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Development and characterisation of sensor prototypes for the BELLE II Pixel Detector

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The B-factory KEKB in Japan is currently being upgraded to SuperKEKB. It will reach a world record luminosity of $80 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$, i.e. 40 times larger than the world record value previously achieved at KEKB. The upgrade program involves a major modification of the Vertex Detector (VXD), with the insertion of two additional Pixel Detector (PXD) layers located between the beam pipe and the four Double Sided silicon Strip Detector (DSSD) layers.

The sensor of choice for the PXD is the Depleted p-channel Field Effect Transistor (DEPFET), organised in a matrix. DEPFETs are pMOSFETs integrated on a highly resistive, fully depleted n-type substrate, with a p⁺-type backside contact. An n-type deep implant under the gate, named internal gate, modulates the current, while an adjacent n⁺-type contact works as a reset mechanism. DEPFETs offer internal amplification, a very small output capacitance, a high Signal to Noise Ratio (SNR) even at room temperature and very low power consumption.

The increased background at SuperKEKB requires fast readout in order to keep the occupancy small. Hence, a high frame rate of 50 kHz is guaranteed by a four-fold multiplexed readout. A small thickness of 75 μm, for multiple scattering reduction, is achieved using cutting edge SOI technology. Three different ASICs, bump bonded on the same silicon substrate, allow the activation and reset of the pixels (SWITCHER), digitisation of the current (DCD) and processing and synchronisation (DHP).

Current developments involve the production and characterisation of a technology-prototype, named Electrical Multi Chip Module (EMCM). With the EMCMs, variations of the metal-dielectric layers needed for control, signal and power lines routing can be studied in detail, which allows the choice of the optimal technology. Moreover, the EMCM represents also a tool for in-depth testing of the control and readout electronics. The innovative and challenging characterisation method of this technology-prototype and the achieved results will be described, along with details on its development. The latest production of the final sensor and its characterisation concept will be also presented.

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