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Final results from the APV25 production wafer testing

The APV25 is the front end readout chip for the CMS silicon microstrip tracker. Approximately 75,000 chips are required and the production phase is now complete. Each chip on every wafer is subjected to detailed probe testing to verify full functionality and performance, and only chips that pass all tests are selected for mounting on detector modules. Over several years more than 500 wafers have been tested and results for all chips have been archived. An analysis of the database allows significant comparisons between chips, wafers and wafer production batches, giving a complete and final picture of the spread in yield and performance experienced in this large scale manufacturing task.

Summary

The APV25 is the 128 channel chip for CMS silicon tracker readout, manufactured on 200 mm wafers in 0.25 micron CMOS technology. A high yield of multi-chip hybrids for detector modules requires comprehensive testing of chips on the wafer.

Each APV channel comprises a low noise front end, a 50 ns CR-RC shaping amplifier, a 192 element deep analogue pipeline, and an analogue pulse shape processing stage (APSP). The pipeline samples the amplifier output at 40 MHz and accommodates the level one trigger latency and buffering of events awaiting readout.
The APSP implements a deconvolution operation on 3 consecutive pipeline samples to achieve single bunch crossing resolution at high luminosities. Analogue output samples are multiplexed onto a single output for subsequent optical transmission to the off-detector data acquisition system. The chip contains system features including bias and calibration pulse generation, programmed via the slow control interface. The on-chip programmable features enable a thorough wafer probe test to be performed leading to a high level of confidence in identifying defective chips.

Approximately 75,000 chips (plus spares) were required to read out approximately 10 million microstrip channels. Wafers were delivered in production lots of up to 25 wafers, each wafer containing 360 viable APV sites. We have previously reported [1,2] on progress and problems encountered during the several years over which this production task has been spread. Because of wafer yield and hybrid production losses we have probe-tested more than 500 wafers (180,000 chips) to obtain sufficient numbers of APVs to complete the tracker construction.

The on-wafer chip tests included detailed verification of both digital and analogue functionality. Digital tests included verification of the slow control interface, and correct operation of the pipeline control logic, and any defect here resulted in rejection. Analogue tests included pedestals, pulse-shape, gain and noise measurements, pipeline uniformity, individual pipeline element storage capability, and power consumption. Performance was verified in all operational modes for all channels. Analogue acceptance thresholds were defined to ensure satisfactory performance for the application. A test time/chip close to one minute, allowed a throughput of 2 wafers/day. All the wafers were tested on a single semi-automatic probe-station.

During testing all chips were identified by wafer name and location on the wafer, maps being produced for subsequent dicing and picking by the hybrid manufacturer. The test results were stored in a database, allowing us to perform detailed analyses comparing performance between chips, wafers and production batches. The results of these analyses provide insight into the stability of performance achievable from a large-scale manufacturing task extended over several years.

[1] APV25 Production Testing and Quality Assurance, M.Raymond et al, Proceedings of the 8th workshop on electronics for LHC experiments, CERN-LHCC-2002-34, 219-223.

[2] Production Testing and Quality Assurance of CMS Silicon Microstrip Tracker Readout Chips, P.Barrillon et al, Proceedings of the 10th workshop on electronics for LHC experiments, CERN-LHCC-2004-030, 148-152.

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