Sensor module prototype for Silicon INTT for sPHENIX

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We are developing a new silicon intermediate tracker INTT[1,2] for sPHENIX, a new experiment at the Relativistic Heavy Ion Collider at Brookhaven National Laboratory. In this article we report on the research and development of the silicon module of the INTT.

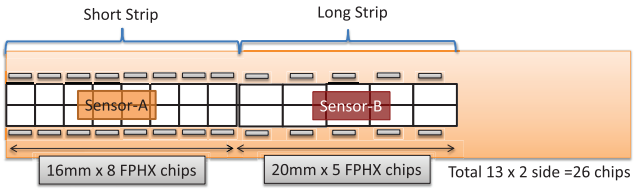

Fig. 1. Conceptual design of the sensor module for layers 1 to 3 of the INTT detector.

Figure 1 illustrates the conceptual design of the sensor module for layers 1 to 3 of the INTT detector. The module consists of two pieces of silicon sensors, named type-A and type-B, and 26 read-out chips (FPHX chips) placed on a fexlible circuit board called high-density interconnect (HDI).

The sensors are single sided, AC coupled sensors. The active area of the type-A and type-B sensors are 128 mm × 19.96 mm and 100 mm × 19.96 mm, respectively. The active area of the type-A (type-B) sensor is divided into 8×2 (5×2) blocks. Each block has 128 short strips that are 78 μm in pitch and 16.0 mm (type-A) or 20 mm (type-B) long, and run parallel to the z (beam) direction. In Fig. 1, the strip runs horizontally. The read-out lines of the strips run perpendicular to the strips and bring the signals to the read-out chips placed on the HDI at the upper and lower edge of the sensor.

FPHX chips, which were used for the Forward VerTeX (FVTX) silicon tracker of PHENIX, are utilized to read out the sensor. An FPHX chip has 128 channels of 3 bit ADCs and it can read out 128 mini-strips in one block of the sensor. The read-out pad pitch of the sensor is thus matched to that of the FPHX chip (75 μm). The FPHX chip has a low power consumption of about 64 mW per chip, which reduces the need for cooling the sensor module. The analog signal of each strip is digitized in the FPHX chip, and the digitized data of 128 channels are sent out through the 200 MHz data-out port of the FPHX chip.

The HDI is a 7 layer flexible circuit board used to read out these two sensors. One type-A and one type-B sensor and 26 FPHX chips are placed on an HDI. The type-A (type-B) sensor is read out by 16 (10) FPHX chips: 8 (5) at the upper edge and 8 (5) at the lower edge of the sensor. The data from the FPHX chips are sent to the front end module though the high speed data bus in the HDI.

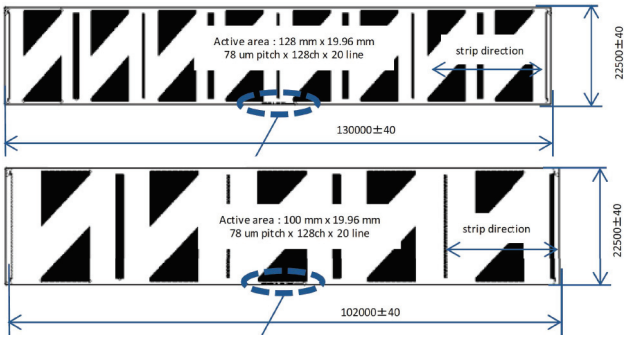

Fig. 2. Part of the sensor design drawings made by HPK.

The sensors will be manufactured by Hamamatsu Photonics Co. (HPK). Fig. 2 shows a part of the design drawings of the sensor made by HPK.

We will produce both type-A and type-B sensors with two thicknesses. One is 320-μm thick, which is the standard thickness of wafers that HPK uses. The other is 200-μm thick, which is made by thinining the 320 μm sensors. The thinner sensor results in lower scattering of charged particles and thus improves the momentum resolution of tracks. However, the signal generated by a hit will be reduced. We will evaluate the S/N ratio for MIP particles for both types of sensors to determine which one we will use for the production.

The design of the sensor at HPK has been completed and they are manufacturing the sensors. We expect the delivery of the sensors by early 2017.

The HDI will be manufactured by Yamashita Co. They will be delivered by early 2017.

The sensors and HDIs are assembed into sensor modules at Brookhaven National Laboratory, where they will be tested with a test bench.

References

1) I. Nakagawa: In this report.
2) Y. Yamaguchi: In this report.

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