Contribution ID: **46** Type: **Poster**

DEPFET active pixel sensors for the vertex detector of the Belle-II experiment

Tuesday 24 September 2013 18:12 (1 minute)

Active pixels sensors based on the DEPFET technology will be used for the innermost vertex detector of the future Belle-II experiment. The increased luminosity of the e+e- SuperKEKB collider entails challenging detector requirements, namely: low material budget, low power consumption, high precision and efficiency, and a huge readout rate. The DEPFET active pixel technology has shown to be the most suitable solution for this purpose. A review of the different aspects of the detector design (sensors, readout ASICS and supplementary infrastructure) and the results of the latest thinned sensor prototypes (50 μm) will be described.

Summary

The active pixel silicon sensor DEPFET technology has been chosen for the innermost vertex detector of the future Belle-II experiment in Tsukuba, Japan. The expected instantaneous luminosity of the future e+e- collider (SuperKEKB) is ˜8x1035 cm2/s which is 40 times higher than the world record set by the former KEKB. The new vertex detector has to cope with stringent requirements in terms of performance and space allocation. It will have to deal with an increased event rate and higher background while still providing a high precision position measurement by minimizing the impact of the multiple scattering on the spatial resolution thanks to keeping the material budget the lowest possible.

The DEPFET technology has shown to be the most suitable for the two innermost layers of the vertex detector, close to the interaction point. This technology combines the detection together with the in-pixel amplification by the integration, on every pixel, of a field effect transistor into a fully depleted silicon bulk. An excellent spatial hit resolution can be achieved thanks to the low material budget while still having a high signal over noise performance. For Belle-II, DEPFET sensors with pixel sizes of 50x50 μm and thinned down to 75 um are currently being constructed. In the first prototypes, with a pixel layout close to the final Belle-II design and thinned down to 50 μm, a S/N of ˜35 and a spatial resolution below 10 um has been measured in beam tests. A description of the key parameters of the sensor design and the different results of various prototypes tested in different test-beams will be presented.

The pixel matrix is read out in rolling shutter mode and different auxiliary devices are needed so a dedicated chain of ASICs has been developed. A DEPFET front-end module consists of a silicon frame where the DEPFET pixel matrix is implemented which also houses the steering and readout devices: Switcher-B, DCDB and DHP. The Switcher-B steers the control voltages of the DEPFET matrix, the DCDB is a multichannel ADC used to digitize the current signals from the sensors and the DHP performs the processing of the digital data, the module control and the data transmission at 1.8 Gbps rate. A general overview of the front-end module concept and mode of operation will be given.

Finally, also an outline of other supplementary systems like cooling, powering, mechanics, back-end electronics, etc. will be presented, together with the current status of the detector construction.

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Session Classification: Poster