Development of pixel modules for the forward region of the ATLAS Phase-II Tracker Upgrade

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Experimental Particle Physics

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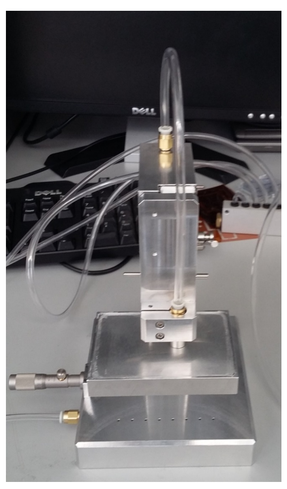
Abstract

The assembly and results from testing of pixel modules for the forward regions of the ATLAS Tracker Upgrade are discussed. Sensors have been developed for the ATLAS FE-I4 and new RD53A readout chips. The module assembly process is described. The characterisation of high-speed low mass cables for data transmission are also discussed.

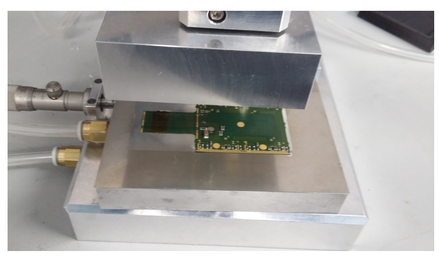
Module Assembly

Mounting of flexible hybrid on bare FE-I4 quad modules

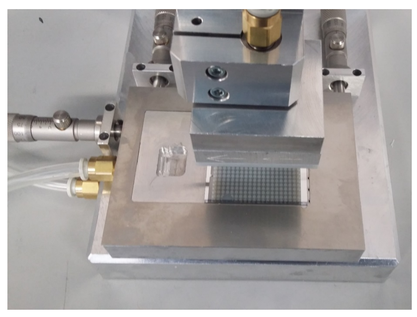
- Require assembly and testing of 10-20 modules/week
- Assembly time about 30mins, allows 10-20 modules to be made over 2 days
- Currently using Araldite 2011, curing time at r.t. 24hrs applied with glue stamp



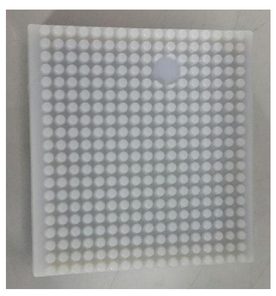
Mounting jig (based on PSI design)



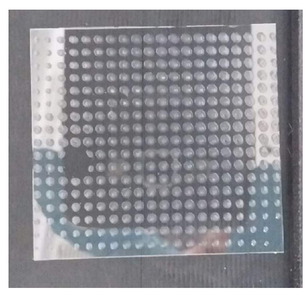
Hybrid ready for pick-up

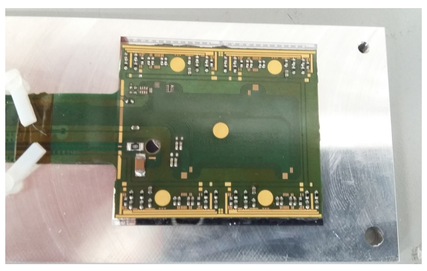


Sensor with glue pattern

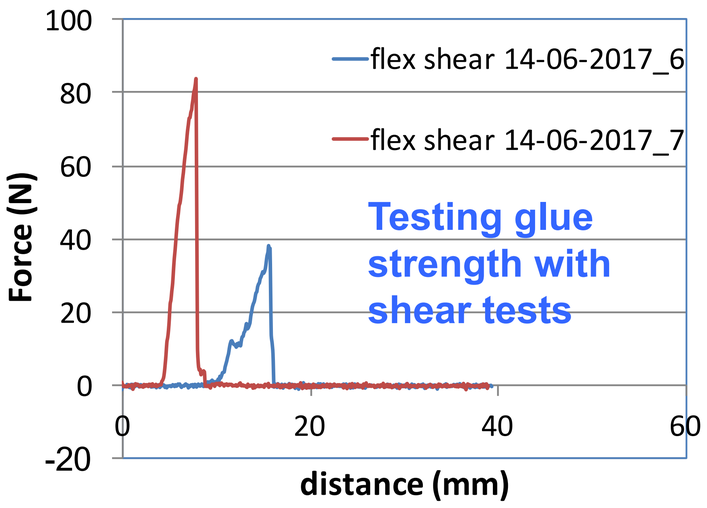


Glue stamp and pattern on glass





Assembled module on Al transport plate

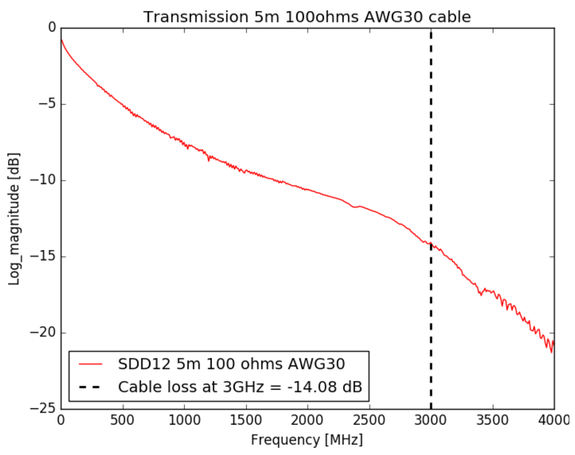


Alternative mounting methods being investigated

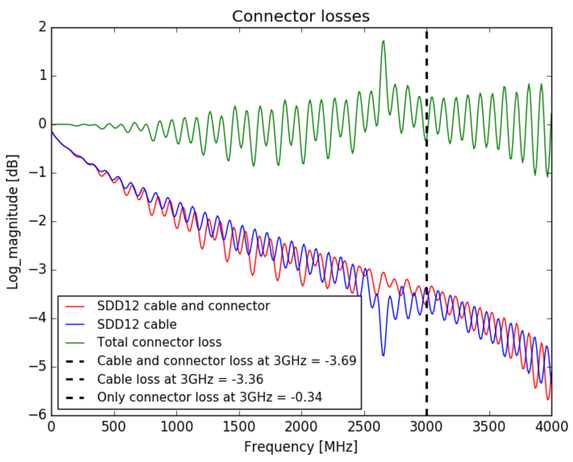
- automated hybrid mounting
- alternative glue application

Data Transmission

Pixel system readout requires high speed multiplexed data transmission capable of handling the high data rates. Development of low mass cables capable of transmitting data at 5.12Gb/s, differential signaling with 100 (or 70Ω impedance) with attenuation less than 20 dB for ≥ 5m at 3.0 GHz, including connectors and Bit-Error Rates < 10^{-13}, using standard pseudo-random data.

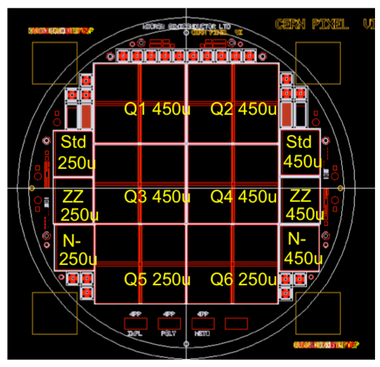


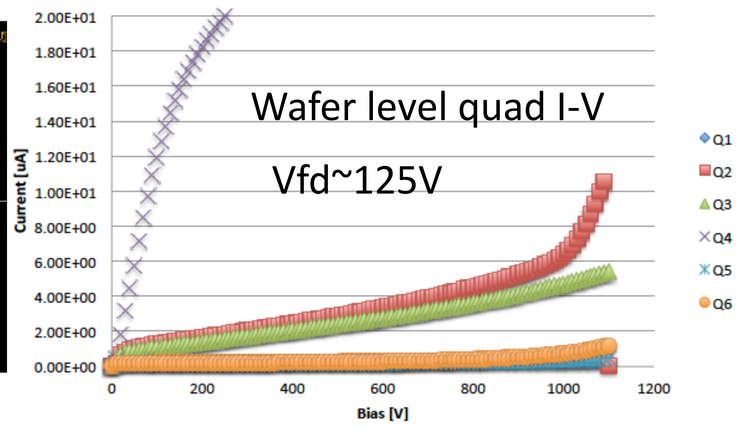
Transmission of low mass twinax cable (AWG30) over 5m



Measurement of loss due to low profile connector attached to cable (1m)

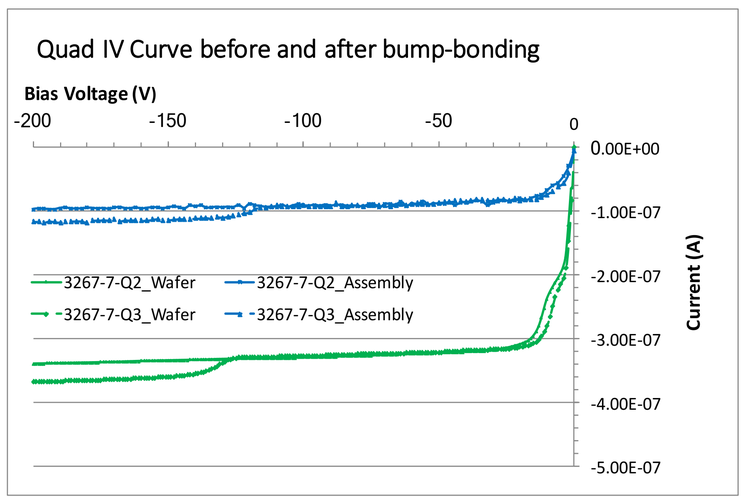
Quad Sensors I-Vs



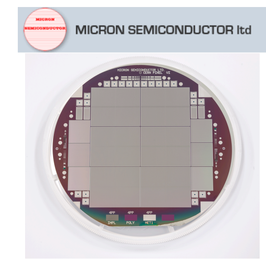


Yield1 – Breakdown voltage > V_{FD}, I_{leak} < 1 uA at V_{FD} = 83%
Based on 25 x 200mm thick wafers

- CERN Pixel VI
- Sensors manufactured at Micron Semiconductor Ltd
- Sensor UBM and flip-chip at Advacam
- FEI4 wafer UBM at Cea-Leti

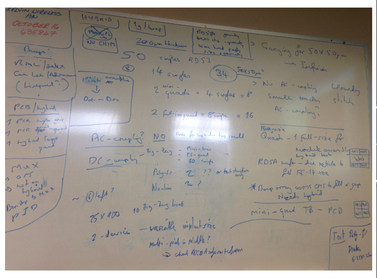


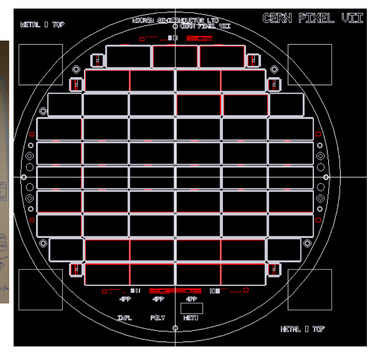
Comparison of I-V curves on wafer and after flip-chip
Difference in I-Vs due to sensor bias structure on wafer and direct connection through FEI4

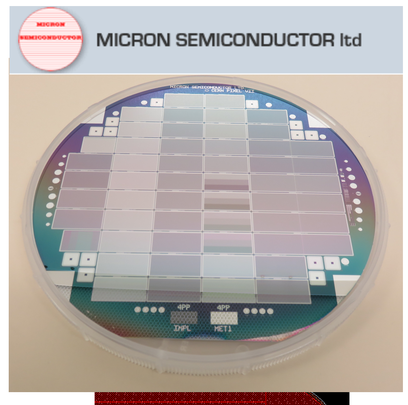


CP7: Sensor for RD53A characterisation

RD53A chip is the prototype readout chip for ATLAS and CMS pixel systems. A new sensor wafer has been developed to characterise the chip

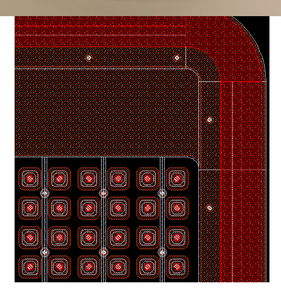






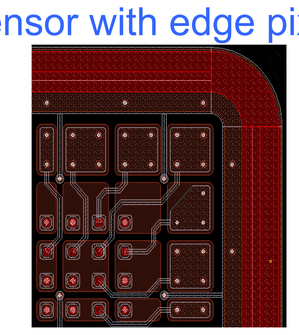
400 x 192 pixels with pitch: 50mm x 50mm
Sensor variations:

- standard (38μm x 38μm) implants
  - with punchthrough bias in groups of 4 pixels
  - standard matrix and edge pixels
  - standard matrix and edge pixels with punchthrough
  - large (44μm x 44μm) implants with "zig-zag" punchthrough bias network
- 400 x 192 pixel matrix with implants of various sizes (44x44μm², 36x36μm², 28x28μm²)



Sensor with punchthrough biasing

Sensor with edge pixels



Summary

- CP6 quad sensors show good yield
- New sensor wafer for characterising RD53A
- Module assembly being developed for production
- Low mass cables for data transmission have been characterised

1. Universities of Edinburgh, Glasgow, Lancaster, Liverpool, Manchester, Oxford, U.C.L. and STFC-Rutherford Appleton Laboratory