FPC board design for TOGAXSI silicon trackers

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We are developing the detector array TOGAXSI[1)] for realizing the ONOKORO project[2)] at RIKEN. In order to accurately measure the angles of particles emitted from cluster-knockout reactions, it is necessary to track the particles with silicon strip detectors with good position resolutions. So far, we have performed test experiments using a prototype detector[3)] and have established a detection and readout method for light ions. As the next step, we designed an electronics board for the silicon detector array for TOGAXSI. In experiments with scarce radioactive isotope (RI) beams, it is necessary to maximize the azimuthal-angle coverage of the detector array covering the cylindrical liquid hydrogen target STRASSE[4)] to ensure adequate yields with limited beam intensity. Here, we report the design of flexible printed circuit (FPC) boards for detecting recoiled protons in cluster-knockout reactions. In order to maximize the azimuthal-angle coverage, six silicon detectors (HAMAMATSU S10938-5847, size: 51.0 mm × 78.4 mm) are arranged in a hexagonal shape as shown in Fig. 1. The distances between the six detectors should be as short as possible. In addition, these detectors have 100-μm strips in the polar-angle direction with respect to the beam axis. In terms of noise, it is essential to connect the APV25s1[5)] chip, including a preamplifier circuit, to the same circuit with short wiring (a capacitance of 5 pF or less). The input-pad spacing of the APV25s1 chip was 44 μm and was routed from a 100-μm-pitch silicon detector with a line-strip spacing of 22 μm. The direction of signal readout is the direction in which the hexagonal silicon detectors are adjacent, which interferes with conventional planar printed circuit boards (PCBs). Therefore, we adopted FPC boards that can be bent 60° over a short distance between the silicon detector and the APV25s1 chip and designed a circuit that satisfies these requirements.

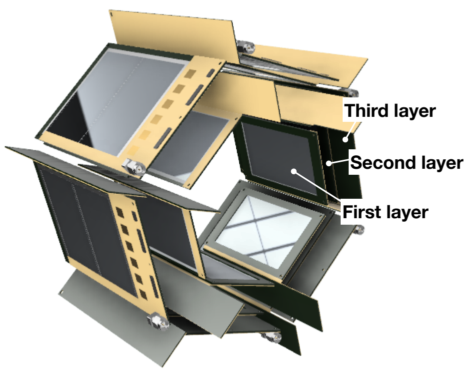

Fig. 1. CAD design of the silicon tracker of TOGAXSI.

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The readout circuit is accommodated radially in six directions between the silicon wafers with respect to the beam axis. The power supply and output signals of the APV25s1 chip, and the connectors for supplying voltages to the silicon wafer are arranged on the upstream side of the beamline in the circuit, taking into account cable insertion/extraction and routing.

In addition, holes are created in the bottom of the APV25s1 chip to ensure heat conduction and to efficiently radiate the heat generated by the 300 mW consumed by one APV25s1 chip. The heat-connection part of the FPC board is designed to be thermally connected to the mounting frame. The frame is cooled by a water-cooling pipe introduced into the vacuum.

It was simultaneously confirmed that the azimuthal-angle coverage was maximized and that the requirements for the TOGAXSI silicon detectors, polar-angle coverages of 36°–67° and 8°–30° and angular resolutions of less than 3 mrad, were fulfilled as listed in Table 1.

Table 1. Calculated estimates of the polar-angle acceptances, polar angle resolutions, and azimuthal-angle acceptances of silicon detectors for recoil protons and light ions.

	Recoil protons	Light ions
Polar-angle accept.	35.3°–67.5°	8°–30°
Polar-angle resolu.	≤2.3 mrad	≤2.0 mrad
Azim.-angle accept.	∼65.8%	∼74.7%

At the time of reporting, the FPC board mentioned above is being manufactured, followed by wire bonding of the silicon wafer and mounting of the APV25s1 chip. We are also designing trapezoidal silicon wafers and FPC boards for measuring light ions by cluster knockout reactions.

References

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