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Ultra-thin fully depleted DEPFET active pixel sensors

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The prototyping of the latest generation of DEPFET active pixel sensors designed for the vertex detector at the Belle-II experiment at KEK, Japan, and experiments at a future linear collider, has recently been finalized. For the first time the thinning technology based on SOI wafers finds now its application in a high energy physics experiment. The DEPFET (DEpleted P-channel FET) is a field effect transistor with an additional implant underneath the channel and integrated on a fully depleted substrate. It combines the functions of a detector and the first amplification stage in one single device. The in-sensor amplification makes it possible to create very thin sensors with an excellent signal/noise ratio for minimum ionizing particles. The fabrication of thin wafer-scale (150 mm wafers) active pixel sensors requires the combination of a highly specialized MOS technology, including two poly-silicon and three metal layers, on fully depleted bulk with MEMS technologies. This approach paves also the way to a self-supporting all-silicon pixel module providing high precision measurements with a minimum of material.

The paper will present in detail the features of the DEPFETs designed for Belle-II and future linear collider applications and gives an insight in the manufacturing technology for thin fully depleted active pixel sensors and the resulting module concept. For the first time we will present a direct comparison between DEPFETs produced on standard thick material (450 micron) and the same devices on 50 micron thin silicon in terms of signal/noise, cluster size and other basic parameters. These measurements are done on a dedicated low noise test stand allowing a close insight into the properties of the pixel cell itself. The mechanical properties like bowing, warp, and distortions of the thin silicon with a full layer stack of poly-silicon, metal traces and inter level dielectrics are probed on self-supporting full size Belle-II modules.

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