Quality Assurance methodology for the ATLAS ITk Strip Sensor Production

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ABSTRACT

The production of the strip sensors for the ATLAS Inner Tracker (ITk) will start in 2020. Nearly 22000 large area sensors will be produced over a period of roughly 4 years. A Quality Assurance (QA) strategy has been prepared to be carried out during the whole production period. Once the process has been characterized as providing the required pre-irradiation specifications and the proper radiation hardness, the onus is on the manufacturer to rigidly stick to that qualified process. Still, sample testing with specific device-element structures and irradiation of devices should be implemented by the ITk collaboration. The main devices that will be used by the collaboration for QA purposes are miniature strip sensors (1x1 cm²), monitor diodes (8x8 mm²), and the ATLAS test chip. The ATLAS test chip contains several test structures to monitor specific technological and device-element parameters, such as conductive layers sheet resistance, critical parameters of the device oxides such as capacitance, thickness, breakdown voltage, flat-band voltage, etc; Si/SiO2 interfaces changes, and strip and inter-strip electrical characteristics.

INTRODUCTION

Implementation:
- 2 QA pieces designed to be diced:
  - Piece 2: Mini sensor & diode (MD8)
  - Piece 1: Test Chip & diode (MDB)
- 4 such pieces (2+2) diced from 2 wafers of each batch in production

Test structures:
- 'Category A':
  - Will always be tested.
  - Results will be used for the batch acceptance decision
- 'Category B':
  - Structures for detailed studies
  - Not always tested during production
  - Acceptance criteria not specified

Capacitors:
- Coupling capacitor
  - \( C_{coupl} \) & check up to 10 V
  - comparable to strips area
- Field-oxide capacitor
  - Field oxide thickness, Flat-band voltage \( \Rightarrow \) Oxide charge
- Coupling capacitor for breakdown voltage test
  - \( V_{BD} > 100 \) V
- Field-oxide capacitor with p-stop implant
  - Oxide properties over the p-stop

Strip & inter-stripe parameter structures:
- PTP structure
  - 10 strip-ends (PTP side)
  - Adapted pitch for probe-card pads
- 3-strips structure
  - Same pitch as barrel
  - \( 3 \) mm long
  - \( R_{implant} \), \( R_{metal} \), \( C_{coupl} \), \( R_{int} \) and \( C_{int} \)
- Mini test EndCap structure
  - 10 EndCap-like channels
  - \( R_{implant} \), \( R_{metal} \), \( C_{coupl} \), \( R_{int} \) and \( C_{int} \)

Mini sensor measurements:
- Wire-bonding of irradiated mini to ALiBaVA System set up and measuring the response to a \( ^{90} \)Sr β-source
- CCE(V) plots show how the peak value of the Landau evolves with voltage for different doses

Batch acceptance:
- Key parameters control charts
- Monitoring through ITk Database

CONCLUSION

A full Quality Assurance (QA) plan is presented for the ATLAS ITk strip sensors. Differently from the Quality Control acceptance tests, the QA is carried out on test devices that will not be used in the final experiment. Commonly used test structures like mini-sensors and monitor diodes will be tested for standard post-irradiation IV, CV, and CCE measurements. Additionally, a newly developed test chip has been designed for the continuous test of the key technological and device parameters during production. A sampling strategy has been planned in order to optimize the available resources while being able to have a proper quality assurance monitoring.

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