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Flexible Front-End Hybrids for the CMS Outer Tracker Upgrade

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The upgrade of the CMS tracker for the HL-LHC is based on a binary readout scheme based on the CMS Binary Chip. The connectivity requirements of this flip-chip ASIC requires the use of high density interconnecting hybrids. Module integration studies indicated that a foldable flexible hybrid circuit results in an optimal module arrangement. A full module size HDI flexible hybrid was designed, integrating eight CBC2 ASICs. The hybrid is fitted with carbon fiber stiffeners and a sharp folding allows connecting the two strip sensors wirebond arrays. The mechanical properties of the assembly and its electrical performance are presented.

Summary

The increase of luminosity planned at the HL-LHC is setting up new constraints for the CMS Tracker that imposes its upgrade. The higher luminosity will result in a significant increase of the rate of events in the tracker that is addressed with the implementation of a binary readout tracker with higher density of channels, and providing a new Level 1 Track Triggering functionality.

The outer and endcap tracker areas are based on modules containing two parallel strip sensors of 10 × 10 cm2 enabling the identification of stubs required for the track triggering function, used to trigger the regular strip data readout. The CMS Binary Chip 2 (CBC2) specially developed for this application, implemented on a flip chip array of 771 bumps with a pitch of 250 microns, became available in 2013. A front-end hybrid circuit was designed to integrate eight of these ASICs to readout the strip signals of both sensors and to deliver the resulting data to a digital testing interface.

The hybrid circuit needs to provide a reliable connectivity with the ASICs, but it needs to provide also a good control of its flatness to enable its wirebonding with the sensors. On this respect, polyimide based circuits were found to provide superior performance in comparison with rigid organic substrate hybrid circuits. A multilayer flexible polyimide circuit matching our high-density interconnection constraints was designed. To allow the wirebonding of this hybrid circuit with the strip sensors and the flip chip bonding of the CBC2 ASICs, two carbon fiber stiffeners were glued on the base layer. The circuit is then sharply folded, and the two carbon fiber stiffeners are glued together, providing in this way a very rigid and flat double-sided wirebond array with adequate CTE. This arrangement allows also aligning the wirebond arrays at the level of both sensors with a gap range comprised between 1 mm and 4 mm. This full size prototype was expanded with a fine pitch test connector, that allows connecting the system with a dedicated test interface.

The manufacturing process flow was validated with this prototype, from the high density flex circuit production, the assembly of parts and stiffeners, to its final mechanical fold. The mechanical properties of the assembly are appropriate for the integration into the CMS tracker modules. The front-end ASICs were properly calibrated and the sensor readout is expected by the time of the conference.

This assembly technique is applicable to other hybrid circuits for this tracker, for instance for the front-end hybrids of the inner tracker modules and for the service hybrids of both types of modules.

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