Precision Optical Metrology of ATLAS ITk Strip Modules for the HL-LHC upgrade

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As part of the High Luminosity LHC (HL-LHC) programme, the ATLAS pixel and strip detector, and transition-radiation tracker, will be upgraded to an all-silicon Inner Tracker (ITk). To ensure each detector module comprising the upgraded detector is produced at a high standard, modules undergo rigorous Quality Control (QC) and Quality Assurance (QA). Several standard QC measures are performed on assembled modules; such measures include: electrical testing, pull testing, precision gluing, and high resolution visual inspection. This work presents the optical metrology surveys on key components of the module such as: the printed circuit board (PCB) containing the readout electronics, the active sensor, and power circuit. Each assembled module has the sensor bowing, and height and position of electronic components examined. These surveys ensure mechanical precision during detector assembly. Measurements are made with a micrometre precision optical Coordinate Measuring Machine (CMM).

To ensure high quality modules, the sensor surface is inspected for uniformity. Sensor bowing is measured using, at minimum, an 11 x 11 uniform grid point scan at 1 cm pitch. Bowing is defined to be the difference in height between the lowest and highest point on the sensor; concave tolerance is 150 um and convex tolerance is 50 um. Hence, employing the most accurate optical measurements, using the optimal focussing device and settings, is crucial. Custom written CMM software achieves this scan with precision and the data is then cleaned and analysed. Faulty, biased, or irrelevant measurements are filtered, or corrected, and properties of the sensor surface are identified; pass / fail requirements are then imposed.

In addition, electrical components of the detector module undergo position measurements and height measurements. The former measures the positions of fiducial markers on the PCB and power circuit, ensuring assembly satisfies the sub 100 um design specifications. The latter measures the height of several electronic components on the PCB and power circuit, ensuring precision for both the individual components and the module as a whole. CMM scripts for navigating to these components for various module geometries have been produced, likewise for the data analysis software.

It is expected that module production be underway before the end of 2022. By performing these metrology surveys, we ensure that the assembled modules meet the intended mechanical precision; detectors assembled on the order of ~10 um. This clears the modules for further QC and QA where it can then be installed into the upgraded ATLAS detector.