Measurements on Truelight Epitaxial Silicon PIN Diode

M.L. Chu and P.K. Teng

June 10, 2004

The performances of the Truelight epitaxial silicon PIN diode before and after irradiation were studied. The rise time and fall time, as well as the responsivity were measured. The 30 MeV proton beam at INER (Taiwan) was used to irradiate both Centronic and Truelight epitaxial Si PIN diodes with accumulated fluences up to 2.1 $\times 10^{14}$ 30 MeV P cm^{-2}, or 5.7 $\times 10^{14}$ cm^{-2} 1 MeV neutron equivalent, to reach the radiation environment (estimated to be 3.7 $\times 10^{14}$ cm^{-2} 1 MeV neutron equivalent, including a 50% overhead) for ATLAS pixel detector. All diodes were reserve biased at 5 volts during the irradiation. The responsivity of Centronic and Truelight PIN diodes tested is 0.5 A/W and 0.6A/W, respectively.

1. Rise time and fall time measurement:

The rise time and fall time of the Truelight PIN diode were measured before and after the irradiation. A home made pulsed light source with ST receptacle was used for the rise time and fall time measurements. The light signal was coupled to the pin diode via a 45 degree fibre. The pin diode was connected directly to a Tektronix TDS5104B oscilloscope. The voltage signal across the scope's internal 50 Ohm impedance was measured to determine the rise time and fall time (20%-80%) of the diode tested.

Figure 1 shows the rise time and fall time of the Truelight PIN diode before the irradiation as a function of reverse bias voltage. Figure 2 shows the results after the irradiation.

2. Responsivity measurements:

Degradation of the responsivity of PIN diodes was monitored during the irradiation by measuring the current of the pin diode illuminated with a constant light source. The PIN current was fed into an OP amplifier circuit which converts the current to voltage for measurements.

Figure 3 shows the responsivity vs fluence with 30 MeV proton beam. All diodes were reverse biased at 5 volts during irradiation. All responsivities shown are normalized to 1 at the beginning. Both Truelight and Centronic PIN diodes show steep fall in the beginning and then degrade slowly with respect to accumulated fluences.

Recent study at IUCF with 200 MeV proton shows a very encouraging result when the diode is biased at higher reserve voltage (Figure 4). All diodes were reverse biased

at 10 volts during the irradiation. As can be seen from the plot, both Centronic PIN diode and Truelight PIN diode shows better radiation tolerance when biased at higher reserve voltage during the irradiation. Although the Centronic PIN diode shows only modulate improvement, the Truelight PIN diode does show a great improvement in radiation tolerance. The total fluences accumulated were 4E14 200 MeV proton/cm^2 (4.6×10^{14} cm^{-2} 1 MeV neutron equivalent).

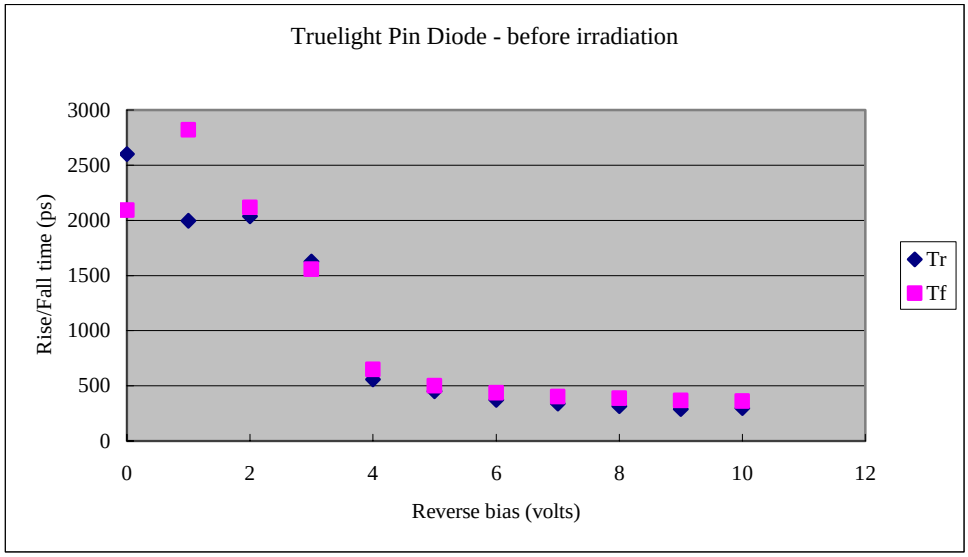

Figure 1: Rise time and fall time of Truelight PIN diode versus reserve bias before irradiation.

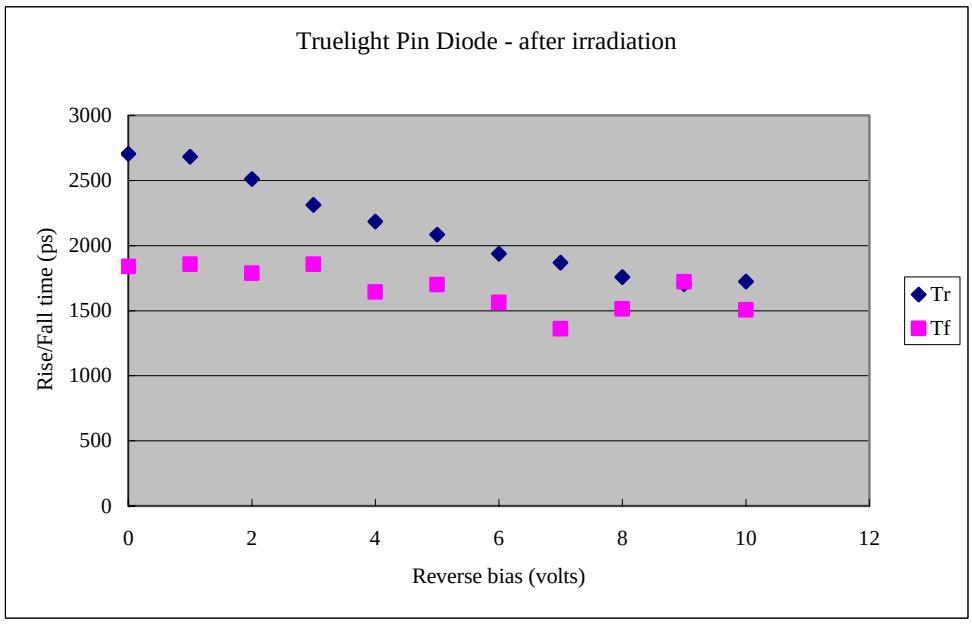

Figure 2: Rise time and fall time of Truelight PIN diode versus reserve bias after irradiated by 30 MeV proton to the 2.1E14 proton/cm^2.

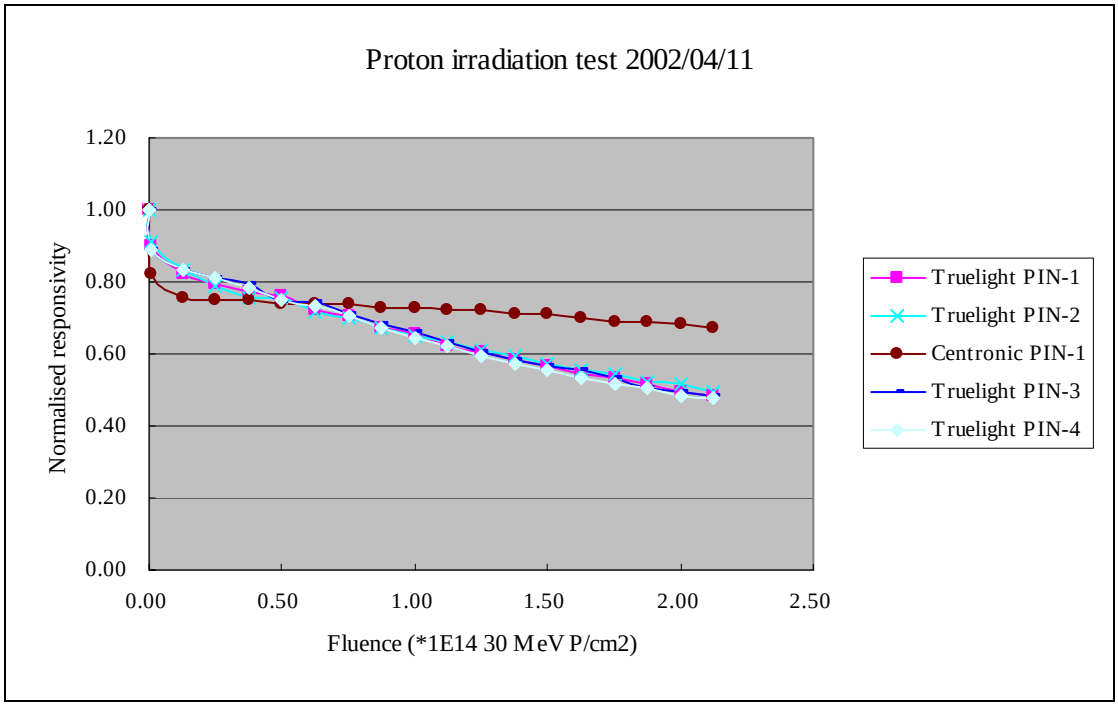

Figure 3: The normalized responsivity of PIN diode versus fluence. All the diodes were reserve biased at 5 volts. Irradiation was done at INER with 30 MeV proton.

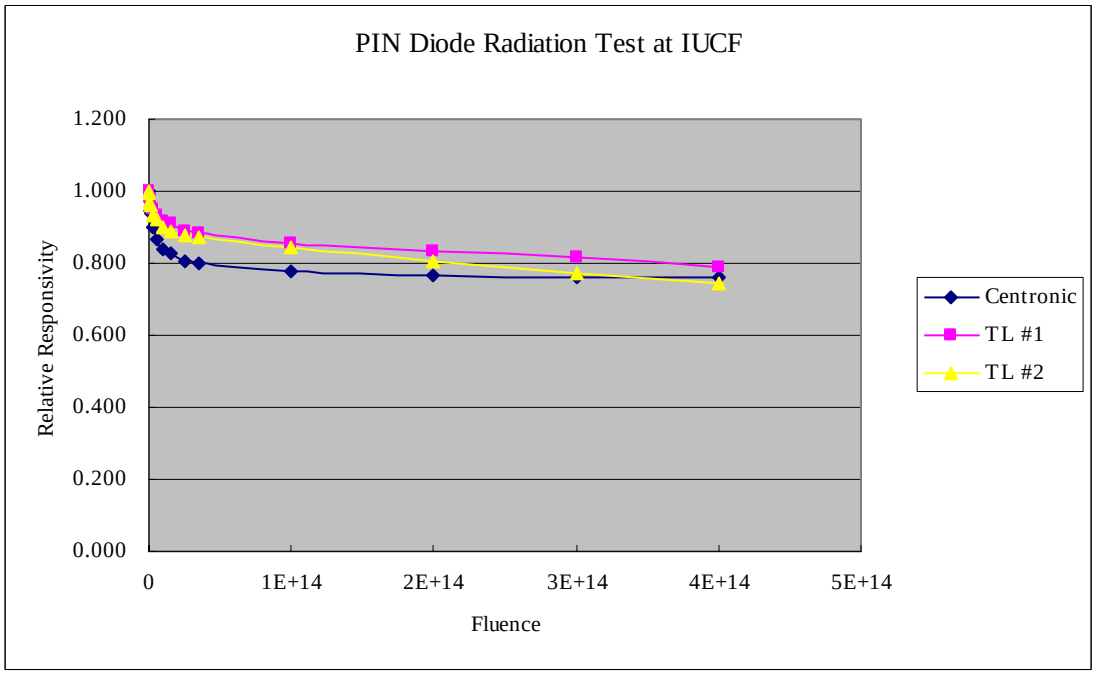

Figure 4: The normalized responsivity of PIN diode versus fluence. All the diodes were reserve biased at 10 volts. Irradiation was done at IUCF with 200 MeV proton.