Status of silicon pixel detector for PHENIX experiment toward RHIC Run-14

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The silicon vertex tracker (VTX) was installed in the PHENIX experiment in 2010, and it successfully collected approximately 5 billion events of Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV in the 2011 RHIC run (Run-11) at Brookehaven National Laboratory (BNL). The main function of the VTX is the separation of heavy flavor (HF) hadrons, charm and bottom, with the measurement of the distance of closest approach of single electrons from their decays. The nuclear modification factor and azimuthal anisotropy for HF were measured, and analysis results have already been reported[1)].

The VTX is composed of two inner silicon pixel detectors and two outer silicon strip detectors. The silicon pixel ladder is the basic component of a silicon pixel detector. The ladder consists of four silicon sensor modules, two readout buses, and a cooling support. The I/O pads of the silicon sensor module are electrically connected to that of the readout bus via aluminum bonding wires that are encapsulated in epoxy resin. The silicon sensor module is an assembly of a silicon pixel sensor and four readout chips bump-bonded with 25-μm-diameter bumps to the silicon sensor. During Run-11, a small fraction of bump bonds were defected due to thermal stress. In addition, some bonding wires were broken due to a thermal stress caused by the difference in the thermal coefficient between the encapsulation and the readout bus. The active area of a VTX was decreased to 60% because of defected bump bonds and broken bonding wires. The solutions for these issues are to change the operation temperature from 0 degree to the room temperature to avoid thermal stress, and to use a different type of encapsulation. The operation temperature was changed from that used in the physics run in 2012.

After the shutdown of the physics run in 2013, the VTX was dis-assembled at BNL to replace the encapsulation with a different type of encapsulation. All pixel ladders that had broken wires were sent to HAYASHI WATCH-WORKS CO., LTD. where pixel ladders had been mass produced. In total, 15 pixel ladders had been repaired with the yield of almost 100% during 6 months. A small fraction of dead area ($< 1\%$) was remained because of the damage to I/O pads during repair process.

The repaired ladders were electrically tested at RIKEN before being shipped to BNL, and the final electrical test was performed at BNL before the reassembly of the VTX. The following are the test items.

(1) Current consumption of a pixel ladder.
(2) Optimization of a reference voltage for DACs on the readout chip of a pixel module.
(3) Bias voltage dependence of the leakage current for a silicon pixel sensor.
(4) Response of the pixel ladder to a β source (^{90}Sr).

No issue was found in all tests. Figure 1 shows the typical response of a pixel ladder to the β source.

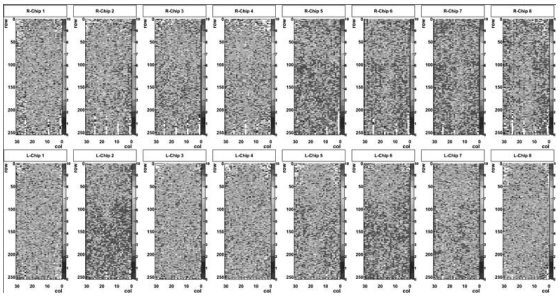

Fig. 1. Response of pixel ladder to a β source. The horizontal and vertical axes represent z and ϕ direction in the PHENIX coordinate, respectively. Low gray-levels represent low number of hits.

Since some pixel ladders had faulty bump bonds, there is a small fraction of unfixable dead area($< 1\%$) in the pixel ladder, and the configuration of pixel ladders in the VTX affects physics data. The optimization of the performance of the pixel detectors had been done by arranging the configuration based on the test results at BNL.

The reassembly of the VTX had been successfully performed at the end of 2013. As a results of the repair work, the active area of the VTX was significantly improved to about 90%. Final optimization of operation parameters for pixel ladders is ongoing. We will collect 200 GeV Au+Au collision data with around 10 times more statistics than that collected in Run-11.

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