Radiation resistance of bus extender cable for sPHENIX-INTT

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We are developing INTermidate Tracker (INTT), which is a new tracking detector for the sPHENIX experiment at RHIC in BNL, which is a successor of PHENIX. The INTT needs to be designed to transmit approximately 14k signal lines through a very narrow space; therefore any commercial detector available in the market will not fit to interconnect the INTT and the downstream readout controller board (ROC).[1)] Thus, we have been developing a long and high-density cable, which is called "bus extender" for the last four years.

The bus extender cable is a multilayered flexible print cable. Liquid crystal polymer (LCP) and copper foil layers are laminated using an epoxy glue, forming a multilayered structure. The LCP and the glue are made of macromolecule materials; therefore, there is concern for their use under the radiation enviroment because macromolecules are known to be weak against a radiation dose, in geneanl. Thus, the cable needs to demonstrate radiation hardness. We list the following two physical characteristics as indicators of the radiation hardness: 1) loss of flexibility, 2) decrease in the peel strength of the glue. The former can be quantitatively evaluated by measuring Young's modulus. The latter was evaluated by a peel force measurement.

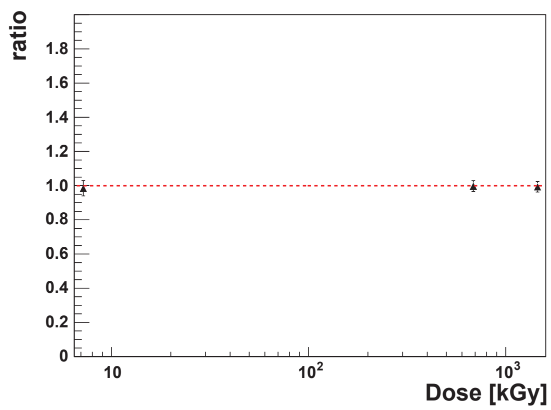

Fig. 1. Ratio of Young's modulus as function of radiation dose.

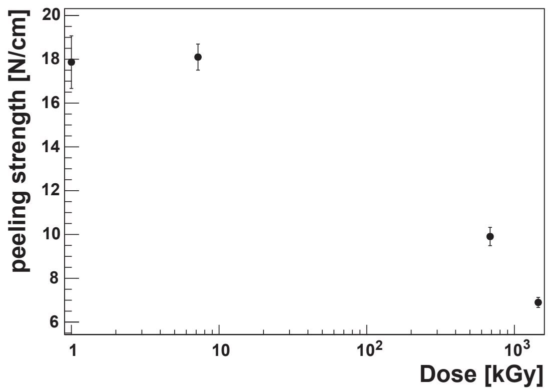

Fig. 2. Peeling strength as function of radiation dose.

Dedicated test samples for the radiation test were fabricated, which have the same layer structure as the bus extender but a smaller size: 40 cm length and 2 cm width each. These test samples are exposed to gamma ray radiation from a ^{60}Co source at a facility in the National Institute of Quantum and Radiological and Technology.

The natural frequency method was employed to measure Young's modulus. The natural frequency can be related with Young's modulus as defined in Eq. (1) where, f is the natural frequency, E is Young's modulus, I is the moment of second-order, A is a cross-section area, ρ is the density, l is the length, and λ is a constant. λ is approximately 1.8 for basic frequency.

$$f = \frac{\lambda^2}{2\pi l^2}\sqrt{\frac{EI}{\rho A}} \tag{1}$$

Figure 1 shows the results of the measurement. The vertical axis shows the ratio of the observed Young's modulus of the samples with and without exposure. The result is constant within the size of the error bars, and thus, there is no indication of loss of flexibility.

Figure 2 shows the radiation dose dependence of the observed peel strength. The peel strength is measured using SHIMAZU MST-I. A clear degradation of the peel strength is observed. However, the degradation is still moderate within the expected radiation dose ∼5 kGy in three of sPHENIX operation. We conclude that the bus extender demonstrates sufficient radiation hardness to be used in the sPHENIX experiment.

Reference

1) T. Hachiya *et al.*, in this report.

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