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Origami Chip-on-Sensor Design: Progress and New Developments

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The Belle II SVD will consist of four layers of double-sided silicon detectors, arranged in ladders. Each sensor will be read out individually by utilizing the Origami chip-on-sensor concept, where the APV25 chips are placed on flexible circuits, glued on top of the sensors. Beside a best compromise between low material budget and sufficient SNR, this concept allows efficient CO2 cooling of the readout chips by a single cooling pipe per ladder.
We present recent developments and improvements of the Origami concept as well as results of beam and cooling tests performed with prototypes at CERN.

Summary

B-factories like the KEK-B in Tsukuba, Japan, operate at relatively low energies and thus require detectors with very low material budget inside the sensitive volume in order to minimize multiple scattering. On the other hand, front-end chips with short shaping time like the APV25 have to be placed as close to the sensor strips as possible to avoid excessive noise, which is mainly caused by the capacitive load of the input amplifiers.
In order to achieve both - minimal material budget and low noise - we have developed a readout scheme for double-sided silicon detectors, where the APV25 chips are placed on a single flexible circuit, which is glued onto the sensor. While the top-side strips are directly connected to the chips by wire-bonding and a small pitch adapter, those of the bottom-side are attached by two flexible circuits, which are bent around the edge of the sensor.
This so-called "Origami"design will be utilized to build the Silicon Vertex Detector of the future Belle II experiment, which will consist of 4 layers made from ladders with up to five double-sided silicon strip sensors in a row. Each ladder will be supported by two carbon fiber reinforced ribs, with a very light-weight Airex styrofoam core.
Placing the readout chip onto the sensor also requires cooling, which will be done by a highly efficient two-phase CO2 system. Thanks to the Origami concept, all APV chips inside the active volume are aligned in a row and thus can be cooled by a single thin cooling pipe per ladder.
In 2010 the feasibility of the Origami concept for 6" DSSDs was demonstrated by building and testing of prototype modules. Based on the results we improved our design and built further prototypes, which were firstly tested with CO2 cooling at a beam test at CERN in autumn 2011.
Soon we will assemble a module consisting of two consecutive 6" DSSDs, both read out by Origami flexes.
Such a compound of Origami modules is required for the ladders of the outer Belle II SVD layers. Consequently, it is intended to verify the scalability of the assembly procedure, the performance of combined Origami flexes as well as the efficiency of the CO2 cooling system for a higher number of APV25 chips.

We will present the revised concept and the assembly procedure of the Origami chip-on-sensor design. Moreover, we will show results of beam and cooling tests which were performed on prototype modules at HEPHY Vienna and CERN, respectively.

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