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Hybrid circuit prototypes for the CMS Tracker upgrade front-end electronics

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New high-density interconnect hybrid circuits are under development for the CMS tracker modules at the HL-LHC. These hybrids will provide module connectivity between flip-chip front-end ASICs, strip sensors and a service board for the data transmission and powering. Rigid organic based substrate prototypes and also a flexible hybrid design have been built, containing up to eight front-end flip chip ASICs. A description of the function of the hybrid circuit in the tracker, the first prototype designs, results of some electrical and mechanical properties from the prototypes, and examples of the integration of the hybrids into detector modules 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, provided with a new Level 1 Track Triggering functionality. The new tracker consists of modules containing the sensors, hybrid circuits and all the data transmission and powering services. The modules will have strip - pixelated strip sensors on its inner layer, and strip-strip sensors on its outer and endcap layers. A dedicated front-end ASIC prototype was developed for the outer tracker layer modules, namely the CMS Binary Chip 2 (CBC2) that became available for testing in 2013, enabling the outer layer hybrid and module development.

In a first step, a rigid organic based substrate has been produced to enable the functional testing of a pair of CBC2 chips and to evaluate the high-density interconnection design constraints that are required for the connection of the ASICs with the strip sensors on both sides of the hybrid. This hybrid circuit was constructed as a six layers built-up substrate using a thin LCP core, following as much as possible the expected module design requirements. The CBC2 chips have been successfully tested on these hybrids, and the hybrids wire bonding and mechanical features to assemble them into modules have been evaluated.

A second prototype rigid substrate hybrid was built, using an aramid core aiming for an improved stiffness, but using the same design rules as those used for the first prototype. Eight dummy chips have been used per hybrid, aiming for a mechanical study of a full-scale rigid assembled hybrid, and in particular to test the feasibility of wire bonding and compatibility of the mechanical integration into a module. This prototype enabled also the testing of fine tracks and via test arrays for manufacturability and reliability studies.

A third prototype hybrid using a flexible circuit made on a polyimide substrate is at this time in production. The very high routing density allows limiting the number of layers to four. The flexible hybrid contains eight CBC2 chips, and the flexible substrate is to be wire bonded to a pair of 10 cm X 10 cm sensors. The circuit is representative of a real size substrate as intended for the modules assembly. This technology implies a different module design; it also requires the development of dedicated tools to embed stiffeners and to enable the manipulation and folding of the flex circuit with accuracy. Results from these prototypes are expected also by the time of the workshop.

For both these rigid and flexible hybrid, the respective issues concerning their integration into the outer tracker modules will be reported.

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