Contribution ID: **305** Type: **Parallel contribution**

STUDY OF THE RADIATION-HARDNESS OF VCSEL/PIN

Friday, 12 August 2011 16:40 (15 minutes)

STUDY OF THE RADIATION-HARDNESS OF VCSEL/PIN

K.K. GAN, H.P. KAGAN, R.D. KASS, H. MERRITT,
J. MOORE, A. NAGARKAR, D.S. SMITH, M. STRANG

Department of Physics, The Ohio State University, Columbus, OH 43210, USA

Optical links are now widely used in high energy physics experiments for data transmission. The links substantially reduce the volume of metallic signal cables freeing up valuable detector space. In addition, the fibers eliminate the cross talk between metallic cables and electrical ground loops between the front-end electronics and the data acquisition system. The high bandwidth of opto-electronics is well suited for multiplexing many input channels and allows for introduction of error checking and error recovery transmission protocols. These features are especially important in experiments where radiation can induce Single Event Effects (SEE) in the digital electronics. Optical communication using parallel optics is now an industry standard, providing a compact solution. The silicon pixel tracker of the ATLAS experiment at the LHC use VCSEL arrays to generate the optical signals at 850 nm and PIN arrays to convert the signals back into electrical signals for further processing. The devices have been proven to be radiation-hard for operation at the LHC.

The LHC is now the highest energy and luminosity hadron collider. However, planning is already underway to increase the luminosity by a factor of five to 5x1035 cm-2s-1. The required data bandwidth and radiation-hardness of the upgraded detector must also be increased. We use the Non Ionizing Energy Loss (NIEL) scaling hypothesis to estimate the radiation dose for the optical link upgrades. The estimate is based on the assumption that the main radiation effect is bulk damage in the VCSELs and PINs with the displacement of atoms. After five years of operation with an integrated luminosity of 3,000 fb-1, we expect the GaAs devices to be exposed to 2.82 x 1015 1-MeV neq/cm2 at the radius of 37 cm from the interaction region. We study the response of the optical devices to a high dose of 24 GeV protons. The expected equivalent fluence is 5.4 x 1014 p/cm2. We also irradiated a small sample of devices to 300 MeV/c pions to test the NIEL hypothesis.

We packaged the PINs and VCSELs at OSU for the irradiation. In the past few years, we irradiated a small sample of VCSEL arrays of various speeds from Finisar, Optowell, and ULM Photonics using 24 GeV/c protons. We observe significant degradation in the optical power during the irradiation but some of the power can be recovered by annealing in the laboratory. Based on the study, we identified the 10 Gb/s array from Finisar as the most radiation hard and irradiated a much larger sample in 2010 to study the variation in the radiation hardness within a sample. The post-irradiation characterization of the devices is currently in progress in the laboratory and we will present the result of the characterization at the conference. In addition, two arrays were irradiated with 300 MeV/c pions and the degradation will be compared with that from the irradiation using protons as a test of the NIEL hypothesis.

In the past few years, we also irradiated a small sample of PIN arrays of various speeds from Finisar, Optowell, and ULM using 24 GeV/c protons. We observe significant degradation in the PIN responsivity during the irradiation but some of the loss can be recovered by operating at higher bias voltage. Based on the study, we identified the 3.125 Gb/s array from Optowell as the most radiation hard and irradiated a sample of twenty arrays in 2009 to study the variation in the radiation hardness within a sample. Unfortunately, post-irradiation analysis in the laboratory revealed that some of the devices broke down at relatively low bias voltage. Consequently we decided to irradiate a sample of twenty arrays from ULM in 2010. The degradation in responsivity is significant but acceptable. The arrays have been fully characterization in the laboratory and we will present the result of the study at the conference. In addition, two arrays were irradiated with 300 MeV/c pions and we will compare the degradation with that using protons as a test of the NIEL hypothesis.

Summary

We investigate the feasibility of using VCSEL and PIN arrays in the optical links for the planned upgrades of the detectors at the LHC, CERN. We irradiated high-speed VCSEL (Vertical-Cavity Surface-Emitting Laser) and PIN arrays with 24 GeV/c protons at CERN and 300 MeV/c pions at PSI up to the equivalent dose of a few 1015 1-MeV neq/cm2. The arrays irradiated were fabricated by Finisar, Optowell, and ULM Photonics. The irradiation using two species of particles allows us to test the hypothesis that the damage is proportional to the non-ionizing energy loss (NIEL) in a device. The results from the irradiations will be presented.

Primary author: Prof. GAN, K. K.Gan (The Ohio State University)

Presenter: Prof. GAN, K. K.Gan (The Ohio State University)

Session Classification: Detector Technology and R&D

Track Classification: Detector Technology and R&D