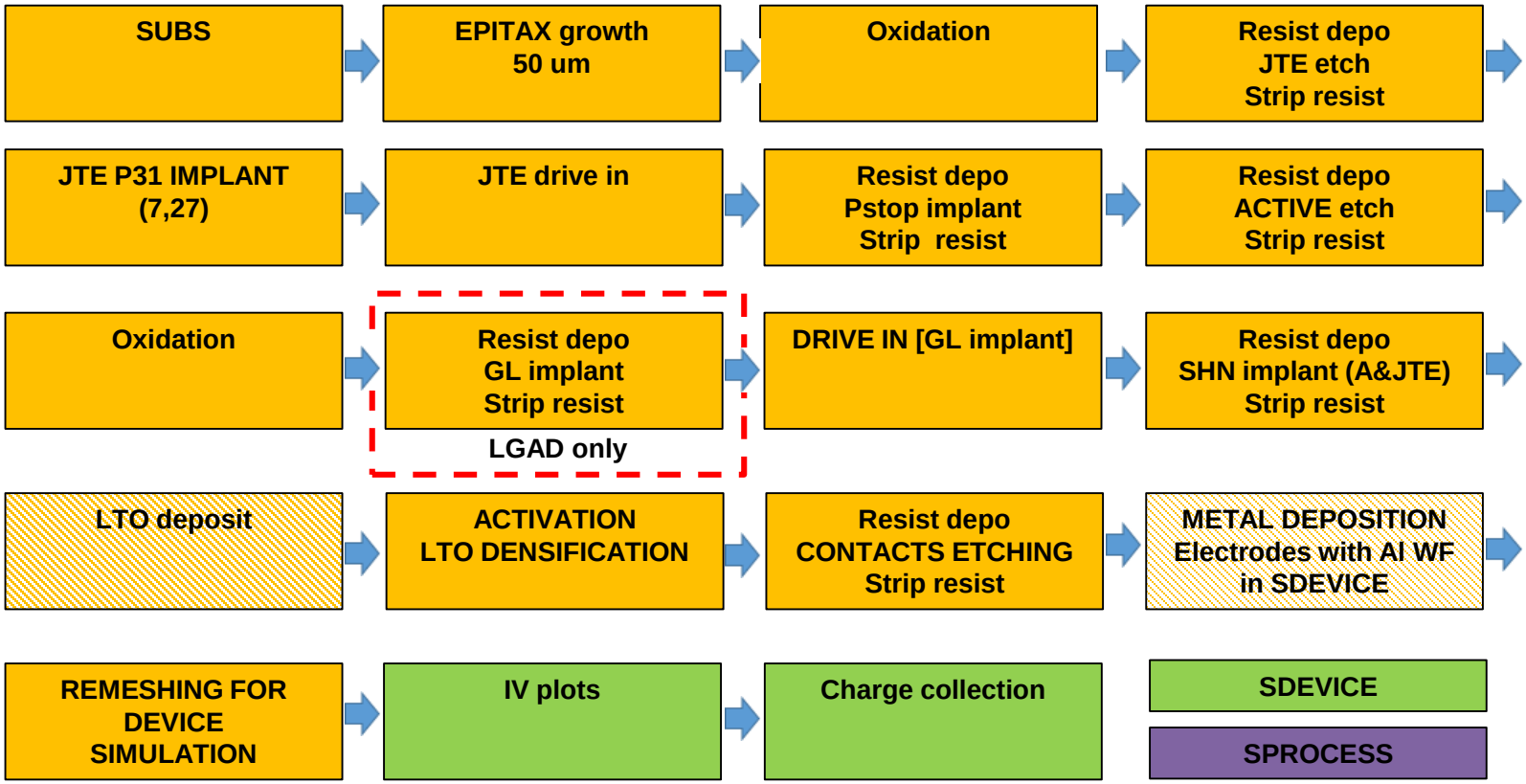


TCAD summary – Gain vs. Dose (E)

- Eight 6” wafers of 50μm thick HR P- epi layer
- Different gain layer implant doses and energy to sample gain region according to TCAD simulations

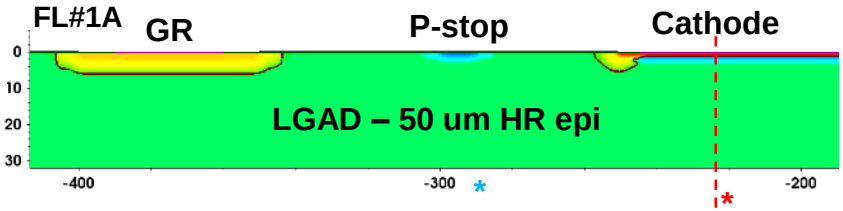
TCAD simulations

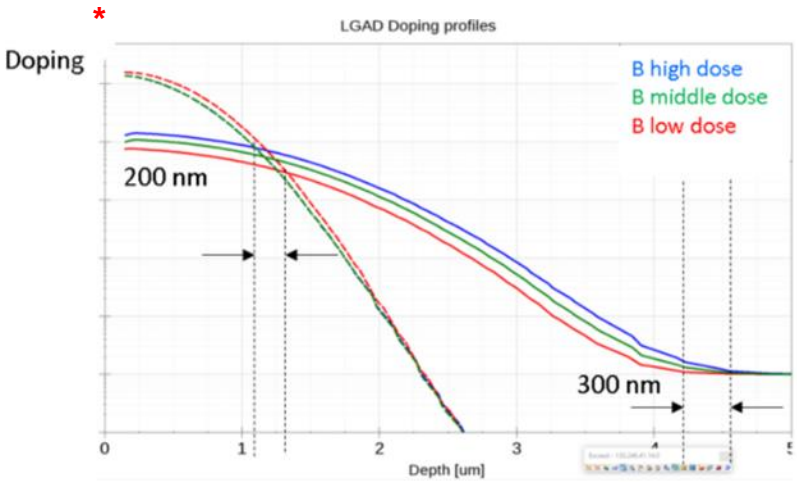
SPROCESS
2D process flowchart



- Full process simulation implemented for LGAD and PiN

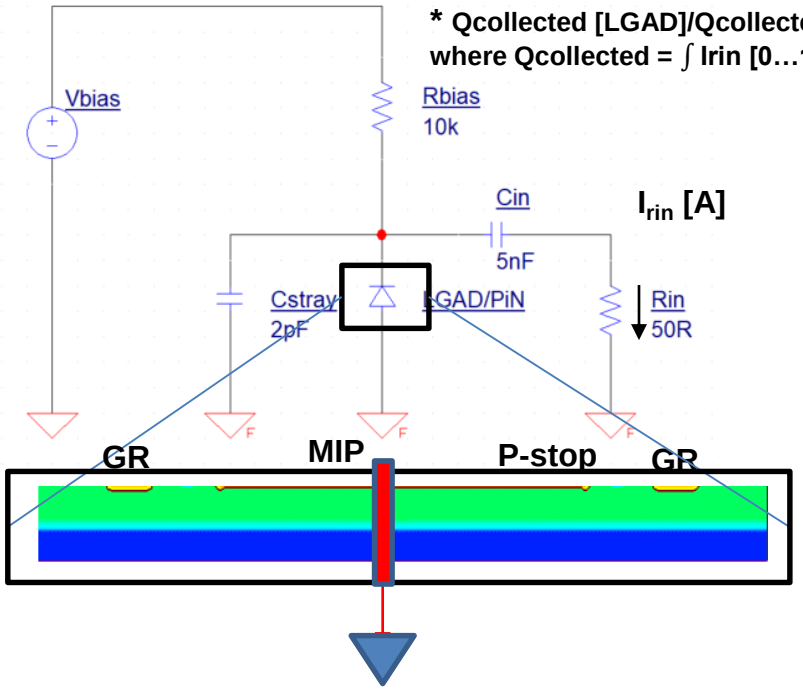
TCAD simulations





- **Extension of GL changes by around 0.5 um in going from LOW DOSE to MAX DOSE**

*** Qcollected [LGAD]/Qcollected [PiN] where Qcollected = ∫ Irin [0…150 ns]**

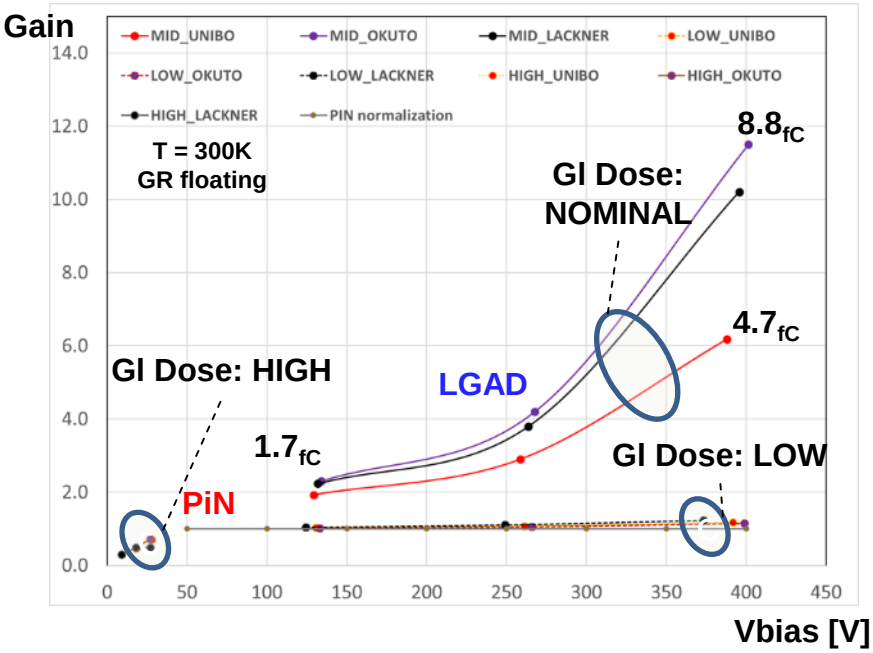


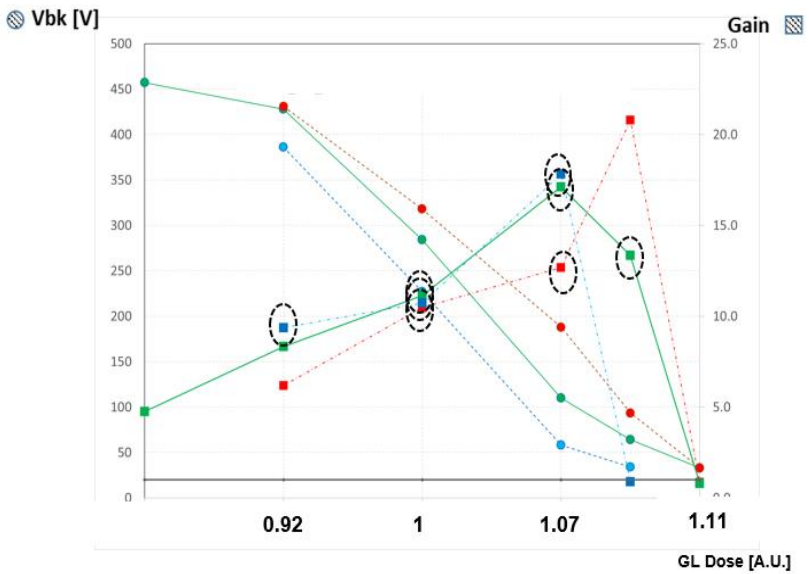
Electrical simulation setup, common to PiN and LGAD, with RC network

- **IV plots**
- **Bulk radiation damage not included in this iteration, but SiO_2-Si interface traps implemented**
- **CCE for vertical MIP hit (80 e/h /um) through centre**

*** with no SRH Qcoll ~ Qinj ± 0.1%**

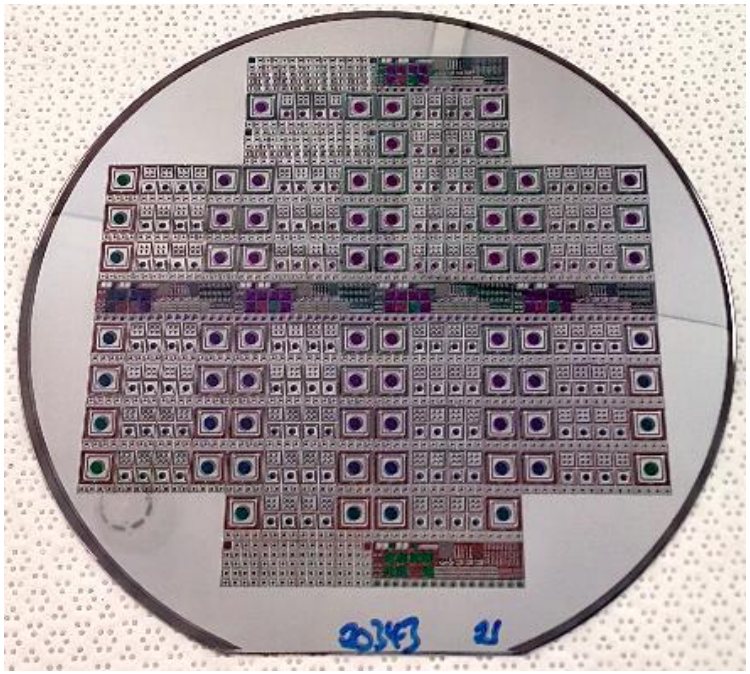
TCAD simulations

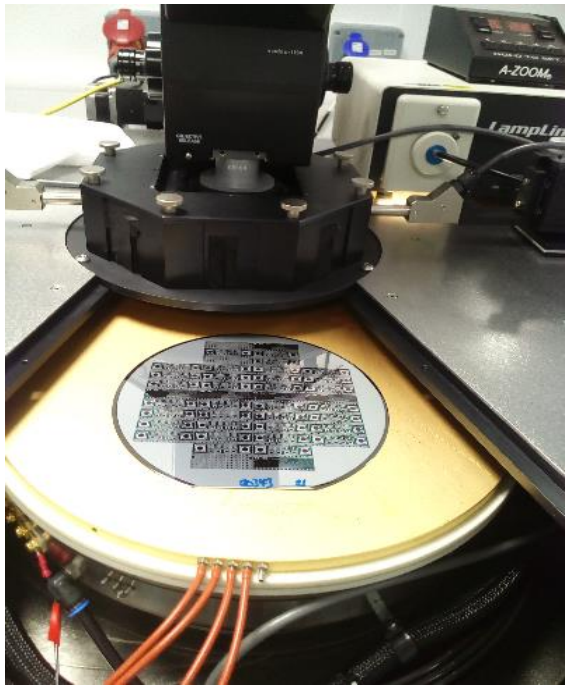




- **Gain is defined as ratio of LGAD/PIN collected charge for a 50 ns transient and normalized to 0.3,0.6,0.9 BV**
- **Each LGAD gain curve is normalized w.r.t. PIN that uses the same Impact Ionization model (3 models used: Unibo, Okuto, Lackner)**
- **A gain of > 10 is predicted for 2/3 I2 models used for the MIDDLE dose**
- **Design based on Impact ionization models predicting lowest gain (UniBo)**

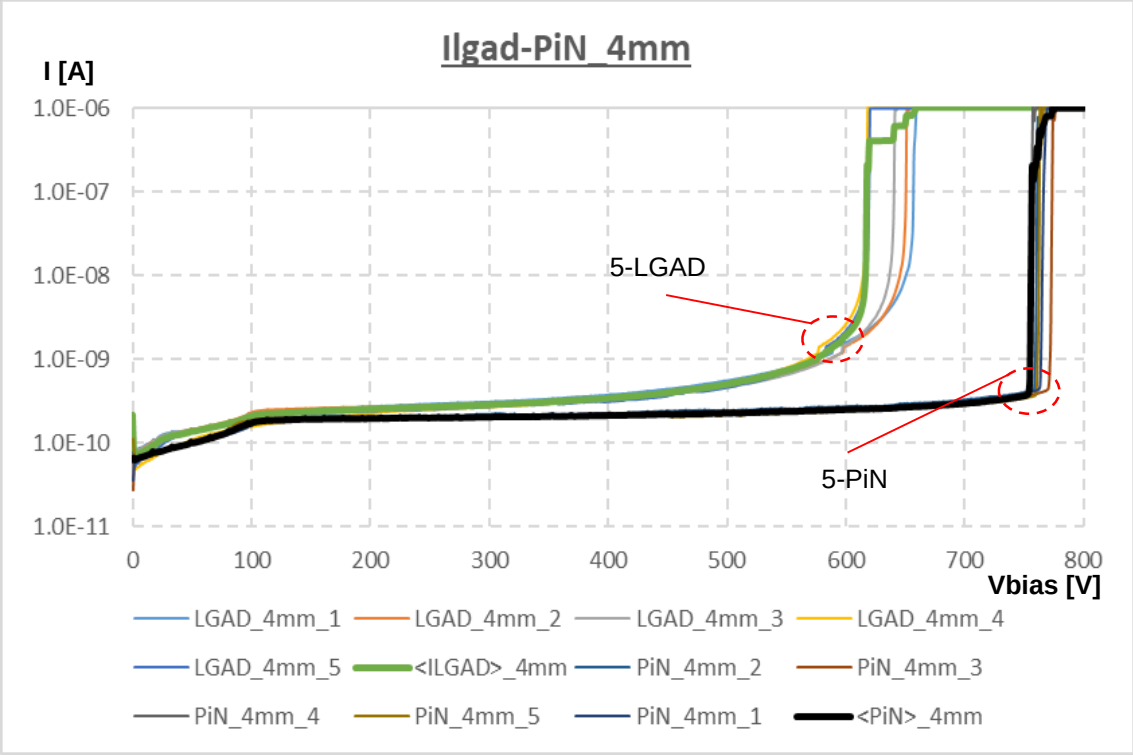
LGAD Project description and goals



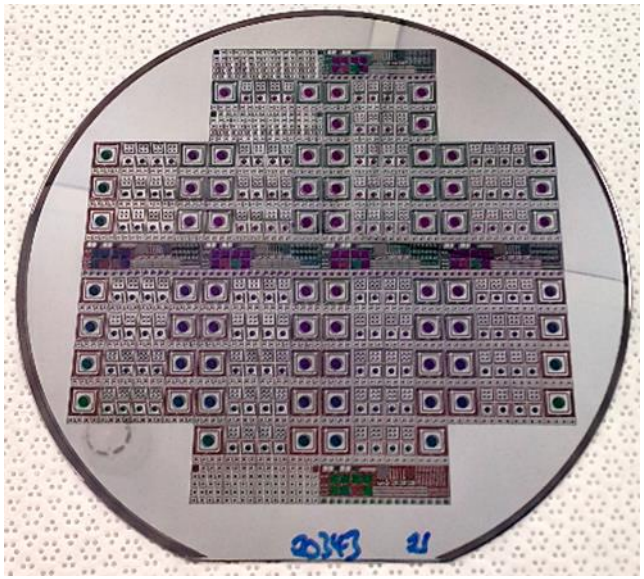


- Fabrication completed November 2020
- First wafer currently being tested at OPMD, Oxford and Birmingham

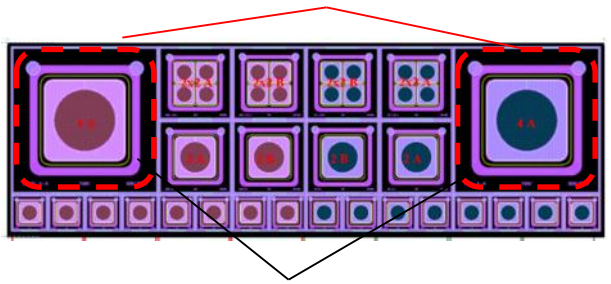
LGAD/PiN IV tests - 4mm



Wafer 21

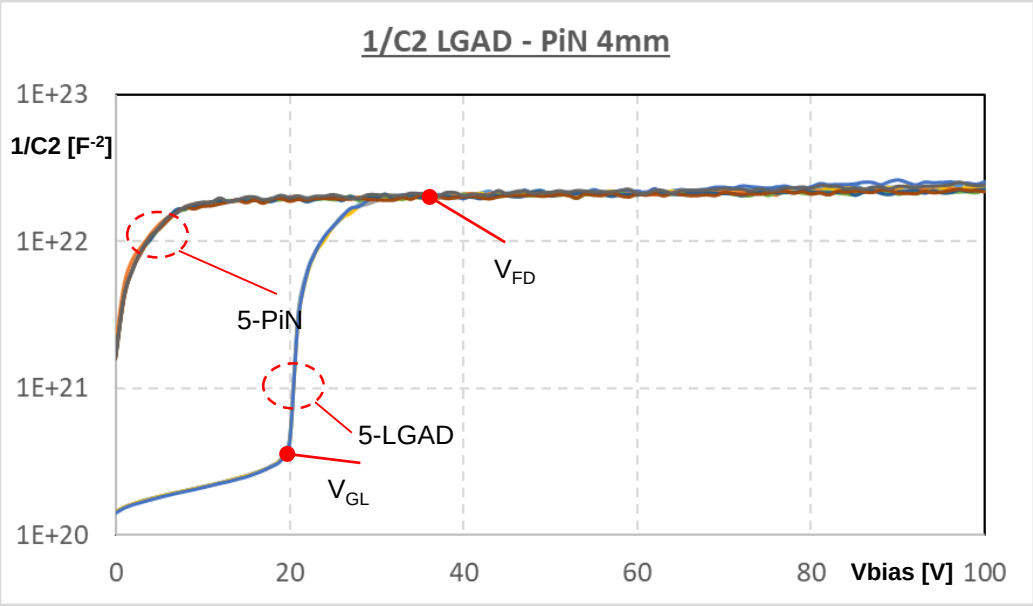


LGAD-4A and PiN-4A

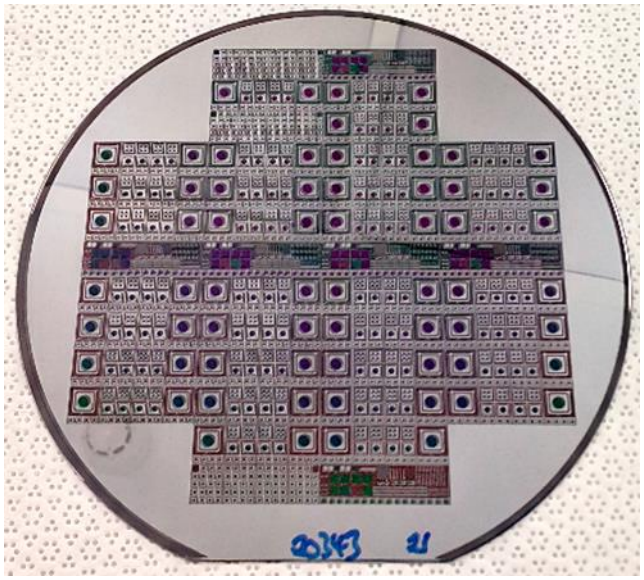


- **IV plots of 5 LGAD-4A and 5 PiN-4A devices on WF 21 (E=1,D=1)**
- **GR floating, T = 21C**

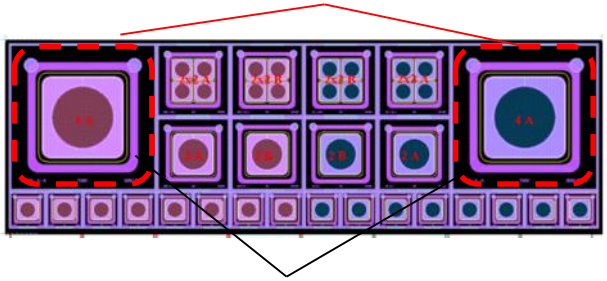
LGAD/PiN CV test - 4mm



Wafer 21



LGAD-4A and PiN-4A



- **CV plots of 5 LGAD-4A and 5 PiN-4A devices on WF 21 (E=1,D=1)**
- **F = 100kHz, AC = 35 mV**
- **GR floating, T=21C**
- **GL depletion voltage ~ 20V, Vfd ~ 32V**

Summary and next steps

- A RAL, University of Oxford, University of Birmingham and Open University project in collaboration with Teledyne e2v foundry has produced the first batch of LGAD devices
- First fabricated samples available November 2020
- Eight 6’’ 50um thick p-epi wafers processed with different levels of dose and energy of implanted GL
- First wafer currently being IV-CV tested at Oxford and Birmingham. Laser dicing on it to be performed next

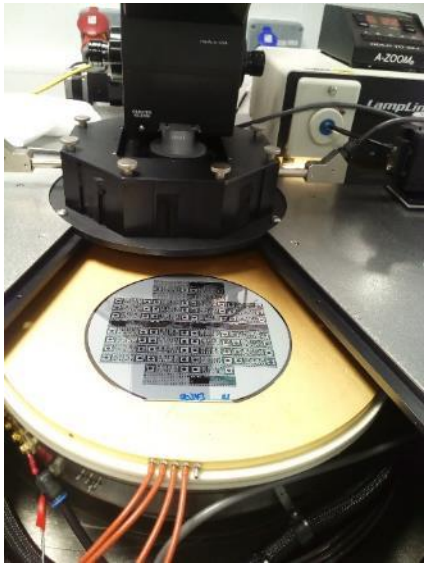
THANK YOU

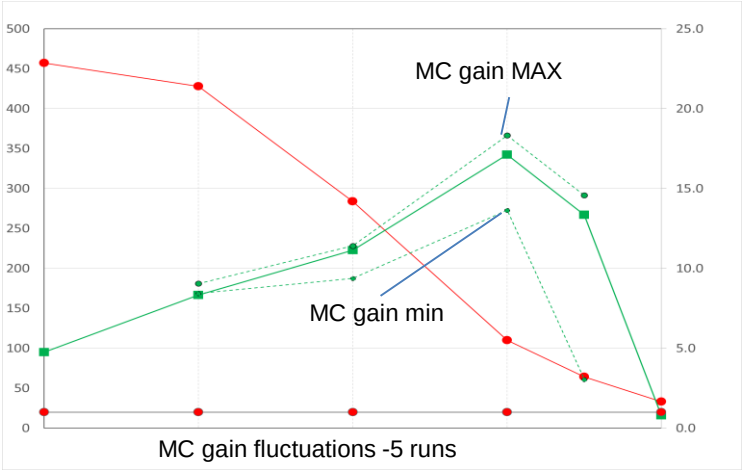
Acknowledgments

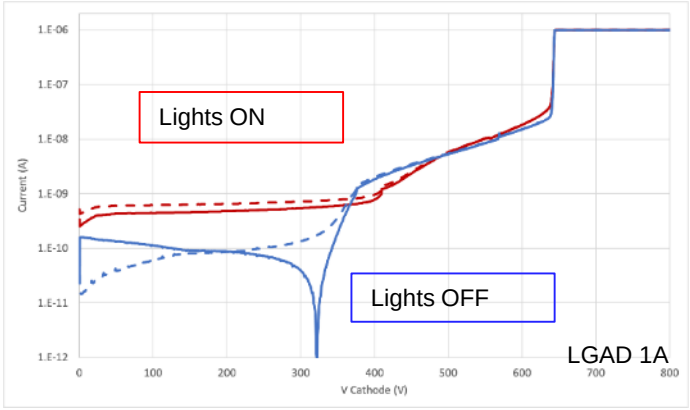
- **Two years project supported by STFC, grant ref.nr ST/T002298/1**

- **STFC, Teledyne e2v, University of Birmingham University of Oxford, Open University**

backup




MC gain MAX
MC gain min
MC gain fluctuations -5 runs


Lights ON
Lights OFF
LGAD 1A
Current (A)
V Cathode (V)