Marconi Phase 2 Packages

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Package #0

The first of the Marconi phase 2 opto-packages contains 2 VCSELs and one PIN diode. Unfortunately the bond wire on the PIN diode lifted off before delivery of the package. We have measured the performance of the VCSELs and both channels are very good. Scope pictures of the VCSELs being driven at 10 mA (see figs below) show very clean waveforms and fast rise and fall times. Most of the waveforms were taken at a clock frequency of 20 MHz (corresponding to 40 Mbits/s data rate for the SCT) but clean traces were also obtained for 40 MHz (corresponding to the 80 Mbits/s required for the Pixel detector).

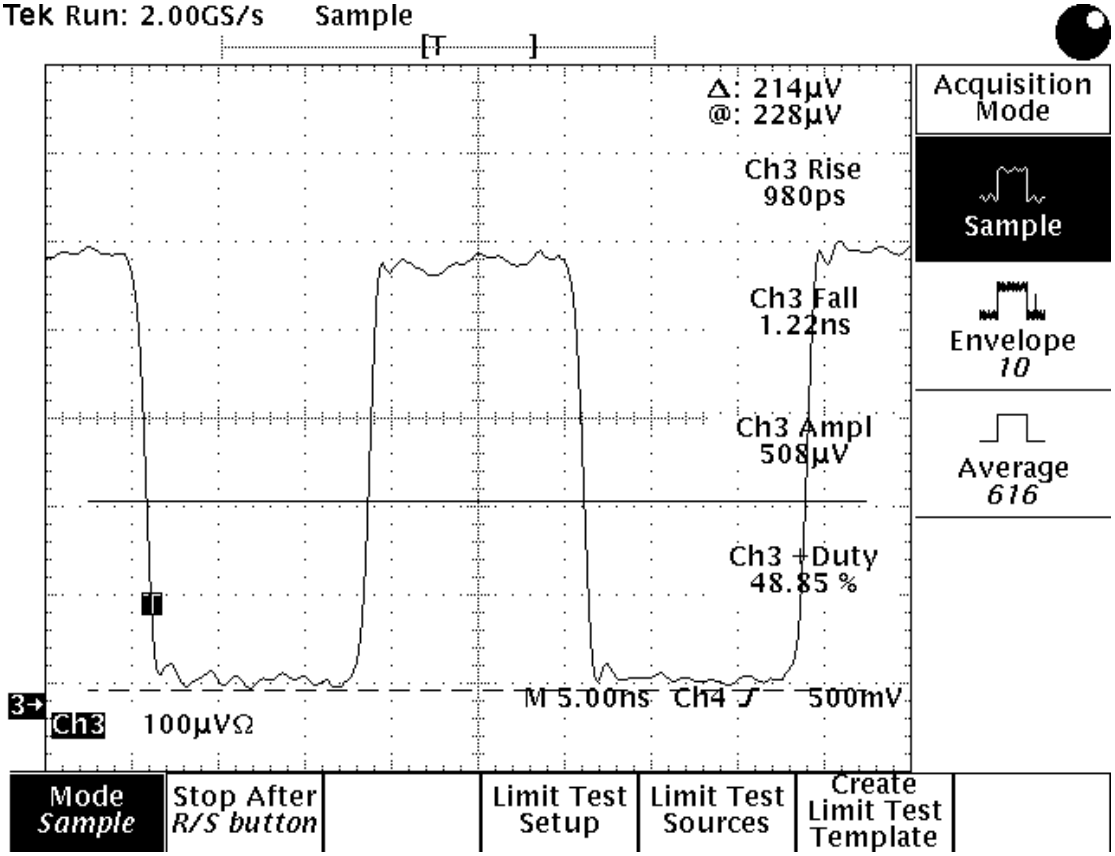


Figure 1 VCSEL1 scope trace using the optical probe.

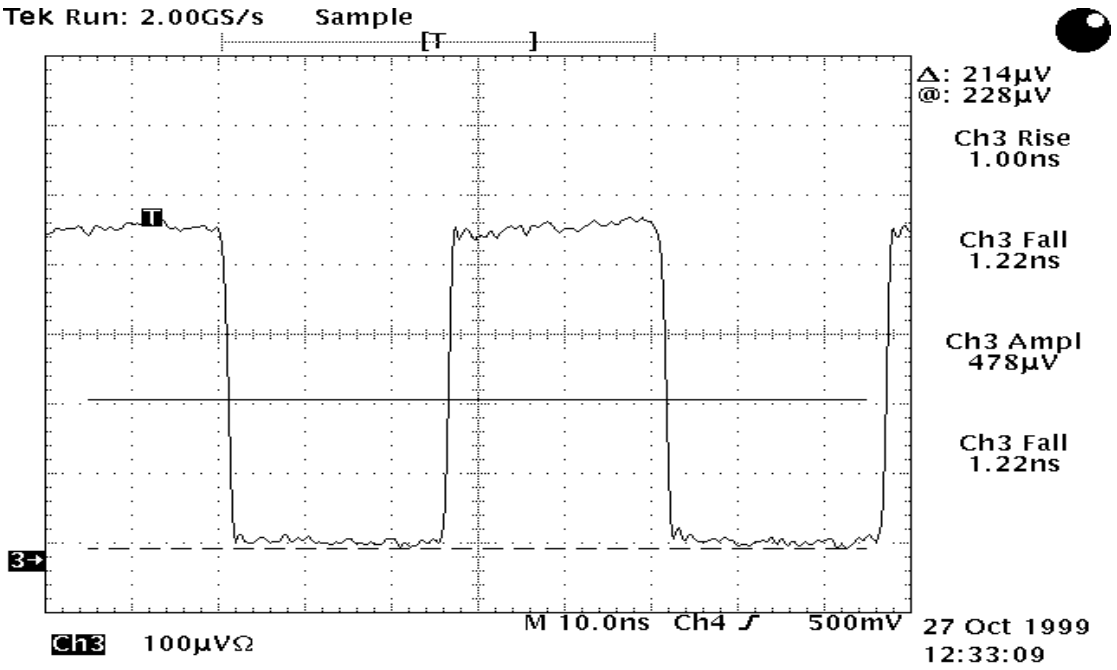
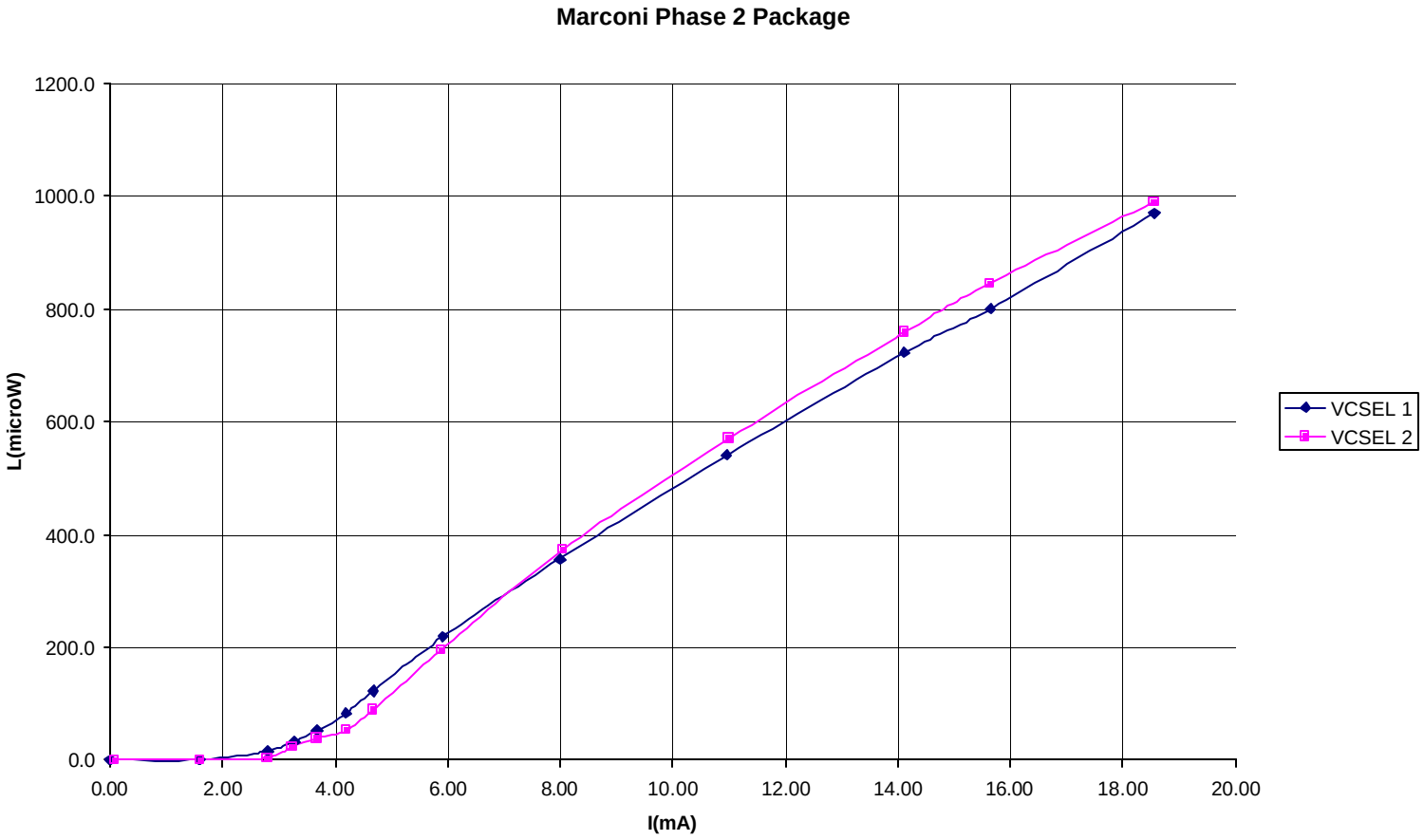


Figure 2 VCSEL 2 scope trace using the optical probe.

The ac LI curves were measured with the optical probe and the results for the two VCSELs are shown below (the input clock frequency was 20 MHz corresponding to the 40 Mbits/s data rate).

To check the noise and stability of the VCSEL scope pictures were taken at 10 mA



drive current with infinite persistance (see figure below). The output was stable and there was no significant laser noise.

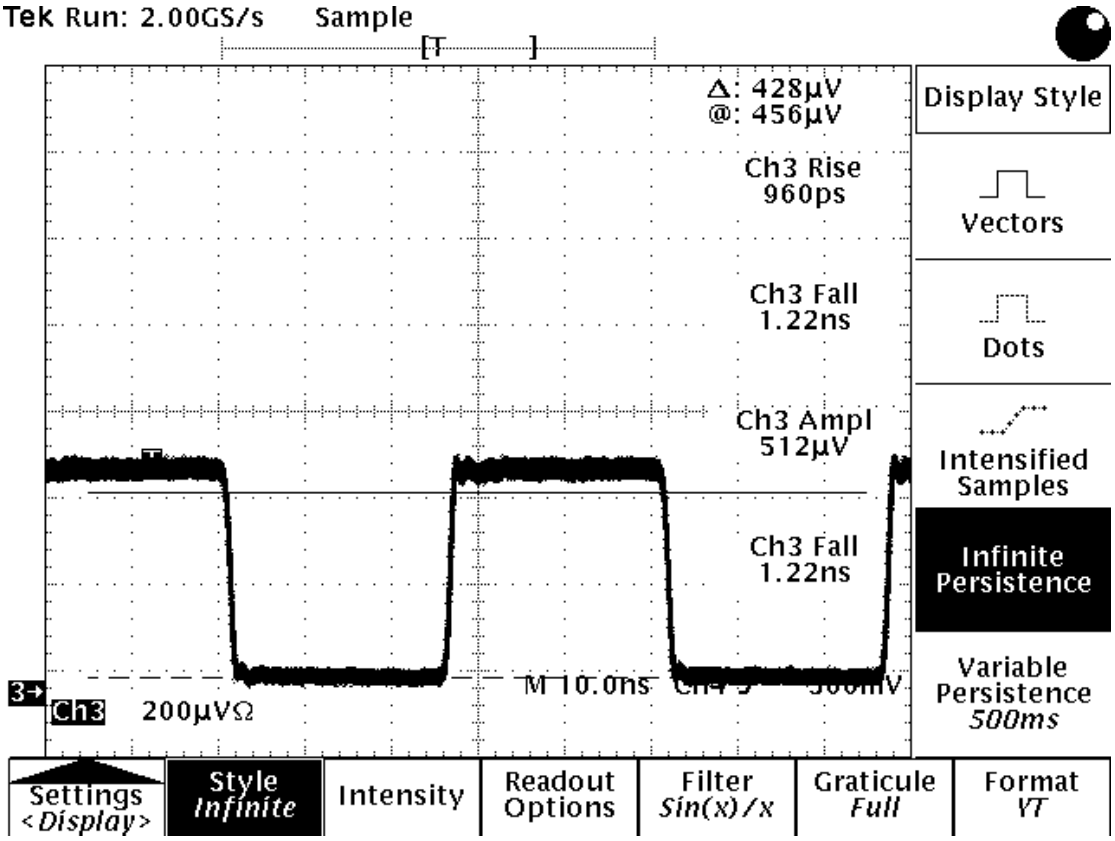


Figure 4 'scope infinite persistence plot of VCSEL output measured with an optical probe.

Packages # 1 and 2

The responsivity of the PINs was measured using light from a VCSEL at ~850 nm. The results are given in Table 1 below. There was no measurable dark current.

Table 1 Responsivity of PIN diodes.

Package	Responsivity (A/W)
1	0.44
2	0.47

Both PINs and VCSELs worked on these two packages. The LI curves for the VCSELs were measured and are shown in Figure 5 and Figure 6 below.

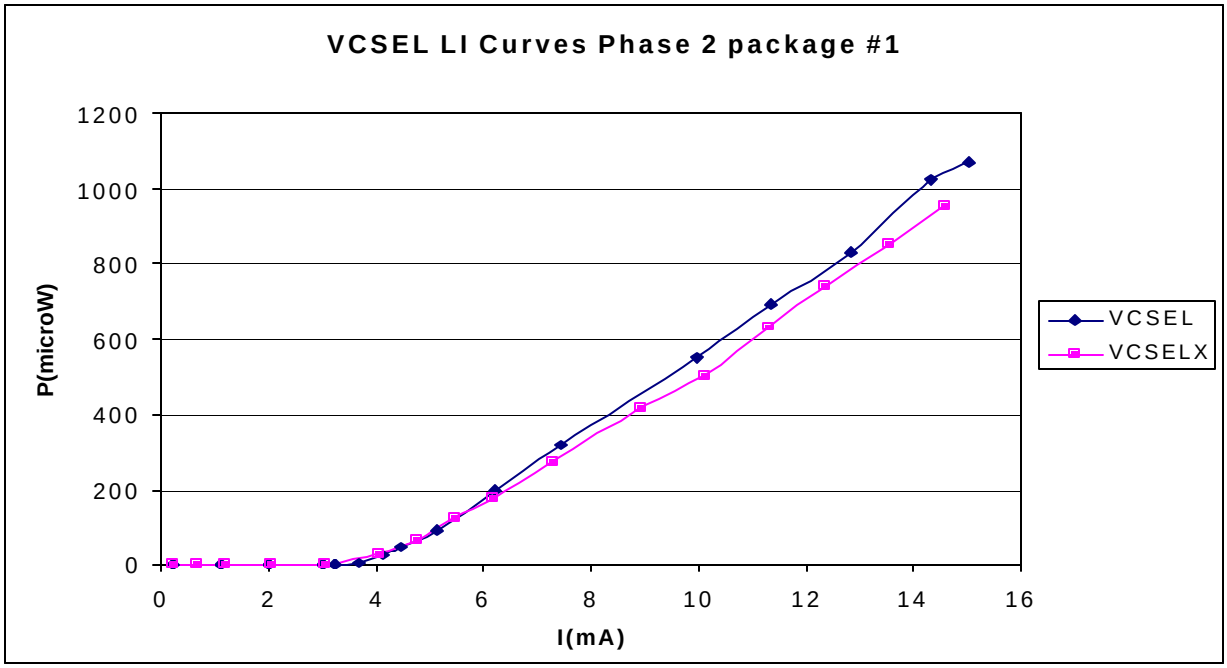


Figure 5 LI curves for VCSELs in package #1

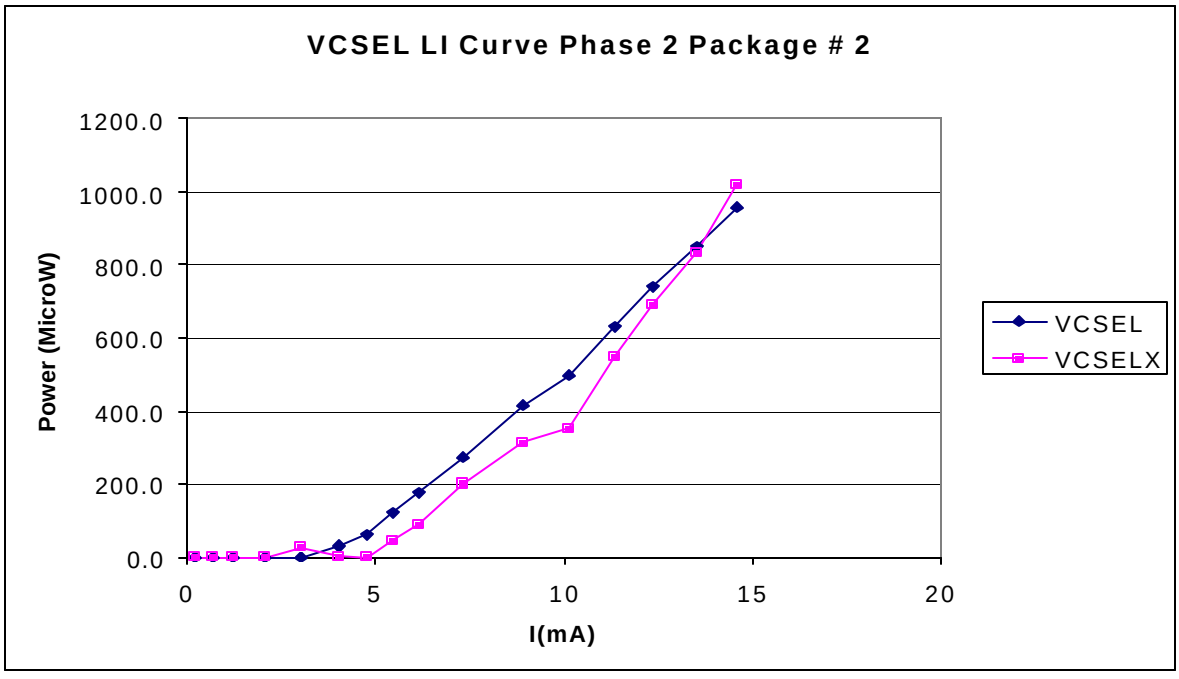


Figure 6 LI curves for VCSELs in package # 2

BER and Cross-Talk Measurements

The Bit Error Rate (BER) was measured in a loop back mode where TTC data were sent to the PIN and decoded by DORIC4. The decoded data was sent to one channel of the VDC chip and the output of the VCSEL was attenuated and sent to the Rudge receiver. The BER was measured as a function of the amplitude of the optical TTC signal and the results are shown in Figure 7.The BER falls to below 10^{-9} for an optical power of about 160 μW which is within the specifications for DORIC4 operation. The measurements were repeated while simultaneously sending asynchronous 20 MHz pulses to the other channel of the VDC chip. In order to simulate the worst case conditions the VDC drive current was set to 20 mA. There is no significant difference between the two curves in Figure 7, therefore we can conclude that there is no measurable cross-talk.

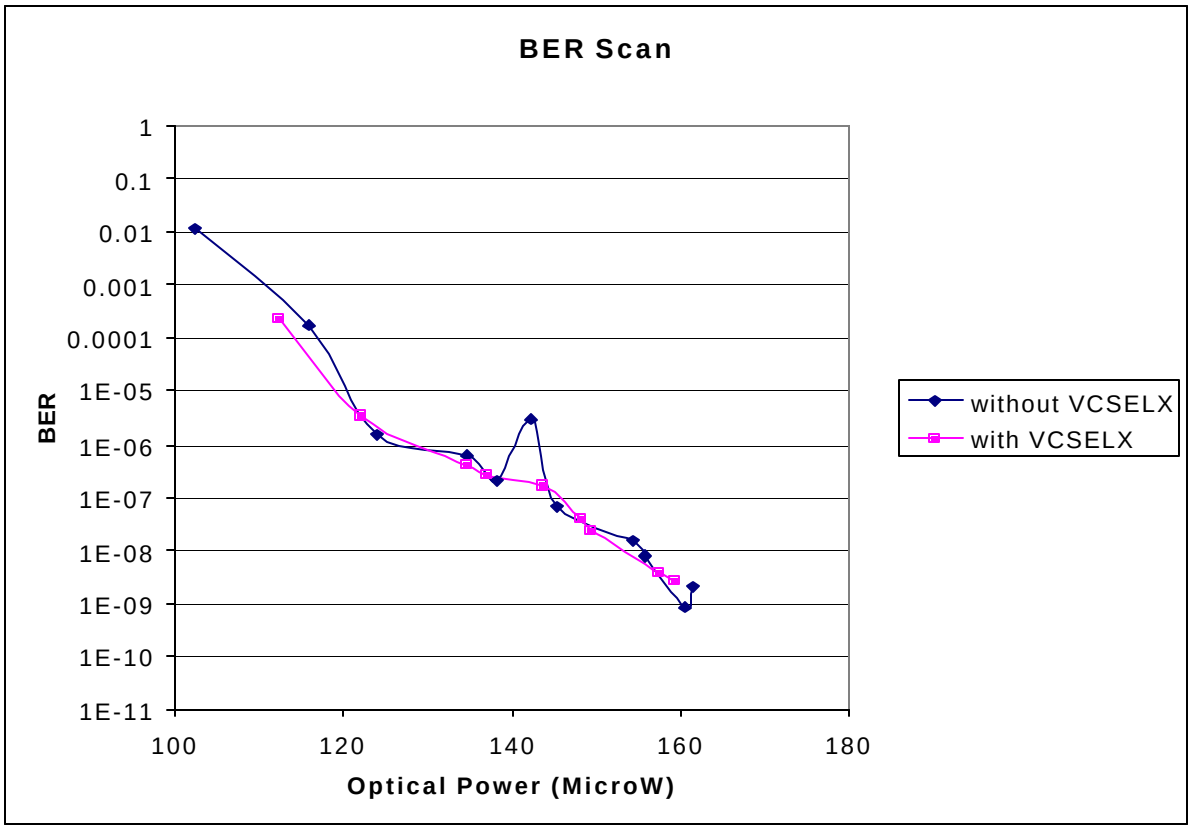


Figure 7 BER as a function of optical power into the TTC link.

The results for a similar scan with readout via VCSELX , with and without pulsing VCSEL are shown in below. Again there is no evidence of any cross-talk.

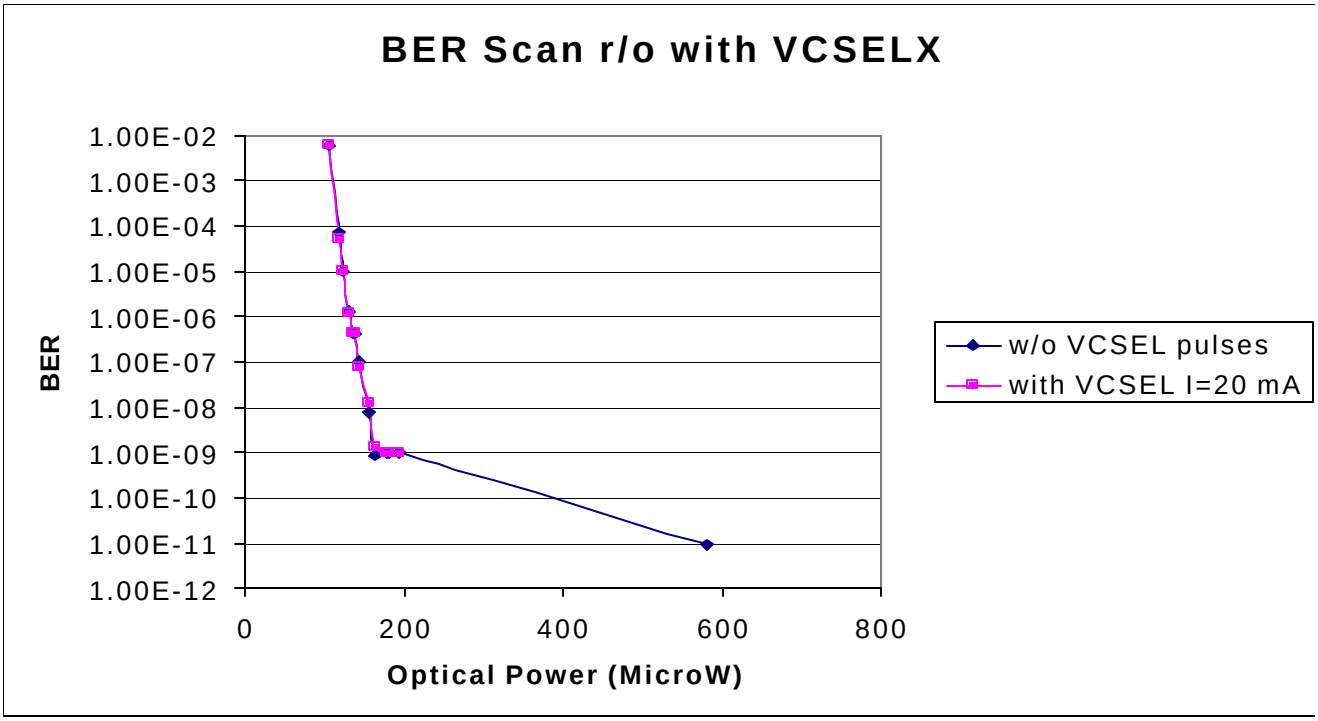


Figure 8 BER scan with readout via VCSELX and with and without pulsing VCSEL. The last point at the highest power corresponds to no observed bit errors in 45 minutes.

Radiation Tests

The responsivity of the PIN diode in package #1 as a function of bias voltage is

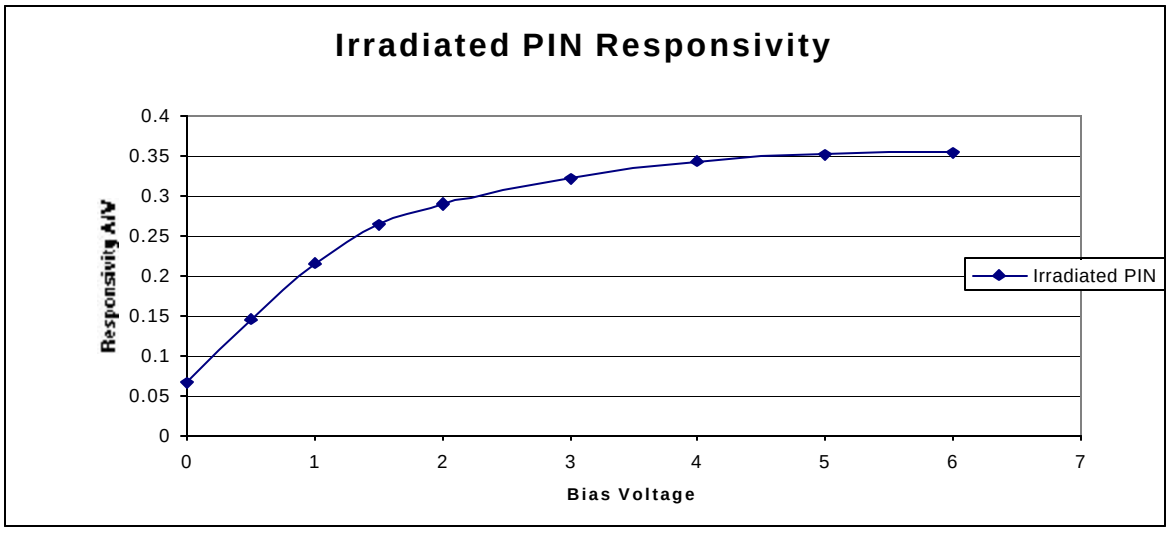


Figure 9 Responsivity versus bias voltage for the PIN diode in the irradiated package.

shown in Figure 9 . The behaviour is quite compatible with the studies of radiation hardness of PIN diodes mounted on ceramic tiles.

As expected the VCSELs showed large threshold shifts after the irradiation but annealed rapidly when operated at 20 mA. The annealing saturated after about 100 hours. The LI curves for the VCSELs in the irradiated pacakges were measured (after annealing) and compared with the LI curve before irradiation. The results are shown in Figures 10 to 13 below.

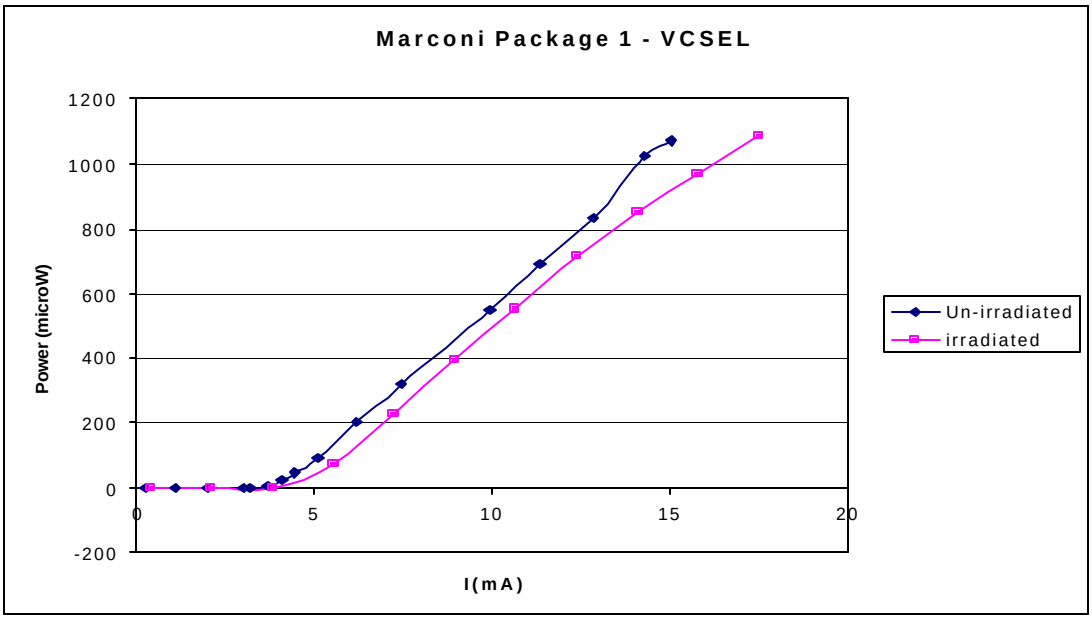


Figure 10 LI Curve for VCSEL in package 1 before and after irradiation.

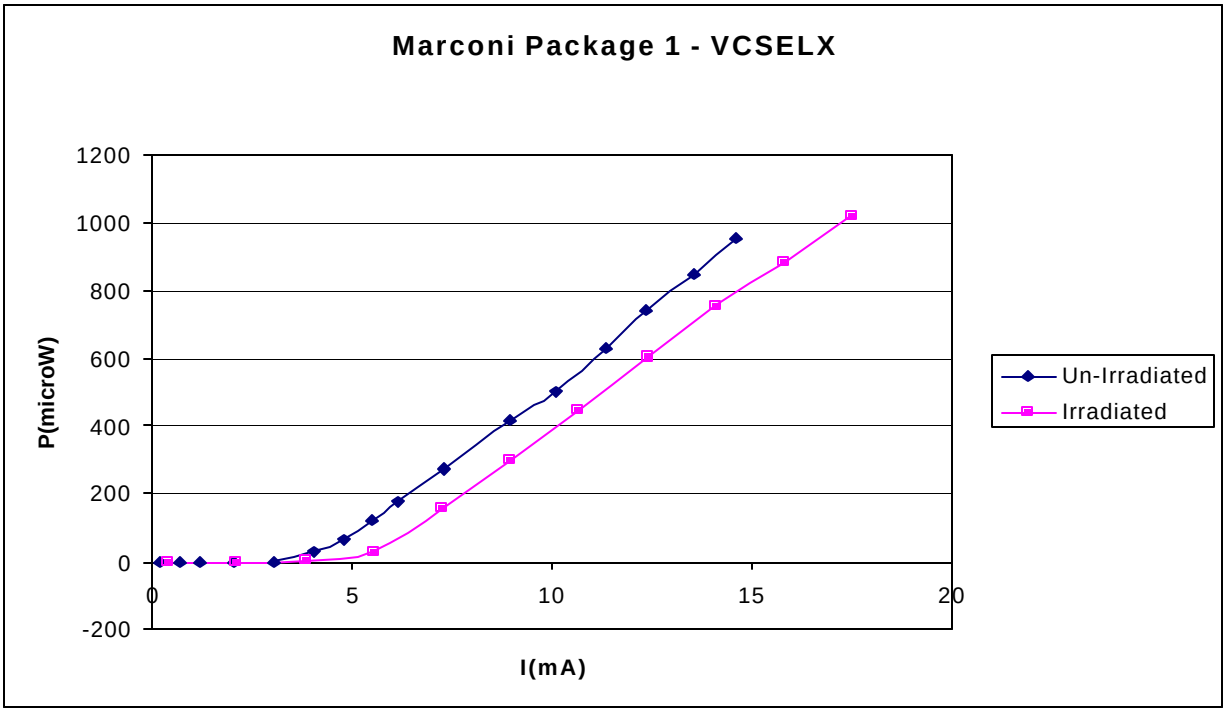


Figure 11 LI Curve for VCSELX in package 1 before and after irradiation.

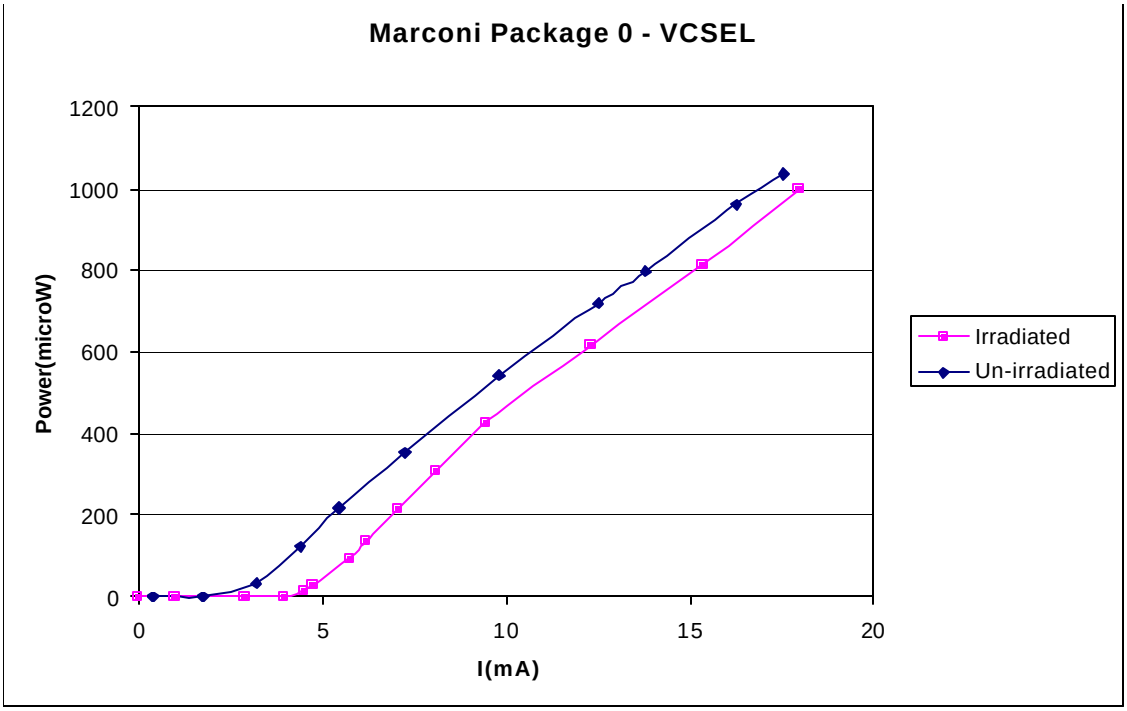


Figure 12 LI Curve for VCSEL in package 0 before and after irradiation.

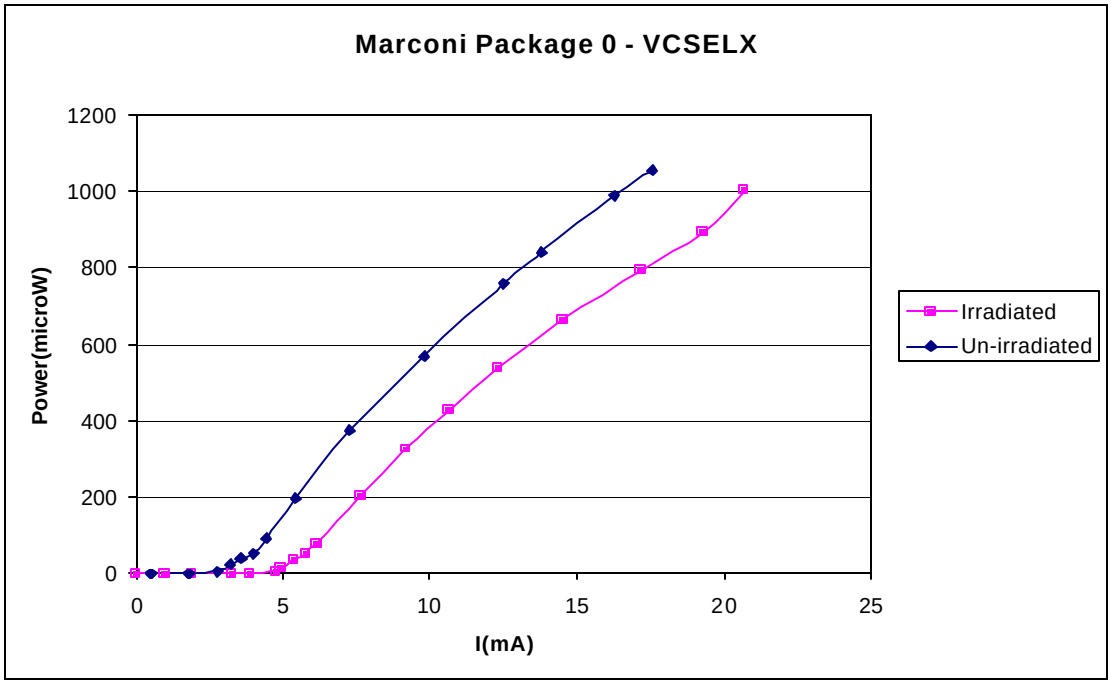


Figure 13 LI Curve for VCSELX in package 0 before and after irradiation.

The data have the expected small threshold shift after irradiation and annealing but show no significant changes in slope efficiency. The shape of the optical waveform was measured with an optical probe and showed no significant differences compared to unirradiated VCSELs. If there had been any radiation induced problems on the packaging, this would have decreased the VCSEL to fibre coupling efficiency and hence reduced the slope efficiency. Therefore we can conclude that the package is radiation hard up to the fluences expected for the SCT.

The BER was measured using the irradiated package #1 and very good results were obtained as is shown in Figure 14 below.

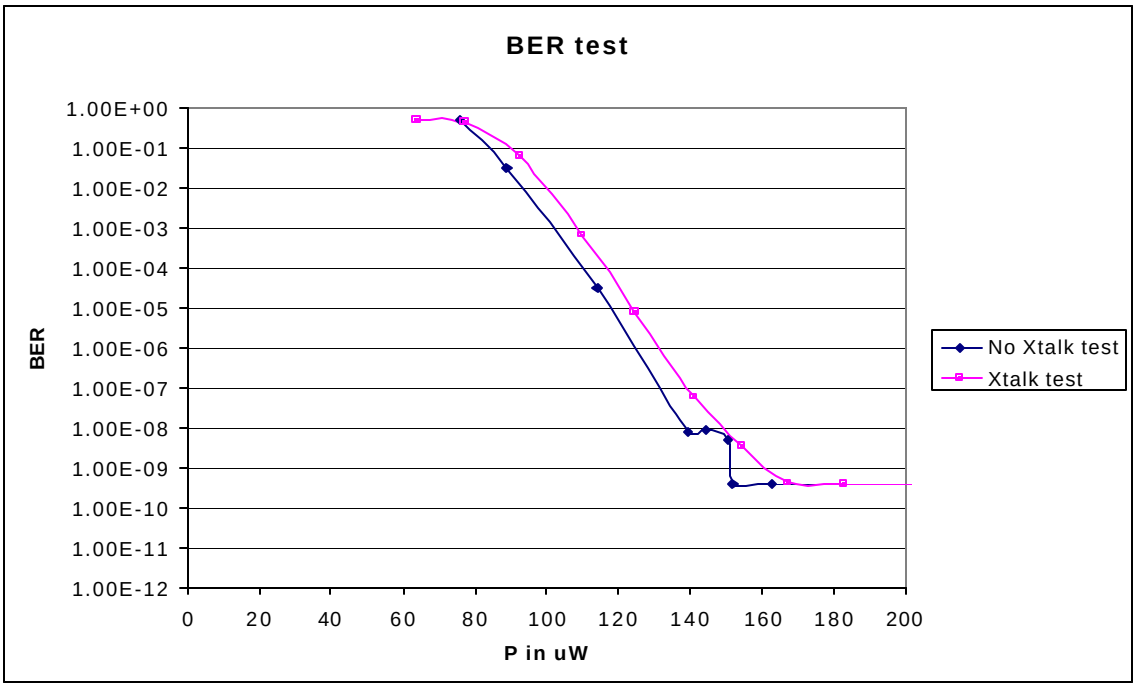


Figure 14 BER versus optical power for the TTC link as afunction of the optical power inout. The VCSELX was pulsed with 20 mA at 20 MHz for the cross-talk

The results show that the package works very well after the irradiation. The performance is significantly better than the specification which states that the BER should be less than 10^{-9} for an optical power of 200 μW (for an irradiated PIN diode).

Conclusions

Measurements of the first Marconi phase 2 packages show that they work to better than required by the specifications. Tests of the full two way links show that the VCSELs and PINs work when combined with VDC and DORIC ASICs on an opto-hybrid/dog-leg assembly. There is no measurable cross-talk with this package. The radiation tests showed that the package was radiation hard up to the fluences required by the SCT. Further radiation tests will be performed on completed packages to study the effects of radiation up to the levels required by the pixel detector.